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Implementing and diffusing innovation at a Swedish construction company

The case of implementing the digital delivery container

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Abstract

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Thrudur Starradottir & Tom Wullimann

The construction industry is often perceived as conservative and slow to innovate. Previous studies have explanations for why this is the case and attempt to look further into why implementing and diffusing innovation in the construction industry is different, and somewhat more challenging than in other industries. Some point towards the fact that a construction project is somewhat a 'temporary factory', where the end product being produced is the factory itself. This creates challenges which other industries do not face, making it difficult to optimize construction projects. Furthermore, is the construction industry a multiorganizational industry, and activities are project based. That means that there are often multiple projects going on parallel, with multiple actors involved, making the industry complex.

In this paper, we conduct a single case study on the implementation of a digital innovation at a large Swedish construction company. The company is a highly decentralized, project-based organization making the study about implementing innovation in such organizations. The results were analyzed using Rogers' framework for the diffusion of innovation. We were able to identify four facilitating factors, along with one hindering factor, for our case of implementing an innovation at a decentralized project-based construction organization. The facilitators were: the innovation should to be somewhat simple to understand and use, the projects implementing the solution require extra resources to be willing to take the risk of implementing a new solution, the implementation needs driven individuals to keep the momentum of the solution going and push the solution through the complex organization, and finally is it helpful to use marketing internally at the organization to bring attention to the solution. Finally, the hinder identified was simply internal politics and the complicated organizational structure of the firm.

Keywords: implementation, diffusion, innovation, construction industry, project-based organization, decentralized organization

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Popular science summary

We want innovation to bring improvements to something that perhaps is outdated and bringing innovation into an organization can often be challenging. Innovation can have positive economic effects, often by increasing efficiency or effectiveness of the processes already being used. In today's society, innovation is often something digital and companies see the value in introducing more digital working processes or products in their operations.

The construction industry is important to the Swedish economy, and there is always a pressure to keep real estate prices down. This means that construction companies are constantly pressured to keep the cost of production as low as possible. Despite this, there was a headline of a news article in 2018 stating that 'construction is worst at digitalization', that is that the construction companies in Sweden are one of the worst industries using the possibilities of modern digital tools in their operations. This study looks into why it is so challenging for construction companies to implement, diffusing and thereby, start using, innovations. To answer this, we conducted a single case study at one of the largest construction companies in Sweden where we followed the implementation of a digital innovation.

The structure of the construction industry must be understood to answer the question. There are previous studies which look into why it seems to be challenging for the construction industry to innovate. Some point towards the fact that a construction project is somewhat a 'temporary factory', where the end product being produced is the factory itself. Not like with more traditional industries, like manufacturing cars for instance, where the process is within a fixed environment and there is a greater opportunity for optimization of the processes. This creates a challenge for the construction industry, that it is incredibly difficult to optimize construction projects in its continuously changing environment. Furthermore, is the construction industry a multiorganizational industry, and activities are project based. That means that there are often multiple projects going on parallel, with multiple actors involved, making the industry complex.

The construction firm studied in this case, NCC, is a highly decentralized organization, where there is a central part which provides management and support for the projects which are happening all over the country, at the construction sites. This creates a challenge when attempting to innovate, since the projects are already very restricted to a pre-determined budget and time-plan for each construction project, but simultaneously should the projects attempt to implement new solutions to make the construction safer and more efficient.

In the case studied, there was an industry wide testbed project which was financed by the state agency Vinnova, where multiple large construction companies came together and the aim is to digitalize the construction industry. NCC was one of the large companies responsible for a testbed, it being called 'the seamless supply chain'. NCC's focus was therefore to identify problems with the logistics and supply chain at a construction site, and introducing a solution. It cooperated with a software company called Qlocx, as well as with some suppliers from the industry, and implemented a solution called 'the digital delivery container'.

The implementation of the digital delivery container at a single NCC construction site was followed and studied, by conducting interviews with those involved and observe a meeting at the

construction site. The data was then analyzed and themes identified which were pointing towards why and how this implementation was facilitated. Since the testbed project ended before the publication of this paper, we know that the implementation ended with the construction site continuing to use the solution after the testbed project's end, and other projects within the organization have shown it interest.

Our results were analyzed using a classic innovation theory framework, which was presented by Rogers. It covers the adoption and diffusion of innovation within a social system. After analyzing our results, we concluded that there were four crucial factors which facilitated the implementation of the digital delivery container at NCC, along with one hindering factor. First to facilitate innovation, the innovation being implemented should be simple to understand by the users, and simple for them to use. Second, the fact that the implementation was a testbed project, where the construction project implementing got the support required from the central part of the organization, as well as funding from the state-agency. This meant that the construction project itself did not have to take the risk that the uncertainty of implementing a new solution brought. Third, there were highly driven individuals involved in this implementation from the central part which could push the solution through the complex organization such that it did not lose momentum. Finally, there was some internal advertisement done at NCC where the solution was introduced, along with the positive effects it had and how to use it. This brought attention to the solution by other projects who showed interest, pushing the innovation further through the organization. The one hinder identified was simply the complicated organizational structure and the associated internal politics within a decentralized project-based firm. We therefore conclude by suggesting the positive benefits of having implementation projects alongside the traditional organizational structure, such that the facilitating factors may be enhanced and the hinder gotten over.

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1 Introduction

This chapter presents the purpose of this research paper. It starts with a short discussion about the Swedish construction industry which is being studied and some of the circumstances in which the research was conducted. Following the presentation of the industry, comes the problematization which results in the purpose and research question of the study. Finally, some delimitations which were faced during the study are presented.

1.1 Background

The construction industry is a quite visible one for us to see all over the world. It is not restricted to factories like many other industries, but we can see construction projects happening when walking in cities or travelling through rural areas. The importance of the industry is not to be debated here, but it has though often been said that the number of tower cranes, as used by the construction industry, over cities indicates directly the economic prosperity at that time (Parker, 2017). Despite its apparent importance, the construction industry has often been perceived as rather conservative in terms of technological innovations compared to other industries (Bygballe & Ingemansson, 2014). During the last century, the way the construction industry has been conducted has barely changed, which is of concern since it represents a significant component to most economies worldwide (McKinsey & Company, 2017). In Sweden, the construction industry has the lowest digital maturity among all other industries and might undercut current innovation practices which effects reputation industry wide (Tillväxtanalys, 2016). As productivity has remained relatively low, costs have risen steadily, which have generated the urge for accelerating innovation not to mention the potentially huge time and cost benefits through the whole supply chain (McKinsey & Company, 2017).

One central barrier opposing effective development is the temporary nature of construction projects and the many intermediate players involved, which complicates coordination of production, planning and logistics (McKinsey & Company, 2017). This is also supported by Holmen, et al. (2005) who discuss that construction research has been pointing to the fact that cooperation between firms in the industry is a requirement for increased industry innovation. Furthermore, a characteristic of the industry is that it is mostly project-based where many actors are involved in the projects (Widén & Hansson, 2007). Researchers often look to the manufacturing industry as some sort of an ‘ideal’ industry, but the difference is that construction projects are temporary. The manufacturing industry produces inside the factory which is a controlled environment, and the processes of production may be repeated within these fixed conditions. Therefore, it may be challenging for some practices and theories on innovation and its diffusion to be applicable on the somewhat unique construction industry. The industry’s self-image might also present a potential problem with innovating. The industry is simultaneously conservative and common norms seem to be ‘cling to a proven way’, or ‘do what the clients want to do’, while simultaneously construction companies want to perceive as innovative. But there is rarely any space for slack resources in any projects, hindering innovation to take place (Nam & Tatum, 1997).

1.2 Problematization

Based on the previous discussion that there is lack of innovation and that productivity has remained constant within the construction industry, an industry wide initiative was started to attempt to change this. The initiative is a cooperation between Linköping University, Luleå Technical University and some of the main construction companies in Sweden, and is called 'Connected construction site' [Uppkopplad byggplats]. The project is mainly funded by Vinnova, a state agency, among others. The overall objective of this project is to increase productivity, security and the efficiency within the construction industry in Sweden through digitizing. Within this project, there are defined four different testbeds, which each have a different focus. The fifth, cross sectional part of the overall design of the project, is the digital infrastructure of the industry (Rudberg, 2018).

To contribute to the challenging research area of how the construction industry can become more innovative, we will conduct a study on how a construction company can implement an innovation. We considered the previously described initiative to be the ideal platform to conduct a study on the implementation of an innovation within the construction industry, since we could be certain that there would be an implementation of an innovation to follow, and a defined time frame for the implementation. Therefore, we could follow this process, and see the potential hinders or drivers that contributed to either a facilitating or challenging implementation of an innovation at a construction company. Specifically, at a project-based organization, since we consider that type of organization best represents a large construction organization, we conducted the study within such an organization and our research question focuses on implementation within a project-based organization.

This lead to the cooperation with the construction firm NCC AB in conducting this study. NCC is the main actor for one of the previously mentioned four testbeds, focusing on the seamless supply chain [den sömlösa försörjningskedjan] (Rudberg, 2018). NCC's main focus is therefore to research how to optimize the construction site, and the automation of logistics systems. NCC has already started to implement a digital innovation in one of its projects, which is supposed to help NCC reach its objectives within the larger project (Interviewee A, 2019). The implementation of this solution is what we used as a case to study in this research.

Our research topic is therefore in general about implementing an innovation at a decentralized project-based organization within the construction industry in Sweden. Our objective was to study the implementation and diffusion of a digital solution, *the digital delivery container [digital leveranscontainer]* at an NCC construction site. We will attempt to identify drivers and hinders for the implementation and the diffusion of this innovation. By doing so, we hope to conclude this study with some identified factors which would be helpful to consider either as drivers or hinders for further innovation within this type of construction organization. This in turn, we hope will contribute to other research that has been done in the industry, helping the construction industry move towards implementing innovations.

1.3 Research question

Our objective will be to study the implementation of this innovation. A central sub-objective is to identify drivers and/or challenges when implementing and diffusing an innovation in a construction setting, from the central part of an organization to the temporary projects in a project-based organization. This in turn, we hope will help in the further understanding of how digitalizing can come about in the construction industry and be done in the most efficient and effective way.

Our research questions are therefore the following:

RQ1: How can the process of implementing innovative solutions within a decentralized project-based construction organization be facilitated?

RQ2: How is the process of implementing innovative solutions within a decentralized project-based construction organization hindered?

1.4 Delimitations

The research was conducted in cooperation with NCC, and on a case which happened at an NCC construction site. This means that we were limited to this case, and the circumstances in which it happened. The implementation of the solution was a part of a Vinnova project and had its own testbed which gave it very specific circumstances needed to be considered as a factor which could have affected the implementation, and therefore might have had effects on our research. We were limited to that one construction site on which the solution had been tested, meaning that the data generated on the effects of the solution were only generated from one project. The effect of the solution might therefore be different if it were implemented in other projects, but we defined this to be outside of the scope of our research from the start and limited us to only one construction site.

We were also limited to this one digital solution, which only effects problems about logistics at the construction site. Therefore, even though we are looking into the area ‘digitalization within construction’, we still limit ourselves to only a digital solution which effects the construction site logistics. We hope though, that by looking at a solution small-scale, that it will give an indication about what might be positive and negative for other future digital solutions and their implementations, despite that they might be digital solutions for other problems at the construction site.

2 Literature Review

In this chapter we will present some literature relevant to our research.

2.1 The construction industry

Rogers and Argawala-Rogers define in their book 'Communication in organizations' an *organization* as "a stable system of individuals who work together to achieve common goals through a hierarchy of ranks and a division of labor" (Rogers, 1983, p. 348). Diffusing an innovation through an organization is a challenge, and the same classical theories on innovation adoption do not apply for organizations in the same way as for individuals (Rogers, 1983). This is also something which was pointed out by Lindgren and Emmitt (2017) when they reviewed Rogers' diffusion of innovation theory. They said that another reason that Rogers had discussed as to why diffusing innovation in organizations is different from diffusing within individuals in society is that there are number of individuals involved in making decisions about implementing or diffusing the innovation within an organization. And that these individuals all play a different role in the decision-making process.

When discussing the construction industry specifically, there are two main attributes which are mentioned as differentiating factors from other industries, namely that activities within the industry are mainly project-based, and the multiorganizational setting of the industry (Bresnen & Marshall, 2001). Simply put, many organizations are involved in each construction project, and construction happens through projects (Nam & Tatum, 1997). This is further supported by Blayse and Manley (2004) who point out that when discussing innovation in the construction industry as a whole, the construction industry network in many countries is primarily built on a great number of small companies, i.e. the industry is multiorganizational. They further discuss that these small companies and organizations often do not have the same resources to innovate much, limiting the innovation for the whole industry. The network therefore might need strong relationships between the players if innovation is desired.

The projects in the construction industry are difficult to optimize, since there is always a difference between the projects, and there is always some level of uniqueness in every project. It has therefore been difficult for the construction companies to reach some repetition or routinize its projects (Bresnen & Marshall, 2001). The construction industry typically represents fragmentation and instability and even if the process is similar to previous projects conducted, there is always some form of uncertainty involved (Vrijhoef & Koskela, 2000). This brings some challenges to the construction projects, for instance challenges to logistics planning at construction sites, and one needs to remember that the industry in many ways differs from others. The construction site is in a way a temporal "factory", and one could also say the end product is the factory itself. The fact that construction sites often are built on novel locations with different prerequisites and different actors, makes them unique from previous constructing activities. This in turn calls for project groups and supply chain configurations which at every new project initiation require a reconfiguration of the project organization (Behera, et al., 2015).

2.2 Innovation in construction

Holmen, et al. (2005) study how the relationships between firms within the construction industry would impact innovation. They found that techniques which often are used when implementing and developing innovations are difficult to transfer to the construction industry since the traditional trial-and-error method between multiple projects cannot be used in construction. They found that the characteristics of the construction industry, i.e. only having unique projects and not considering the impact of long-term relationships between projects makes it difficult to use these relationships which are necessary for the industry to innovate. They found that partners were too frequently changed and that was prioritized higher than innovating, especially when technical innovations were studied.

Specifically, when discussing digital and/or technical innovation within the construction industry, a construction organization's core competences should be kept in mind. As Blayse and Manley (2004) conclude in their review on innovation strategies within the construction industry, the organizations within the industry are not fit to innovate technical solutions. They conclude that it would be beneficial for construction organizations to get the assistance and necessary knowledge from other firms whose specialties are more technical. That way they are able to get the necessary skills and knowledge to implement solutions which would otherwise be unknown to them. This is also known as using *innovation brokers.* Innovation brokers can be universities, construction research bodies and other professional institutions. These innovation brokers introduce therefore new technologies or make new competencies aware to construction firms and inform them what there is more to know outside the firm. In a way, bridging the gap between the knowledge and the construction firm (Blayse & Manley, 2004). Flipping the coin, there is also a study that concludes that the construction industry may take technologies from outside the industry, i.e. from innovation brokers, and re-innovate them to fit the needs of the industry. By doing so, different solutions are created through the adoption of a technical solution (Whyte, 2003).

Innovation champions are those individuals in an organization which lead innovation forward. This goes hand in hand with the notion of the innovation broker but is in this context the individual at the construction side of things that identifies the need for the bridge and maintains it. "In one sense, all innovation depends on individuals" (Nam & Tatum, 1997, p. 265). If these individuals would not have been a part of the project or absent, it would have delayed the whole process of the innovation. These individuals were described as 'champions' by others involved in the project (Nam & Tatum, 1997). In diffusion literature, Slaughter (2000) identifies that the role of the champion changes over time. She mapped five different roles to his five implementation stages*:* the *idea generator* and the *gatekeeper* which are needed for the actual identification and evaluation of the innovation. These champions function as technology filtering agents and thus play an important role as to which technology later gets adopted. The *champion* which was influential in the commitment stage and gaining traction within the firm, and the *project leader and coach* which were necessary for the formation and use of the innovation (Slaughter, 2000, retrieved from: Shibeika & Harty, 2015).

As was discussed in the introduction of this study, there is potential for more economic gain by having higher levels of innovation within the construction industry (McKinsey & Company, 2017).

This is further supported by Blayse and Manley (2004) which discuss that in many countries the construction industry and its surrounding industries, i.e. its supply chain, account for about 15% of national production. There is therefore a high potential for gain by innovating industry wide within construction. This is also an argument made by Schumpeter (1983) when he presented his theories on creative destruction and entrepreneurship, that innovations lead to economic growth. Social gains of innovation within the construction industry are also quite simply because it has the potential to lower cost of living. By innovating in production of buildings and housing, it lowers the cost of production, lowering the price for people to purchase real estate (Slaughter, 1998).

Literature suggests that there is room for improvement in the industry, and a huge potential for digitizing (Bygballe & Ingemansson, 2014; Whyte & Hartmann, 2017). This is supported in an article by Walker (2016) which studies the trend in innovation within the construction industry over the years 2005-2015. His findings were that there was digital innovation on some levels, but that the industry was not utilizing the growing powers of computer processing. Moreover, engineering firms are struggling to embed new technologies and their associated working practices for the digital delivery of major infrastructure projects (Shibeika & Harty, 2015). Many construction organizations try to pursue today's vast digital benefits but depends deeply on user acceptance. Shifting from a paper-based to a fully digital operation requires colleagues and linked organizations to be in unanimity when using and diffusing digital innovations. Failing to do so, users may find it detrimental and thus its perceived productivity gains alienated. Technology and innovation management are according to Shibeika and Harty (2015, p. 453) activities not only concerned with "how to implement and make the best use of digital technologies", but also to integrate them within the projects. This is in order to develop best practice and spreading that across the different business sectors of the firm. In addition, activities should also be concerned with how these technologies become standard practice and to remain competitive.

When discussing innovation in the construction industry, Davidson (2001) mentioned that it is quite natural that it does not follow the same 'logical path' which it often does in other industries, simply because of the nature of the construction industry. As Davidson points out, innovation is a process, of *how* something new (product or process, etc.) is developed and introduced to markets or into practice. He argues therefore, that the process is naturally dependent on which industry it is introduced in, since it results in a change in that specific industry. He says that what we often want to be the 'logical' way for the innovation process to follow is "...predictable path leading from invention to applied research, patenting, pre-production and marketing, and finally to production and its management." (Davidson, 2001, p. 234) But given how projects work in construction, and how each project is its own new manufacturing site in a way, it is very difficult to apply this logical path in construction.

Another study on technological innovation within project-based construction industry by Mitropoulos and Tatum shows that deciding which solution to implement is also a struggle within such an organization. That is because there are two types of managers, the top managers (from the central, overall part of the organization), and then project-level managers who have control of the projects, and these two types are not looking for the same type of technology solutions. The top-managers are looking for innovation that best fits the needs of the company as a whole, while the

project-level managers are looking for specific solutions to the problems they face in the projects. This has the potential to create a challenging environment for diffusing an innovation within a construction firm (Mitropoulos & Tatum, 1999).

Innovation management theory suggests that there needs to be some balance between how organizations spend their resources on exploring and exploiting. For an organization to be successful in innovating, there needs to be a good balance between the two. This is because the organization wants to simultaneously explore new solutions or new markets and be more active in its business and exploit those solutions and processes which have been established to reach a higher level of efficiency. By standardizing routines and procedures, an organization is acting more passively and is exploiting its resources. This has the potential to increase efficiency, but the danger is that there is no room for innovation (Benner & Tushman, 2003).

The push-pull strategy is described by Chau and Tam (2000) as a driving force for innovation and its diffusion of new technology. The mindset behind these two concepts; technology-push (TP) and need-pull (NP) - originates from two different arguments as to what actually drives innovation. The first school, namely technology-push argues that science is what drives innovation which in turn drives technology and its application. Chau and Tam (2000) further elaborates that as science continuously discovers new and better tools, performance in its indented area of use increases and thus inevitably diffuses as the perceived benefits favor the former. Continuous improvements in technology drive incremental improvements by one of two ways according to Von Hippel et al. (1999); the innovation owners self-governing research and development, or through the close interaction with lead users who are then testing and validating the innovation, which could be seen as the need-pull strategy. Chau and Tam (2000) argue that user needs, and demand are the drivers of the diffusion of innovations. This could according to them be exemplified as workers feeling low satisfaction level with existing computer systems within a software company or inability to meet existing market needs. This leads to individuals “pulling” innovation through experimentation and progressive improvements. And further elaborating on the origin of innovation studied Nelson and Winter (1977) how innovators search for solutions, one of which were government-sponsored innovation through universities and large corporate R&D facilities. There they stressed the importance of business strategy to innovation.

3 Theoretical framework

The aim of this chapter is to present the relevant theoretical frameworks for the study. It is divided into two main parts, first we define the term innovation. Second, we present the framework developed by Rogers (1983) which is the main framework used for the analysis of the data.

3.1 Defining innovation

We first want to present a definition of innovation which we will base this analysis on. There are multiple definitions of the term innovation circling around in research, but we will use the definition provided by Slaughter (1998, p. 226), which Blayse and Manley (2004) said was broadly accepted as an appropriate definition of the term:

> Innovation is the actual use of a nontrivial change and improvement in a process, product, or system that is novel to the institution developing the change.

There is therefore a competitive factor to be associated with the term innovation, as we can see from Slaughter's definition. She mentions that the significant (nontrivial) change must be novel to the institution developing the change. Innovation therefore is something that is developed at institutions and should result in some sort of novelty for the developing firm. This goes well with Schilling's (2013) opening discussion in her textbook on managing technical innovation. She discusses how managing innovation at organizations has become increasingly important, as innovation becomes increasingly one of the main reasons for competitive success in multiple industries. This is, among other reasons, because of increased globalization and how markets have become larger and more integrated across geographical boarders. Firms must be able to keep up to the diverse demands of all these various markets, and the speed of change in customer demands. Innovation has therefore become something which firms can use strategically to gain a competitive advantage (Schilling, 2013). What we also further want to identify as a crucial aspect to the definition is the 'actual use' of a solution or a change. We therefore recognize that the implementation of a solution, which is being studied here, is one of the essential parts of an innovation becoming a successful innovation since it shows the actual use of the innovation.

Schilling (2013) also discusses how it is not only creativity, or some sort of a new inventive solution to a problem that is needed to end up with an innovation. Resources and expertise are needed to complement the creativity or invention, such that the creative idea may be embodied into something that creates value or is of use to either the firm or other potential users. The process of doing so is the innovation process.

3.2 Diffusion of innovation

A framework which was used to analyze the results of this study was developed by Rogers (1983) and includes four elements which he argues are a part of every innovation diffusion. These elements are:

1. The innovation
2. Communication channels
3. Time
4. Social system

Rogers' framework has though been criticized for being too linear and not really applicable in its basic form on diffusion of innovation within organizations but is rather only appropriate when viewing homogeneous social groups consisting of individuals. We therefore will also present some alternative views to the framework, mostly based on the criticism developed on the framework by Shibeika and Harty (2015). In their study on diffusion of a technical innovation within a project-based construction organization, they used Rogers' framework as a base for the analysis, as we will do, but with some critical points which we believe are good to mention here as well.

3.2.1 The innovation

An innovation has been defined above, but this first element in Rogers' (1983) theory is understood by him as the new thing that is being adopted in this diffusion process. He even further says that the innovation has a certain ability of being diffused, based on these characteristics:

1. *Relative advantage*: Is the innovation perceived as something better than what it will replace?
2. *Compatibility*: Is the innovation perceived as fitting to the needs of the users, their past experiences and values?
3. *Complexity*: Is the innovation perceived as being difficult to understand and use?
4. *Trialability*: Is the innovation something which may be tested and experimented with on a limited basis?
5. *Observability*: Are the effects of the innovation something that will be noticed by others?

Rogers argues that these attributes of the innovation will influence its diffusion. When focusing more on a project-based organization, Shibeika and Harty (2015) found that regarding the innovation itself in such an environment, there is a struggle between central management and project management. That is because the management from the central part wants to standardize the innovation, but it still has to be applicable to the local standards of the projects. It might therefore be that the innovation can tick all the boxes which Rogers found to be important for its adoption to be a success, but it must also fit with the standards being implemented at the firm, while simultaneously fit the needs of the projects.

3.2.2 Communication channels

Rogers (1983) discusses how communication channels are crucial for the diffusion of an innovation, such that information may be shared about it. He even defined communication as "the process by which participants create and share information with one another in order to reach a mutual understanding" (Rogers, 1983, p. 17). The communication channel is therefore the means through which communication can take place. This is essential to the diffusion of innovation such that new potential users may get the knowledge of its existence. This is further supported by Kaminski (2011) who discusses that diffusion of innovation is quite simply how people communicate an innovation between each other.

What Rogers (1983) discusses as the lack of common language is a specific challenge regarding communicating innovation. By that he means that the technical competences and knowhow between those involved may not be the same, which leads to ineffective and sapping communication between the two parties. Those that have already been exposed to the innovation

might understand its technology and function, and if it includes technology which is complicated or difficult to understand, the communication to the next potential user might become difficult.

What Shibeika and Harty (2015) found was that communication channels were not fixed throughout the diffusion process in a project-based organization. Rather, that it depended on the stage of diffusion, since they furthermore argued that there were multiple stages of diffusion happening in parallel at the organization, that influenced what communication channels were being used to spread knowledge about the innovation.

3.2.3 Time

The diffusion of innovation process happens over time, and Rogers defines five different steps within this process, all happening over time:

1. *Knowledge*: when someone (individual, organization, etc.) is exposed to the innovation and knows of its existence.
2. *Persuasion*: when that someone forms an attitude towards the innovation, either a favorable one or an unfavorable one.
3. *Decision*: when that someone either chooses to adopt or reject the innovation.
4. *Implementation*: when that someone puts the innovation to use.
5. *Confirmation*: when that someone reviews the innovation and has the opportunity to reverse the decision to use the innovation if it shows a conflicting message.

The rate of adoption is through which rate the innovation is adopted through a system and Rogers (1983) represented the adoption by defining five categories of people, and certain characteristics for each group. Furthermore, the categories may be viewed with either a S-curve (see figure 3-1), or a bell-curve (see figure 3-2).

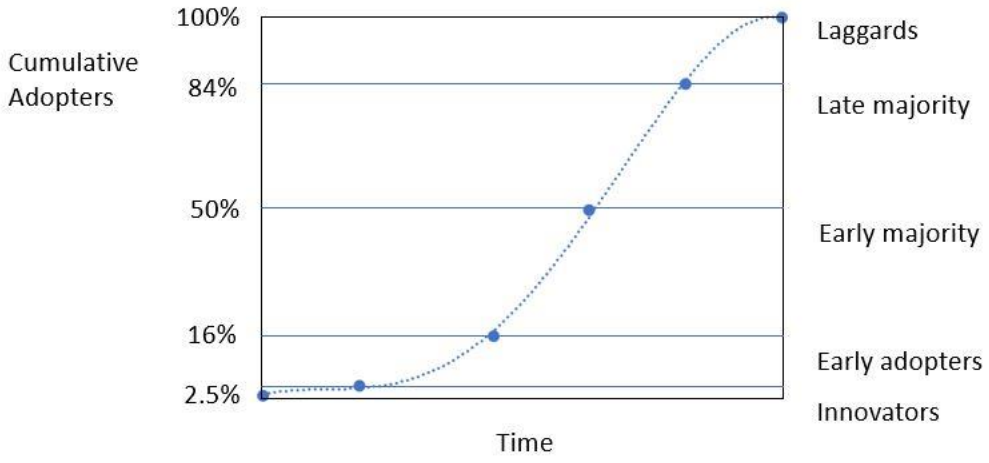

Figure 3-1: S-curve representing the diffusion of innovation

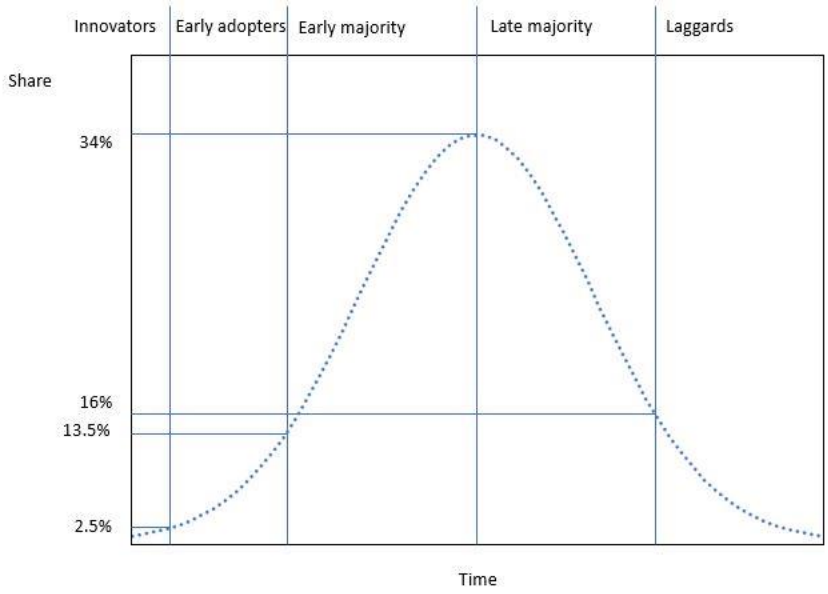

Figure 3-2: Bell-curve showing diffusion of innovation

Rogers defined five groups of people through which an innovation diffuses; innovators, early adopters, early majority, late majority and laggards (Rogers, 1983). Innovators are those that are the first to accept and try the innovation. They are comfortable with taking risks. The early adopters ware the second category which accepts the innovation, and they are those which are most likely to have opinion leadership within a group of people. Others might look up to them for advice or information on innovations. The third and fourth groups of adapters are quite similar, called early majority and late majority. The early majority group adopts the innovation just before the average people, while the late majority are a bit slower and adopts just after the average. What differs between these groups is that the typical person in the late majority group is usually quite skeptical towards innovations and might only accept it because of outside pressure. Finally, in the last group are laggards, which are those who adopt last to an innovation. They are highly skeptical towards innovations and usually make decisions only based on own past experience, not from advice from others (Rogers, 1983, retrieved from: Schilling, 2013).

A critical factor which should be kept in mind, is the chasm which Rogers defines as the point which is difficult for the innovation to move past. By crossing the chasm, the innovation has the potential to grow quite exponentially, since as may be seen on the bell-curve (figure 3-2) are there many on the other side of the chasm which the innovation will then reach. The chasm is between the groups of early adopters and early majority, and according to Rogers' framework, has the innovation therefore only reached 16% of people before it must cross the chasm (Schilling, 2013).

What may be criticized in Rogers' time element, is that it is quite a linear approach to the process of adopting innovation. As Shibeika and Harty (2015) found, there are multiple diffusion processes happening simultaneously when diffusing innovation in project-based organizations. That is, that the previously mentioned stages of specifically knowledge, persuasion and decision are happening in multiple places and in multiple times throughout the organization, making the diffusion much more complex than Rogers' framework perceives it as.

3.2.4 Social systems

Lastly, Rogers argues that the same innovation can have a different rate of adoption depending on which social system it is being diffused through. Therefore, he makes the social system an element in his framework, and he defines a social system as: "a set of interrelated units that are engaged in joint problem solving to accomplish a common goal" (Rogers, 1983, p. 24). These 'units' that are a part of the definition may be either individuals, organizations, informal groups, and/or subsystems.

What Shibeika and Harty (2015) found was that there were multiple different social systems within the large project-based construction firm which they studied. That is, that there were multiple social systems acting within the organization, such as the central management wanting to standardize processes and/or technologies, versus the projects having to focus on what was expected of them by the market and act accordingly. These social systems could therefore be pulling in different directions, even though they are working towards the same common goal, e.g. of making the firm profitable, which Rogers mentions in his definition (Rogers, 1983).

3.3 Acknowledging the chosen theory

Since the case studied in this study is innovation within an organization, it must be mentioned that even Rogers himself admits that there are gaps in researching the diffusion of innovation within organizations. Rogers (1983) quotes Professor Neal Gross, et al. (1972, p. 22) in his discussion on organizational innovativeness and agrees with them that the classical model presented here on the diffusion of innovations may be applicable to simple innovations and its diffusion between individuals, but organizational innovations cannot be explained with the model. Despite this, we decide to use the model to analyze the data presented in this study but are very well aware of the criticism it has received (Shibeika & Harty, 2015) for being too linear and simple to represent the truth in organizations fully. Shibeika and Harty (2015) pointed out in their literature review how the research field of the diffusion of innovation has evolved and moved from researching the diffusion through homogeneous systems and focus more now on heterogeneous systems, such as organizations. The choice of using this theoretical framework for the analysis is rather an attempt to create a timeline structure on the analysis and bring in classical theory and see if it is applicable for diffusion of innovation both within an organization, and in a multiorganizational setting.

4 Method

In this chapter the choice of research methods used and applied throughout the research will be presented. They will be argued for, why they were chosen as the appropriate methods, and which potential advantages or disadvantages the chosen methods might bring.

4.1 Research approach

As presented earlier in this paper, the research question proposed searching for potential drivers and/or hinders when diffusing an innovation in the construction industry. To answer this question, there is the need for us to gain an insight into the process of diffusion of innovation and understand, and attempt to map out, how the diffusion could potentially happen. Because the innovation being used in this particular research involves many different actors, and a diffusion over time, it is appropriate to use a qualitative research method. Qualitative methods have often been described as more appropriate when researching how events potentially unfold over time, while quantitative methods would be more appropriate when researching static data. Since the research is viewing a process, involving interactions between people representing actors in the industry, qualitative methods are more appropriate (Bryman & Bell, 2011).

Because of the very specific circumstances which surrounded this case, a research design of a *single case study* was chosen. According to Bryman & Bell (2011), this is this an appropriate research design when studying a case which has unique circumstances, so no comparison will be made to other implementations of the innovative solution in other potential companies, nor will other projects within the large project 'Connected construction site' be followed.

4.1.1 Qualitative research

When discussing the differences between quantitative and qualitative research, the most obvious one is that quantitative research is mostly associated with numbers, while qualitative research is rather associated with the use of words. As previously mentioned, a qualitative approach is also more appropriate when viewing a process, or dynamic data, rather than static data (Bryman & Bell, 2011), and we argue that the implementation and diffusion of an innovation is a dynamic process making this an appropriate research approach.

Some point out that it is quite difficult to define what it is that makes research qualitative, and it often ends up with defining qualitative research as being what quantitative research is not. As Sachan and Datta (2005) conclude when reviewing qualitative and quantitative research methods in supply chain management research, qualitative research has become increasingly popular as a research design within the field. This, they argue, is because previously research was focusing more on asking "what" aspects of a phenomenon being studied were problematic, important, etc. but now, as the field has matured, the questions asked are rather "how" and "why". And to answer these types of questions and gain a deeper understanding of the value of multiple parts of the chain, qualitative research methods are more appropriate. They point out that by using qualitative methods, there is an opportunity for the researcher to study behavioral issues, which might potentially be affected by things such as culture, relationship, trust and power. This, we argue, is the case for our study when viewing the diffusion of digital innovation within a complex organization, and further supports our choice of using qualitative methods. To study relationships which might affect the implementation and diffusion of an innovation, as well as relationships

between the multiple actors of the value chain which all are concerned with the case studied, requires qualitative research methods to gain an understanding of "how" and "why" certain things are the way they are.

4.1.2 Inductive research

When conducting a qualitative research, Jonker and Pennink (2010) argue that the researcher is often working with an open research question which may continue developing during the scope of the research. By using an open research question, the research is inductive and follows the empirical cycle shown in figure 4.1, developed by Jonker and Pennink (2010, p. 78).

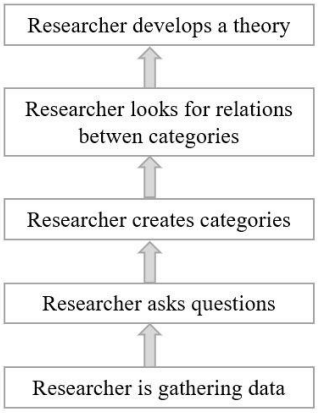

Figure 4-1: Empirical cycle - inductive

The aim of this type of empirical cycle is not to accept or reject a particular theory, but rather to explore a case, leading to new elements in the form of new findings which might lead to a theory. After the theory has been developed with the study, it may later be tested by using other methods and follow deductive reasonings (Jonker & Pennink, 2010). The expected results from this type of qualitative research should therefore be "the development of a mini theory with local validity" – which could be used as the basis for future quantitative or qualitative research (Jonker & Pennink, 2010, p. 81).

We argue that following an inductive research approach was appropriate for this case, since the aim of the study was always to explore an implementation and analyze its process. That being said, empirical data needed to be gathered before knowing which parts of the process were potentially influencing the innovation implementation. After the first interview and presentation of the problem at NCC, where a deeper understanding of the context and problem at the organization was gained, an open research question was formed which later was changed partially on two separate occasions after even more data had been gathered. Following this inductive, and iterative, research process, we believe that we ended up with a research question which projected the most important factors in the implementation process, and as a result generating the most knowledge to the organizations involved, and to the research field at large.

4.1.3 Case studies

The design of the study is a case study design. As Bryman and Bell (2011) mention, a case study implies that a case is studied and analyzed intensively and in detail. Then the discussion must go

towards defining what a case is. It could be a single event which has happened and could be studied, it can be a single factory or organization, or it could potentially be a person which would be studied as a case. What all of these have in common, and what then defines a case is that it simply is "an object of interest in its own right, and the researcher aims to provide an in-depth elucidation of it" (Bryman & Bell, 2011, p. 60).

The case studied in this research is involving organizations. As Jonker and Pennink (2010) discuss, all people do not perceive 'reality' in the same way or to be the same, that is there is not a single situation or condition that defines the one reality we operate in. Organizations are the product of people, and arguably the same goes for them, that there is not a single reality true for all organizations. A single organization is also in a way, its own reality and operates in it. With the specific circumstances which we present and define for this case, and since it is within organizations and their reality, we argue that a case study is appropriate for this research. It must be made sure that the organizational reality which is true for this case is presented in a transparent way, such that knowledge may be generated by the study.

Scholars have criticized case studies for being too specific and that it is not possible to generalize the results of case studies, especially those of a single case (Flyvbjerg, 2007). The knowledge generated with a case study is therefore quite context-dependent, and not necessarily able to be theoretically generalized (context-independent), but that does not mean that the knowledge generated is less valuable. If viewed with critical eyes, the knowledge from cases may help us learn, rather than prove something (Flyvbjerg, 2007). The aim of our case study is therefore not to focus on generalization and being able to generate a general theory. Rather will we focus entirely on the particularity of the case. To present those factors that make the case unique, such that the results presented are valid for this particular case setting. To obtain this, we put some focus on understanding the circumstances of the case, and we view the context as a primary source of data. This is one of the factors which Jonker and Pennink (2010) view as a source of data to consider when conducting qualitative studies, and we find especially important to keep in mind for the case studied in this research.

As previously touched upon, a drawback of case studies is that they cannot be generalized. Other criticism on case studies, is that they are simply an excuse for researchers to visit the industry 'to take a look', without having a clear purpose. That case studies are just a justification for 'industrial tourism', and that specifically in Scandinavia, researchers have become just like consultants that do no rigorous research and focus solely on being relevant. It should never be an excuse for a researcher to stop being rigorous, because he or she shifted focus to being applied and relevant (Näslund, 2008). This is something we found crucial to bear in mind while conducting this study. As has been discussed, the case is studied within its context, and making the context a part of the study and the case being a practical problem within the industry, could have shifted our focus towards the practicality of the solution, rather than making a rigorous research.

4.2 Empirical collection

This section will present how empirical data was collected during the study. The different methods used with the data collection will be presented in a general way, and we will argue for why the use of specifically these methods was appropriate for this study.

4.2.1 Primary data

The data which we generated ourselves during this study, using the appropriate data collection methods on each occasion, are primary data. Primary data are new knowledge which was collected to answer the proposed research question of a study (Hox & Boeije, 2005). The primary data which was generated in this study was done by conducting interviews and one observation. There were 9 interviews conducted in total. All interviews but two were between 60-90 minutes long, and they were all, but two taken in person, with the last two taken over the telephone.

4.2.2 Secondary data

The primary data which are collected in a study, becomes available secondary data for other researchers (Hox & Boeije, 2005). Therefore, are all data that was used in both the theoretical framework chapter, as well as in the literature review chapter, secondary data to us. These are data which other research has generated, making it secondary to us. The collection was made through searching the university library online database for relevant research papers and books to gain insights into the field being studied.

The theoretical framework and literature review chapters were worked on throughout the research period. Before collecting any primary data through interviews and observations, literature about specifically these topics were studied: the construction industry in Sweden, innovation within the construction industry, innovation diffusion within project-based organizations, logistics in construction, and digitalization within construction industry. This list is not complete but covers the most important topics studied. These were the topics we believed were the most relevant for the study and based on the knowledge generated from this initial collection of secondary data, we were able to form a better conceptualization around the problem being studied and form some questions which we thought relevant to ask in interviews. Later in the process, after receiving the first presentation from NCC about the problem and forming the problematization even better based on primary data from NCC we revisited the literature and focused more on topics like logistics at the construction site, and even deeper on diffusion of innovation within the construction industry. This allowed us to reroute the focus of the literature somewhat, to make it even more relevant to the problem of the case and allowing us to form interview questions which were even more fitting. The collection of literature secondary data was therefore iterative throughout the process, to help us gain deeper insight throughout the process, as well as allowing for better fitted data to complement the primary data collected.

Other sources of secondary data are reports such as the annual report from NCC and a presentation of the implementation of the digital container at NCC, as well as some statistics which NCC had generated after studying the implementation process. In addition to this, the websites of main actors involved, such as Qlocx, NCC, Ahlsell and Ramirent were studied and used as a secondary source of data, industry reports by governmental institutions and other universities, and internal marketing statements by NCC discussing the digital container.

4.2.3 Observations

Participant observation is when a researcher collects data by observing what goes on, by joining the working group for a period of time (Bryman & Bell, 2011). By doing so, the researcher hopes to gain some insights into how things are in the reality of the firm and collects empirical data for

the research. When we conducted an observation, we made everyone in the room aware what our purpose of being there was, such that all participants knew that they were being observed. This naturally leads to the complication that the observants might behave in a different way than what they would have done without us there, wanting to perform in a certain way during the observation. Since the observation which we conducted was by sitting in, and observing, a short 30-minute meeting at the construction site where the implementation of the digital container was, no performance was being observed, but rather just for us to understand the implementation process at NCC. We do therefore not consider the risk of a changed behavior being high, and the empirical data which was collected through the observation, was rather used as understanding and defining the circumstances in which the implementation took place, rather than to specifically gather data to answer the research question directly. When we did the observation, there were 4 participants in the meeting, three of which employees of NCC, and one from a subcontractor at the construction site. We observed by sitting at the same table as the others, but not taking part in the conversation. Notes were written down when needed, and the participants' roles were noted.

4.2.4 Interviews

Bryman and Bell (2011) argue that interviewing is probably the most widely used method of collecting qualitative data. They further discuss that it is because it is a flexible method of collecting data, the researchers may gather a lot of data in a relatively short amount of time, especially if compared to the time needed to observe and gather substantial data using that method. Using qualitative interviews gave us an opportunity to be flexible in our line of questioning, if something interesting came up we had a chance to explore that further. When using quantitative interviewing, the same questions must always be asked such that the data gathered can be processed and coded quickly (Bryman & Bell, 2011).

A vast majority of the primary data collected during the study, was done through interviewing. In total there were 9 interviews conducted, with representatives from 4 different industry actors, which all were a part of the implementation and development process of the digital innovation. The role of the interviewee, which firm they represent, what type of interview it was and duration of the interview are all presented in table 3-1.

Organization	Interviewee‘s role	Interview type	Interview duration	Interview guide	Interviewee reference
NCC	Digitalization Project Manager	A	N/A	N/A	Interviewee A
Qlocx	COO	B	1:12:21	Appendix 1	Interviewee B
Ramirent	Customer Service Manager, Electricity & Energy	B	1:30:16	Appendix 2	Interviewee C
NCC	Head of Production, Building Sweden	B	1:03:44	Appendix 3	Interviewee D
NCC	Head of Inventory at production site Herrjärva	B	1:06:21	Appendix 4	Interviewee E
Ahlsell	Construction logistics and flexible inventory manager	B	1:24:32	Appendix 2	Interviewee F
NCC	Manager at construction site Herrjärva	B	34:59	Appendix 4	Interviewee G
NCC	Development manager, production	C	1:02:46	N/A	Interviewee H
NCC	Digitalization Project Manager	D	N/A	N/A	Interviewee I

Table 4-1: List of interviews

To distinguish between the interviews which were conducted, and how they were conducted, we define four different ‘interview types’, as seen in table 4-1. Type A was a completely unstructured interview, and included a dialogue between the researchers and a representative from NCC. It also included a presentation from NCC about the project, its implementation, what had already been done and which problems NCC wanted us to explore further. For this type of interview, notes were taken to collect the data generated, as well as the presentation-slides used by NCC were sent to us via email for our use. Type B was the main type of interviews, all being semi-structured, and conducted after we had gotten some insights about the problem and which sorts of questions were appropriate for us to ask, and in which direction we wanted the interviews to take. Type C was conducted later in the research. Its main purpose was to ask those questions which needed even more clarifications and was therefore completely unstructured. Finally, interview type D was a follow-up interview with the same person as had given us the initial interview. This was done over the phone, and the duration of the phone call was around 20 minutes. There we mostly asked about what had happened to the digital delivery container after the ‘Connected construction site’ project was over, since this was a month after the project’s completion.

All interviews of type B were semi-structured, where an interview guide was used as a support but further questions were asked depending on what was being said in the interview. In those interviews the interview guide was sent via email to the interviewees the day before the interview was scheduled, such that they could have an idea of which sort of questions they might be expected to answer. It was explicitly stated that no preparation was expected of the interviewees, and it varied between the respondents if they had prepared some ideas for answers, or not. The interview guides may be viewed in appendices 1-4, since there were different emphases on specific matters, depending on which position or which company the interviewee was representing. The two last interview, contra from the others, were even more unstructured since we had developed some new questions which had come up throughout the process of collecting data. We therefore wanted the focus of the last couple of interview to be relaxed, and for us to ask those questions which we felt had come up after the previous data collected showed some gaps, or to further elaborate on issues raised in other interviews. By doing so, we argue that we were able to clear some issues up which had appeared after we had started looking at and coding our data, making the empirical data collection inductive and iterative.

All the interviews were conducted in Swedish and the quotes used in this paper are all translated quotes from Swedish to English. The data that was collected through the interviews got coded in such a way that there were two iterations while going through the data. First all interviews were gone through and main themes identified. Later were the data from the various interviews all pooled together, with the identified themes. By pooling them together, we were able to identify which themes were reoccurring in the data and came up in multiple interviews. Finally, were there even more detailed themes identified and the most important topics extracted into this second round of themes. By coding the data in this iterative manner we are certain that the most relevant topics to answer the research question were identified.

All interviews of type B and C were recorded, and then transcribed. All these interviews started by us asking the interviewee permission to record the interview, which all interviewees granted. All these interviews also started with a short introduction from our side, about the project, which university and company we were representing, and what our aim of the research was. By stating the aim of the research, we believe that the interviews had a better structure, since the interviewees could then keep the answers structured towards the subject being researched. The downside of doing this is that some of the interviewees might then have attempted to answer some questions in a way that they believed was more toward the answer we wanted to receive.

4.3 Quality of the research

According to Bryman and Bell (2011), there are three criteria that are the most widely used to evaluate the quality of a research. Those are reliability, replication and validity. Both reliability and replication are more applicable to quantitative research, and since we focus on the uniqueness of the case presented in this study, we do not think that it is appropriate to discuss replication in great detail. We naturally present the methods used for conducting the study, such that it may be repeated by others, but the circumstances of the case are still very case-specific and might be difficult for others to repeat. Therefore, we will discuss further in this chapter the validity of this

study. We will also end the chapter by a short discussion about those ethical concerns which might have come up during this study.

4.3.1 Validity

Simply put, validity is a term that covers which conclusions are drawn from the data presented (Bryman & Bell, 2011). The external validity of this research is low, since the conclusions drawn are based on this specific case presented and its unique circumstances. We will therefore not be able to generalize the conclusions drawn, even though they might act as a guideline for other similar practical cases and generate knowledge in that way. On the other hand, we argue that the internal validity of this research, also known as the causality of the research, is high. Since the research approach used is qualitative, and the data collection methods are interviews, we believe that we were able to gain a deep insight in the case and which factors might have led to certain results. By taking interviews with representatives that were very involved with, and a big part, of the implementation process we believe that the results presented, and the conclusions drawn upon those have a high internal validity.

4.3.2 Ethical concerns

One major concern when discussing ethical issues in business and management research is if there is any potential harm to the participants (Bryman & Bell, 2011). This is something which we considered while conducting all primary data collection, and we tried to form the interview questions in such a way that they did not force the participant to answer something about their personal experience in the implementation process. This was done such that there was not a potential harm for the participant's career or role within their company.

Another concern when presenting the results of our study, is that we interviewed representatives from different actors within the same industry, so we will have to consider if any business secrets were discussed which other firms should not know about. Since the testbed project being followed in the case is a cooperation between many actors and is an industry wide initiative, we realize that the circumstances are special. This means that all the players that are involved have the same goal and want to see good results and bring their resources together to make a development project a reality. Hopefully, this means that the risk of business secrets being discussed and presented in this study is relatively low.

Getting informed consent is something that Bryman and Bell (2011) also mention as one ethical concern. No participant was forced to take part in the study, and all contacts were made through NCC, making it quite clear who we were representing. In addition, we also stated in the beginning of every interview that we were researchers from Uppsala University, and doing a study in cooperation with NCC. We also argue that by informing all participants in the beginning of each interview that they were being recorded and that we would transcribe the interview, the participants had the opportunity to know not to discuss things or views that might be either harmful for their personal careers or the company and its competitive position.

5 The case

In this chapter, the case studied is presented. First, we present the context in which the project was conducted, i.e. the larger project 'Connected construction site', the organizational structure of the focal firm and its effects on the project and the other actors involved. Second, we present the results of the implementation, i.e. the factors that were challenging or facilitating the implementation and diffusion of the innovation, and the effects the solution had on those involved.

5.1 Connected construction site

As has been mentioned, this study is a part of a bigger industry wide project which is financed by Vinnova. Vinnova is an organization of the Swedish state, whose vision is to make Sweden an innovative force in a sustainable world, and mission to open up for innovation which makes a difference. They act in a way as a coordinator between universities, the society and firms from the industries. They do this by having projects which encourage cooperation between multiple actors, such as in this case where many players of the construction industry come together with one common goal of enhancing digitalization and innovation within the industry (Tell, 2019). The project studied here, 'Connected construction site' has the defined time frame from December 2017 until August 2021 and Vinnova supported it financially with about 25M SEK donation, where all projects within the larger projects are a cooperation between the industry and the universities through the testbeds (Vinnova, 2017).

The organization of this large project is that there were created testbeds which are tested on real construction sites. The testbeds are shown in figure 5-1, where the defined testbed for NCC is 'the seamless supply chain'. Furthermore, the objectives of 'Connected construction site' which NCC's testbed should target: construction logistics, increased productivity and safer working environment.

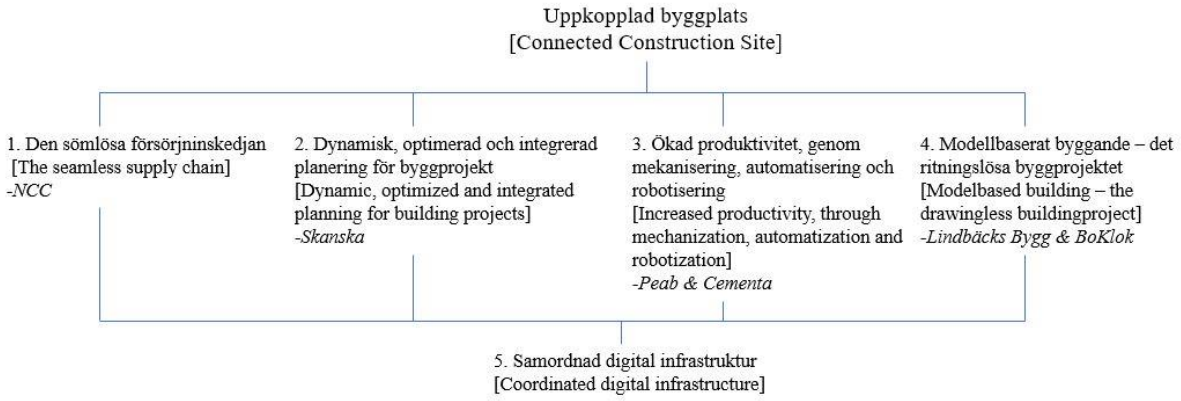

Figure 5-1: Testbeds within connected construction site

It is stated that the long-term objective of the project is to create the smart, 'Connected construction site' as well as the associated smart supply chains. The project is therefore, and must be, a cooperation between multiple construction firms, to pull the industry together towards this development, with the involvement of both ICT companies, suppliers within construction, start-ups and universities. Even with all these actors, the main focus of the project is still on the

construction site, its production and supply. The project has a defined time frame, and the long-term goals are presented in table 5-1. These goals should be reached by focusing on the smaller objectives, which are for the industry in cooperation with external actors, to develop digital working methods, more automated production, more effective and efficient construction logistics, and more integrated planning of the construction projects (NCC, 2019b).

Aim of project	**Desired effect**
Reduced time of construction	Lower costs
Increased productivity	Lower costs
Safer working environment	Increased safety at the construction site
Climate smart processes	Decreased negative effects on climate

Table 5-1: Long-term goals of 'Connected construction site'

Before the testbed projects started, there was a joint introduction meeting with multiple actors, suppliers and other companies relating to the construction industry. Companies were invited to send representatives to this meeting, where they got an opportunity to see which testbeds were a part of the project, and which would potentially fit their operations and capabilities best. This was a sort of matchmaking, where the companies could then choose to join the testbed where their strengths would be used in the best way (Interviewee F, 2019).

5.2 The focal firm – NCC - a project-based organization

NCC is one of the largest construction companies in Sweden, with around 16,500 employees in 2018 (NCC, 2018). Its organizational structure is presented in figure 5-2.

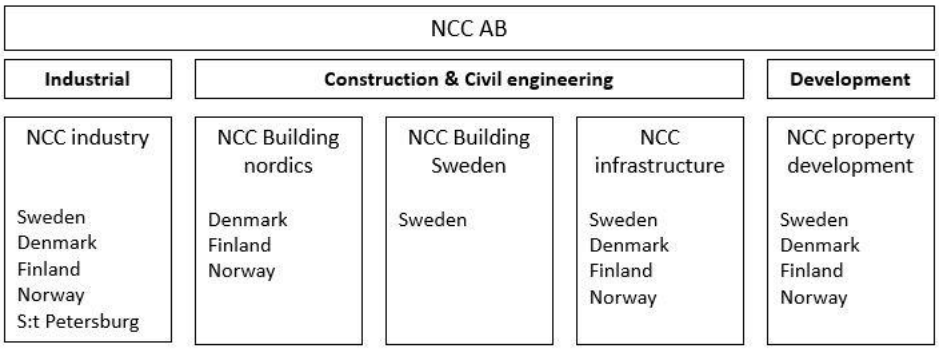

Figure 5-2: NCC's organizational structure

Furthermore, is NCC a project-based organization. It has a central part, whose headquarters are in Solna, Stockholm, and all construction is done through projects which operate from the multiple construction sites. It is a very decentralized organization, where the projects have a lot of power and can decide much for themselves (Interviewee F, 2019). As a simplification, one can look at the construction sites as different projects, which have their own hierarchical structure while the central part of the organization provides support functions.

In the case studied, the innovative solution was a physical product, enabled by a digital component, and will be used by the projects of NCC, i.e. the construction sites. But the initiative of wanting to implement the innovation came from the central part of NCC. Reflecting on how to implement

and diffuse innovation and new solutions in an organization like NCC, and how the organization is structured one interviewee said:

> the challenge is that it [the organization] is so decentralized. The projects become like some sort of islands and in a way like their own companies
>
> (Interviewee D, 2019)

When an innovation is presented to the organization, it can therefore be challenging for the owners of the solution to know which part of the organization to target and pitch the solution to. Simultaneously, should the aim for the external provider of the solution to be able to implement the solution and diffuse the solution. But this is a challenge as the projects are important for the implementation, since they are those that will implement and use the solution, while it becomes easier to diffuse to other projects if the implementation is supported by the central part (Interviewee B, 2019). This was the case in this project as well, since the decentralized project used the solution while the initiative came from the central part of NCC.

It was mentioned by a few interviewees that the projects themselves have much power over the way they work, and the central part does not control everything that goes on at the construction site. The project managers, or construction site managers, must approve everything that goes on in their project. Also, that it was the managers at the construction site who would be those to determine and make the final call if new products, such as the solution implemented in this case, would be used at the site or not (Interviewee G, 2019).

Finally, a construction project was chosen, and it accepted to be a part of the testbed project at NCC. The site is called 'Herrjärva', located in Solna, Stockholm. It is the construction site on which NCC is building its own new headquarters. The construction project started in the second half of 2017, and planned end is in 2020. The buildings will in total be about 32.000 square meters (NCC, 2017). The new headquarters are located directly beside the old headquarters – so the geographic distance between the current central part of the organization and the project is almost none.

5.3 NCC's testbed – seamless supply chain

Before choosing which solution NCC would implement, there was a workshop held with workers from the construction site Herrjärva. The aim was for the representatives from the central part of the organization, those involved directly with the 'Connected construction site' project, to understand the needs of the projects and which problems they were facing. During this workshop some problems were identified which might be beneficial for the solution to target. Since the defined testbed was already known, the workshop focused on identifying problems within logistics at the construction site such that the solution would be appropriate for the seamless supply chain testbed (Interviewee A, 2019). During the workshops the question asked was "what do we want to solve for the production?" (Interviewee H, 2019). This also translates into asking what problems the projects are facing.

During this workshop, it was recognized that there was a problem with small deliveries at the construction site. It was mentioned that the way the recipiency of deliveries had been conducted at the construction site was highly manual and analogue, and that the documentation of it was

inadequate. The problems which were specifically mentioned as a result of the delivery system being how it was are presented in table 5-2 (NCC, 2019b).

The invoicing process gets more difficult
The appropriate person receiving the delivery at the construction site must receive a phone call
The appropriate person receiving the delivery at the construction site is disrupted in his/her work to receive the delivery
The delivery is often made at the wrong time
The delivery is often made at the wrong place (within the construction site)
The delivery is often containing the wrong contents

Table 5-2: Problems NCC had identified as a result of its delivery system

NCC summarized the workshop in a report which discussed that receiving deliveries at the construction site had been both unnecessarily resource- and time consuming within construction projects and recognized that digital solutions might have the potential of making the logistics at the construction site simpler, the deliveries more flexible and last but not least, the construction site safer. With the analogue logistics NCC mentioned that a challenge had been that receiving a delivery meant that a worker would be forced to be disrupted in his/her work to receive it, and that deliveries often were delivered in the wrong place at the site, or simply got lost at the construction site (NCC, 2019a).

After the solution was chosen, a timeframe was defined for the testbed project at Herrjärva of five months. NCC also defined some goals which it wanted the project to meet, such that the progress, and potential success or failure of the project could be determined after its end. The defined goals which NCC wanted to reach were three:

- Less disruption
- Less waste
- Increased safety

Since the ‘Connected construction site’ project was an industry wide initiative, there were other actors that were a part of the testbed. The cooperating partners within this testbed were officially: NCC (as the main contractor), Qlocx (as the digital solution provider), Ramirent (supplier) and Ahlsell (supplier). At first, it was only deliveries made to NCC which were delivered in the digital delivery container on site, but as the five-month long project went on, even the subcontractors on site could receive deliveries in the digital container (NCC, 2019a). The project group worked using agile project methods, where half hour meetings were held every week with those involved at the construction site (NCC, 2019a). There problems could be identified and solved quickly, to-do list and in-action tasks could be made in cooperation with all involved such that problems could be identified quickly and dealt with (observation, 14. February 2019). By using agile methods NCC wanted to get the input directly from the users of the solution, and from the construction site using it (NCC, 2019a).

To understand the context of the case, we present here the cooperating partners shortly. Ramirent specializes in renting out machinery and equipment for construction, and some complementary

services to the rentals, like for instance on site support, planning the worksites, logistics, safety planning, and more. Ahlsell is Sweden's leading supplier of construction materials and tools of all sorts and sizes. When looking at all construction projects in Sweden's three largest cities, Stockholm, Malmö and Göteborg, Ahlsell delivers to 80% of all the construction sites in these cities. Ahlsell is therefore a huge supplier within the industry (Interviewee F, 2019). NCC is one of both Ahlsell's and Ramirent's biggest clients (Interviewee F, 2019; Interviewee C, 2019), and has high bargaining power as such (Interviewee F, 2019). At the Herrjärva construction site, Ramirent is the main supplier of machinery and helps put up the temporary offices and other things at the construction site itself (Interviewee C, 2019). Ahlsell is the main supplier to the Herrjärva project and makes multiple deliveries to the construction site every week (Interviewee F, 2019).

Qlocx is the owner and developer of the innovation being implemented in this case. Qlocx is a Swedish start-up company whose slogan is "deliveries made easy". It specializes in digital solutions for deliveries and has a wide variety of products which all are based on a digital lock which makes deliveries safe and easy. On Qlocx's website, its complete product portfolio may be found, ranging from a personal large mailbox which people can have by their homes and receive packages in – to a digital delivery container specialized for receiving deliveries at construction sites. Qlocx was founded in 2016, after the founders got tired of the problem of receiving deliveries. They mention that so many other things in our society are becoming more digitalized, and people are increasingly purchasing various things online, from food and clothes, to movies and music. But they recognized that there was a problem with one thing with this shift towards e-commerce: the deliveries. Often, if you are not home when a delivery gets delivered, it will not be left at your door and you must instead go to the post office and pick it up. The founders also had some experience within the construction industry and knew that receiving deliveries was a problem at construction sites. Based on recognizing these problems, Qlocx was founded with a solution in mind. The solution which they had found was a digital lock which can be put on mailboxes or other containers to which both the receiver and the courier have access through a mobile app which both parties have (Qlocx, 2017a).

For the construction logistics specifically, Qlocx has a few solutions which they introduce on its website. These are "smart leveranszon" [smart delivery zone], "leveransrum" [delivery room] (specifically for projects with limited space, like building sites at central locations in busy cities), and finally "leveranscontainer" [delivery container] - which is the focus of this case. The basic idea of all the different types is that the zone, room or container are locked with the smart Qlocx system and digital keys are distributed through a mobile application to the appropriate persons, both on the delivery and receiving end. The lock system also registers data on the individual level, so if needed there is a possibility to back trace which persons received keys or entered the room and at which time, etc. What Qlocx mentions on its website is that the lock system is applicable for those types of solutions which will work best for each specific project. So, depending on the size and environment of the construction site, the lock system should always be applicable and a solution can be implemented to include smart logistics as a part of the project (Qlocx, 2017b; Qlocx, 2017c).

Qlocx had been invited to the 'Connected construction site' introduction meeting and recognized that they would be a good fit for NCC's testbed of a seamless supply chain (Interviewee B, 2019). Representatives from Ramirent and Qlocx then had a dialog at the meeting and bonded in the coffee room, and the Ramirent representative recognized that this project would perhaps be a tough battle for Qlocx to take on itself. Ramirent is also the head supplier at the Herrjärva construction site, so a cooperation between Ramirent and Qlocx seemed quite justifiable (Interviewee C, 2019). Ramirent is the owner of the actual container, in which Qlocx's digital lock system is implemented. The cooperation between Ramirent and Qlocx is therefore crucial.

The solution was then pitched to NCC when it received presentations from multiple companies with potential solutions to some of those problems identified in the workshop. One of the reasons why Qlocx was chosen as a cooperative partner for this project was that the solution was quite easy to implement and had already been developed somewhat. Other presented solutions were more complicated and would have taken more time and effort to get going. Choosing Qlocx meant that the testbed project could start quickly (Interviewee H, 2019). Qlocx then contacted Ahlsell which thought that the solution was interesting and decided to join the project, also being already involved as a main supplier at the Herrjärva construction site (Interviewee F, 2019). Some people involved thought that the solution was even *too* easy to use in a testbed project, since it already existed and had been implemented in a few companies within the industry and was therefore not seen as an 'innovation'. Moreover, it had also already been pitched to NCC a half a year prior to the 'Connected construction site' project start, but not been implemented. Those in favor of the Qlocx solution for the testbed argued that, 'if it is such an easy solution, why has it not been implemented and diffused successfully within NCC already?' (Interviewee H, 2019; Interviewee A, 2019).

5.4 The solution implemented – the digital delivery container

The focus of this case is to follow the implementation of the Qlocx solution at NCC's construction site in Herrjärva, the *digital delivery container [digital leveranscontainer]*. The container is designed to receive small deliveries, and to be integrated into the building site fence, with one door opening from the street, and another door opening from inside the construction site. That way, the delivery of these smaller deliveries can be made without the courier ever entering the building site, increasing the security at the site. Qlocx's website mentions that over half of the deliveries to a construction site are small deliveries which can fit into the digital delivery container (Qlocx, 2017d). Without the container, when a delivery would arrive the chauffeur had to call the receiver from outside the building site since no non-authorized vehicles or persons are allowed inside the construction site. The chauffeur therefore had to call, then wait for the receiving person to arrive to the gate and receive the delivery. This meant that there was waiting time and that each delivery would take more time, and that the receiving person also was disrupted in their work to get the delivery at that time (NCC, 2019a). With the digital delivery container, the chauffeur can open the container with a digital key in his/her mobile Qlocx application when he/she arrives by the construction site, enter the container from the street – that is without entering the actual construction site – and deliver the goods in the container. After the chauffeur has made the delivery and leaves the container, the digital key which he/she received in the mobile app is destroyed, so the container gets locked securely again from the street. When the chauffeur has made the delivery,

the assigned receiver of the specific delivery receives an SMS from the Qlocx system, notifying that the package has been delivered. The receiver may then decide if he/she chooses to pick up the delivery straight away or later in the day if there is no rush for this specific delivery. When the receiver decides to pick up the delivery, he/she receives a digital key in his/her Qlocx mobile application and can enter the container from the construction site's side of the container. The container may therefore be strategically located somewhere in the construction site's fence to minimize the distance needed to walk to pick up packages. After the receiver has picked up the delivery, the digital key which he/she received gets destroyed and the container is locked once more from both sides, keeping all possible deliveries which might be waiting there safe (Qlocx, 2017d). At the Herrjärva building site, it was not possible to include the Qlocx container in the fence as it is meant to be. This is because the Herrjärva project had already started when the testbed project started, and the construction site had already been planned (Interviewee A, 2019). The Qlocx container was instead located just outside of the main site offices, just a couple of meters outside of the construction site.

Some interviewees mentioned that the digital delivery container solution is not really a groundbreaking solution in itself, but rather that the innovation in this case is the digital lock by Qlocx. The idea of a container which could be opened from both the out- and inside of a construction site already existed, but the digital lock and mobile application which is a part of this solution was called an 'enabler' for the solution by a couple of interviewees. The trouble of having physical keys to the container was always a problem, so the solution had not been successful in the past. The digital tool provided for this solution was therefore a key to why it was possible to implement at all.

5.5 Cooperating with a software company - Qlocx

NCC is a construction firm whose core competences are building and construction, not technology. This was confirmed by those interviewed working at NCC. Still, they also said that NCC has developed in the last years and decades and that it possesses many more competences now than it used to. It used to be only engineers working within construction firms, but now the human resources are much wider and there are special professionals on all sorts of things, such as the environment or sustainability, economics, etc. In that way, the competences of NCC have evolved (Interviewee H, 2019).

But developing and implementing a solution like the digital delivery container was a cooperation between NCC and other actors, especially Qlocx which defines itself as a software company (Interviewee B, 2019). And NCC wants to include other perspectives and competences from other firms which itself perhaps does not possess. As one interviewee said:

> We are involving [in this project] other competences than to say to a builder to develop something new, because then they will just think in the same tracks as they always have done. But if you include completely different competences which have never worked in the industry and then they will look at a problem and see other solutions that we don't even know about. […] And then they bring [to the industry] a whole different set of experiences and perspectives than we have in our world.
>
> (Interviewee D, 2019)

What seemed also evident by the data collected was that it may be positive for firms of different sizes to work together, since simply their size can be a part of their competence. By being a large organization, it was mentioned that there are more resources available and more power, while being a small firm means that decisions can be made very quickly. On this subject one interviewee said:

> We must cooperate with multiple companies to find a good solution. Big companies have the problem that you get stuck in some tracks and everything is so heavily rooted, so we need these small companies that come with fresh air.
>
> (Interviewee C, 2019)

Another more specific benefit with the small size of companies like Qlocx as a cooperating partner in this project was noticed by another interviewee:

> Smaller companies listen to every small detail, so if you mention something at a coffee break one day, then they have a solution to it the next day. They are so eager to be there and to get their products out there that they listen to everything. So, this is something that characterizes start-ups, that they don't really have a product that is ready, but are almost ready and are therefore more willing to customize. This is a huge difference.
>
> (Interviewee H, 2019)

Other interviewees involved agreed with this, that since the developer of the solution was a small company, it acted fast and was able to act according to those needs that NCC had. Even though all interviewees agreed that the industry must pull in the same direction and more cooperation between actors is needed to innovate industry wide, this may include a challenge for NCC as a company and for it to develop its competences in-house. Having external actors develop necessary tools and techniques for NCC to use is therefore not necessarily all positive. As an interviewee said:

> But this is a bit what the problem is I think. That we choose that others should do everything on the outside, instead of us having our own product development.
>
> (Interviewee D, 2019)

5.6 Implementing the solution

Here the implementation of the digital delivery container will be presented. Some different themes have been identified as to have effects on the implementation process, which will be looked at in more detail.

5.6.1 In a decentralized project-based organization

As was presented previously in this chapter, is NCC a highly decentralized project-based organization. Therefore, there were identified some challenges with implementing the solution from the data collected, since each project somewhat operates as its own company. Then there is also the challenge from which direction an innovation should come from. From below, i.e. originating from the projects, or from above, i.e. originating from the central part. There is the potential for tension between the central- and project part of the organization. One interviewee from the central part said:

> [historically at NCC] all product development and improvement work has happened quite centrally. That we catch up something, and then we make a big deal out of it, and then we initiate a development project, and you invest a lot of time and resources on consultants and smart people and then you are going to implement it. And then the projects don't want to receive it, because they don't feel like they have been a part of the development process. Or, that it has taken so much time to develop that the idea is too old, and there are new ways of working. […] So that is why I believe that it has to happen from the other side. That it must come from below and up, and that we must have processes which can scale up ideas quickly and test it.
>
> (Interviewee D, 2019)

Who should make the decisions in such a decentralized and large organization can also potentially become a challenge. The workers using the innovation might like it, i.e. the projects like the solution, but there are decisions to be made either higher up in the project or in the central part which are hindering either the continuing use or diffusion of an innovation. This was noted by an interviewee:

> [...] go quickly through the deciding gates [of the organization]. Otherwise you will get stuck easily in some politics [...], where the product is ready and the construction sites like it but there is the question about which part of the organization is going to own the product and take responsibility for it rolling out.
>
> (Interviewee B, 2019)

Throughout the text, there has only been made a difference between the two parts of the organization at NCC, that is the central part and the projects. But this of course is overly simplified and not an entirely true representation of the truth. It is an attempt to make it clear that these are forces that can either pull in the same direction or go against each other in the organization of NCC. There are though more forces, and the central part consists of multiple levels and different departments which all have their own responsibility. It is therefore difficult to talk about 'they', as being the central part in its entirety, and 'they' as all the projects. As is evident by what one interviewee which is from the central part of the organization said:

> And immediately when we were going to implement we got a ton of questions from our IT department about how they had not been a part of this and how we do not have a budget to implement this. What value does this entail, and have you done all the analysis that should be done, no, you have not? And such. And then they did not want to move forward with this. So, you notice right away that there is resistance from the start.
>
> (Interviewee D, 2019)

Showing that there may even be tension within the same parts of the organization, not only between the different parts.

5.6.2 Cooperation between various actors

The multiple organizations that were involved in the project, and were present at the construction site, also brings some potential challenges. It may be that all the actors at a construction site agree on a problem, and it affects them all, but still it can be difficult for them to unite in solving the problem. Just as an example of how, is that in the basement of the construction site there was no

mobile coverage at all. Since both NCC and the subcontractors on site need to receive deliveries, this presented a problem for all the actors on site. Especially before the digital container, since then it was necessary for the receiver to answer a phone call and meet the deliverer. But also, after the implementation of the digital container, if a delivery came into the digital container while the receiver was working in the basement, they would not know about it until they left the basement. No internet and no mobile coverage were down there, meaning that no messages could be delivered to them through a mobile phone. In an interview this came up and the interviewee said when asked if it would cost so much to install a wi-fi hotspot in the basement:

> No, but it is just that it will then have to be a permanent one [hotspot], and then will NCC want Sahlén [the electrical subcontractor on site] to prioritize it, and then there will be some resistance. Decisions must then be made and maybe the project is already behind schedule. The thing is that this is an extra cost, and who should take this cost? Everyone on site can use it, but no one wants to pay for it. That's how it is. Everyone must then become a part of it, and maybe not everyone will want to.
>
> (Interviewee E, 2019)

This simple example sheds a light on how complex the relationships on site can become and how there can be resistance from the construction site to adopt things that were not in the original project budget or plans.

5.6.3 Budget constraints

The budget that the projects must follow during the project seems to also be an influence on what detours from an original plan or risks the managers on site are willing to take. As was discussed in one interview that if an innovative solution gets presented or pitched to the central part of the organization, the central part still will have to find a project to implement the solution on (Interviewee B, 2019). And this is not always so simple for the projects, as just to accept all solutions which are pitched from the central part. One interviewee said:

> [the problem is] that everything is so concerned around costs, everything that does not fit into an excel sheet is a risk. […] And the drawback is that no one wants to take a risk.
>
> (Interviewee C, 2019)

The issue with who should carry the cost of solutions and what is implemented and tested remains still an issue. One interviewee said:

> The problem is that I can imagine that it [digital innovations] often comes from the central part, and that they can come with a lot of things, but then they put the cost of it on the projects, and that the projects perhaps don't want it that way.
>
> (Interviewee E, 2019)

Just as it is evident by the digital delivery container, that a main reason why it was accepted at the construction site was that it was free for the project (Interviewee G, 2019). The circumstances around this case was that the externally financed project 'Connected construction site' paid for the solution, and only the resources needed to implement and use the solution had to come from the construction site. Simultaneously as it can be difficult for the central part to find a project willing

to implement an innovation, the providers of the solution have found that it is not effective for them to pitch the innovation to the projects directly. A representative from Qlocx said:

> If I take my idea directly to a project, they will be less eager to test it, since they will be the first ones to do so. Since we haven't done this before. It will therefore require a bit of administrative work from the project's side, and then they become hesitant. And then there is the problem that if we find a project to test it on, it is difficult to take it from there and on to other projects [within the organization].
>
> (Interviewee B, 2019)

He further went on to say that Qlocx only pitches ideas now to the central part of an organization. Both because it makes it easier to diffuse the solution throughout the organization, as mentioned above, and because the solution then becomes more compatible with all of the construction sites at NCC. Qlocx attempts to understand how NCC's construction sites function, and which platforms are being used, which relationships are in place, etc. and by being supported by the central part of NCC it is able to make the solution compatible to all construction sites. That is, some sort of a small-scale standardization of its solution. This makes the development and implementation at each site easier and faster (Interviewee B, 2019).

5.6.4 Driven individuals

What became very apparent in the data, was that from all different actors and especially from managers within the central part of NCC and construction site managers, that all mentioned that 'driven individuals' were key to the successful implementation of the digital delivery container at Herrjärva. Specifically, were these individuals those that NCC had made a part of the project-group around the testbed project, and in a way defining their role in such a way that they should be motivating and driving the testbed project forward. Furthermore, were these individuals very committed to the testbed project and had dedicated their time to the project.

A manager within the central part of NCC, when asked straight up if it is down to individuals to drive innovation forward simply answered with: "yes, it is" (Interviewee D, 2019). This came following a discussion in the interview about *why* the implementation of the digital delivery container had been going well at Herrjärva. He believed that it came down to individuals driving the implementation forward and pushing the solution through those decision gates which come along the way. That within such big organizations as NCC, there are always some internal politics and then there is the need for individuals to go directly and talk to those in managing positions to make decisions at the organization. And this comes down to how the individuals drive the innovation forward (Interviewee D, 2019).

This was further supported by external actors, since a representative from Qlocx said that the digital delivery container had been pitched at NCC a half a year before the 'Connected construction site' project started. And then nothing had happened. The product being pitched was the same, he had pitched the idea with a representative in the central part of the organization, but it had proven difficult to find a project to test it on, and no one to pull it forward. Therefore, nothing had happened, and the solution never got implemented within the organization (Interviewee B, 2019).

During the ‘Connected construction site’ project, the ownership of the solution stayed with the large project ‘Connected construction site’, but not with project Herrjärva (the construction site). This meant that the individuals that were highly involved with the implementation were not only from the construction site, but also from the central part of the organization and had the time and motivation to be very driving in implementing and eventually diffusing the solution. This became evident by hearing from an interviewee from the construction site’s side of the organization:

> They [individuals from the central part] have been very driving. We do neither have the time nor energy to bring something like this forward in the project, we are here to build houses really.
>
> (Interviewee G, 2019)

Showing, that the individuals driving are important to the implementation. And that the main focus of the construction site is not to find new solutions, they only have time to focus on building houses. Taking this discussion further, that there is the need for driven individuals that drive the solution forward and to the correct managers in the right positions, the managers must also be ready to implement change. On this subject, another external actor said:

> I think that it comes down to being a question of leadership, really, to dare to challenge both internally and externally. And simultaneously dare to integrate even more.
>
> (Interviewee F, 2019)

5.6.5 Spotlight on the solution

During the project and while implementing the digital delivery container at NCC, the professionals from the central part decided to do some internal marketing around the solution. A short article, 3 pages long including pictures, was written where the digital delivery container was introduced. The main user of the solution at the construction site was interviewed and some photos of him using the container complemented the article. This was then spread through NCC’s internal web platform, like some sort of internal advertisement. This was identified as an important theme in the data, and something which seemed to have some effects on both the implementation and the potential diffusion of the solution throughout the organization.

The central part of the organization wants to support the projects, but an interviewee from the central part said:

> How I see how such an innovation spreads, partly it is that we can spread within NCC that this is a good solution and make some investigations on it and then some internal marketing for it quite simply. So, we do not push the information out to the projects, but we rather inform them about the positive benefits.
>
> (Interviewee H, 2019)

This shows again that the central part of the organization does not have the power over the projects to ‘force’ them to implement specific solutions. They cannot push solutions upon them, but rather what they can do is inform them about solutions that are available and what sort of benefits they might bring. This was further supported by another interviewee from the central part of the organization, that the internal advertisement had been one of the success factors of this testbed project (Interviewee D, 2019).

Furthermore, it was said that the internal advertisement initiative had started very early in the project. Even before the digital delivery container had been implemented fully had the article been published, pushing even further for the success of the solution within the organization. This was done as an attempt to not lose momentum and the objective of it was explicitly said to be that the central part did not want the solution to only be implemented in one project, and then be forgotten.

> We decided to test this thing with the internal marketing even before the project had been anchored entirely internally. And it is obvious that there was a push then. We started marketing this to the projects here internally, and then the projects started contacting us and wanting to test. Then, when it comes from these small islands that they want to test the Qlocx solution, and we say that it's not ready yet. Then there is a big push from below that they want the solution, and then it is much more difficult for those making the decisions here inside [the central part] to say no.
>
> (Interviewee D, 2019)

5.7 Effects of the implementation of the solution

The solution implemented in the testbed project has had effects at the construction site, as well as on those actors involved from the outside such as suppliers and transporters of goods. Here we present some of the effects that the solution has had on those involved, by looking at each actor individually.

5.7.1 Effects on the NCC construction site

In the beginning of the implementation the solution only had effects on one employee at the construction site, who is responsible for the inventory at the construction site. He was the only one, from NCC, whose work got disturbed and disrupted when a delivery arrived at the construction site and was forced to go and receive the delivery physically. There are others at the site which have a similar function, but for the sub-contractors, as he does and also got disrupted. He mentioned that it was a big difference after the digital delivery container was implemented in his ways of working that he could plan his day upfront, not being disrupted all the time (Interviewee E, 2019). Before the testbed project started, he received on average 5 phone calls per day regarding deliveries, but after the Qlocx container had been implemented, the average went down by 40% to 3 phone calls on average each day. In addition to this, the number of times he was forced to disrupt his work to go and receive deliveries reduced from an average of 7 times a day, down to only once a day. This is still with the same average number of small deliveries arriving at the construction site, which is 4 deliveries a day (NCC, 2019a).

Safety at the construction site is an important factor which the industry as a whole wants to increase and it was even mentioned that this was also one of the appealing factors of the Qlocx solution and why it was the one tested in the project (Interviewee B, 2019; Interviewee D, 2019). One of the ways in which construction companies want to increase safety at the construction site is to limit the traffic into the site. This is a positive effect which the Qlocx container has, since it is located on the outside of the construction site. There is therefore no need for a transporting vehicle or truck to enter the construction site. It was mentioned that this is though only a way to transfer the safety issue to the outside of the actual construction site, and maybe that is not necessarily better or safer (Interviewee H, 2019). By keeping the delivery happening on the outside of the fence, requires

planning of traffic on the outside and potentially creates safety risks for regular people who are not aware that a part of the operations that are connected to the construction site are happening on the outside of the fence.

5.7.2 Effects on Ahlsell

Ahlsell is one of the most important suppliers to the Qlocx container at Herrjärva, and after speaking with a representative from the company, it seemed like those involved with the container were happy with it. Ahlsell wants to become a bigger part of the logistics chain within the construction industry and offer more support to its customers through logistics services and solutions. What Ahlsell saw as a big opportunity with the container was that supplies are not limited to being delivered during the opening hours of the construction site. Ahlsell is not a delivery company but has a very close relationship with the deliverer of the supplies to the site. The delivery companies see big opportunities in not being restricted to only delivering between 'regular hours' i.e. between 06-17, but also use evenings and nights for deliveries. This might lead to less disruptions during the day when traffic is heavier, and faster deliveries since traffic jams are less likely during the night. This is only possible since the container has the digital lock so that no person has to be on site enabling the delivery. What Ahlsell mentions as the biggest success factor with the container is that the workers at the construction site are not being interrupted in their work by deliveries, which hopefully keeps customer's satisfaction high for Ahlsell. The construction site is its customer, and if there is less interruptions by Ahlsell during the day, it should lead to a more successful supplier-buyer relationship, according to an interviewee from Ahlsell. Also, Ahlsell is concerned with the safety at the construction site and for those doing the deliveries, so increased safety is something Ahlsell sees as a positive effect of the container (Interviewee F, 2019).

5.7.3 Effects on Ramirent

Since the tools and machinery used at the construction site are rented out by Ramirent, what had been the biggest problem for Ramirent was to get the correct information of the location and usage of tools, such that the invoicing was correct. It had been a challenge at Ramirent to get the correct information about how long the machinery had been in rental, and when they had been returned, etc. and a lot of time and effort was spent on credit invoicing because of wrong information. This is something which it saw as an opportunity with the digital lock on the container, that the usage of machinery could be tracked and traced more efficiently and correctly by having a digital stamp on those tools that went through the digital container. There was still no data available on if the invoicing had become more efficient after using the digital container, but these were the effects that Ramirent hoped to see (Interviewee C, 2019).

5.8 Diffusing the solution

After the testbed project ended, the construction site at Herrjärva decided to take ownership of the container. They were happy with the effects it had had on site and wanted to continue using it. Very little happened in trying to diffuse the container to other projects straight after the testbed project ended, and for a month afterwards nothing new had happened. This time delay was simply because of lack of human resources which had time to spare to focus attention on the digital delivery container. Finally, some time opened up and the success of the solution was apparent after

the Herrjärva project wanting to continue using it, and many more projects had started enquiring about it. Therefore, has the central part of NCC decided to negotiate the terms of using the container for all those projects that want it. A representative from the central part said that it wants to make an official agreement with all actors involved for all of NCC's projects to have the same terms when deciding to use the container, rather than having all the different projects order a container on their own. By doing this, the digital delivery container will officially be available to NCC's projects, if wanted, and may be implemented from the beginning of projects (Interviewee I, 2019).

The following two sections go through those themes identified in the data when looking at the diffusion of an innovation within a project-based organization.

5.8.1 Standardization

Building on the discussion above that NCC wants the digital delivery container to be available to all projects, we see that the solution can be viewed as being available as a standard solution at NCC. The issue of standardization came up in the interviews, and it was both discussed around making tools and solutions a standard within NCC, as well as within the industry and between multiple actors. This can be challenging to do, but multiple interviewees discussed how the industry must cooperate to create solutions which all actors can benefit from. This was specifically for solutions which are aimed at increasing safety at the construction site, since that is not something which the construction companies use as a competitive advantage, but rather something which all the companies want to increase, together. Making the Qlocx solution compatible to multiple actors in the industry was discussed in some interviews, such as:

> I was very clear to say that this should not only work towards Ramirent alone, but a function that works towards anyone. That is the first rule in all of this, you can't develop something which is tied to a single deliverer, no company in NCC's size will agree to that. Not when it comes to digital tools.
>
> (Interviewee C, 2019)

> It was important that the Qlocx container didn't just become some Ahlsell box, because that we could have done with any other container. Here we have the possibility to get a number of delivery companies included, and that they have Qlocx in their phones.
>
> (Interviewee F, 2019)

Furthermore, it was discussed that the solution needed to become a standard and used by multiple different actors such that the difference would become noticeable by using it. If only one actor was able to use the container, then the measurements that were being done of the effects would not be as great, and there might even be a risk that the traffic through the container would be so little that it might become a liability rather than a benefit to the project to use it (Interviewee F, 2019).

When looking rather at how the solution should become a standard within NCC, it seems to be an important factor for the solution to diffuse at a greater speed. The construction site needs a lot of planning and it is difficult to change things after they have been decided. The digital delivery container has to be efficiently located at the construction site for it to have the positive effects that

are potential, and it must therefore be a solution taken into account from the start of planning a project. On this matter one interview said:

> There is simply an immense amount of problems that need to be solved when starting a construction problem. So, it isn't guaranteed that when it comes down to 'now we will include the Qlocx container'. Which means that it might not be until after the project has started that it gets included. At least when it is such a new and not established technique.
>
> (Interviewee H, 2019)

5.8.2 Measuring the effects of a solution

Most interviewees agreed that there must be a way to quantify the benefits of a solution to convince other projects or organizations to implement them. As discussed, projects have a tight budget and all that is not accounted for at the start proposes a risk to the project. One interviewee summarized:

> … to summarize why the industry is at large so slow to innovate. If you do not have a very clear economic benefit which can be proofed on paper, then it is basically guaranteed that you won't accept it [an innovation].
>
> (Interviewee C, 2019)

To focus on these quantifiable measurements was also said to be an important part of the implementation itself, since it may show if the solution is worth moving forward with or not. In the case of the digital delivery container, NCC collected data on the benefits by quantifying the number of phone calls its worker received during a day, the steps he needed to walk, and how often he was disrupted in his work. As was said:

> If you are efficient at putting in some key numbers in some sort of a system, then you can see entirely what is going on. Then you can start to improve already at day 10 in a project, and you don't have to wait until day 200.
>
> (Interviewee F, 2019)

So, it became evident that the measurements could be beneficial during the implementation, for a more effective solution. The measurements were also important for external actors, to use as a convincing tool. A Qlocx representative said that after this project it has started to demand that measurements are done before, and after implementing a digital delivery container. This was because it had found that firms always asked for statistics and data on the benefits of the solution, or they would not be convinced to use it. And Qlocx also knew that it could not produce this data themselves, since it had the potential of being biased and that companies would not believe that the data was accurate. Qlocx had therefore starting to require the firm implementing the solution to take measurements of the effects of the solution, such as those measurements NCC did on the disturbances for its workers, etc. (Interviewee B, 2019). This also meant that the solution could diffuse easier, since data was available to convince others to implement it. As an interviewee said:

> …because then we can prove that we have a product that actually makes a big difference, and that it does not only safe money but that it creates a better working environment, increases safety at the construction sites and when you can prove these sorts of things, then it usually starts to move quickly.
>
> (Interviewee B, 2019)

6 Analysis and discussion

Four elements have been described in the theoretical section on diffusion of innovation by Rogers (1983). These four elements are: the innovation, communication channels, time and social systems. In this chapter, the empirics from the previous section are analyzed against this theoretical framework, and the criticizing points made by Shibeika and Harty (2015).

6.1 The Innovation

The innovation, which is the first element of Rogers' diffusion, is considered in light of the results to be one of the first things a potential adaptor identifies and where the initial interest is inherent. The perceived characteristics of the innovation, what it sets out to solve and how it does it, seems to be of utter importance when trying to explain the digital container adoption. From an early stage, tracing back to where external partners presented their solutions, the empirics show that the perceived value added from this particular innovation was a very clear cut. The advantage in working processes were apparent very early both after simply introducing the solution, and after its implementation. First, it was easy to understand which benefits it would bring just by seeing the idea of the solution, and then after it had been implemented the benefits were measured in number of interruptions. Many of the problems which were identified and to be resolved within the testbed 'Seamless supply chain' were more or less objectively eliminated in light of this solution, and NCC, Ramirent and Ahlsell saw this at an early stage. Roger describes his first innovation characteristic as its relative advantage. What matters here Rogers (1983) states, is the individual's perception of the innovation's advantage and our results show that each representative of the actors involved saw the digital delivery container as advantageous.

What's particularly interesting is the convenient nature of the innovation. While one interviewee stated that this particular innovation was not fit for the project as a whole because of its simplistic nature, the empirics shows that for majority of individuals, this was exactly what sped up the adoption rate. Rogers (1983) argues that relative advantage can be measured by different factors: economic, social prestige, convenience and satisfaction components. The convenience, more specifically the rather easy integration and intended use of the innovation can here be seen as drivers for adoption for some, whereas for others this can cause resentment. Here, social prestige could be identified as a barrier for the innovation, since the initial thought of the solution was not matching with perceived scope of the innovation initiative. Rogers' second characteristic; compatibility seems to accommodate his first characteristic in this case. Rogers describes it as "the degree to which an innovation is perceived as being consistent with the existing values, past experiences, and needs of potential users" (Rogers, 1983, p. 15). All three of these factors are clearly present in our study. The past years digitalization within the construction industry have made itself known as lacking, and for such a big company as NCC in particular, it has become a hallmark of innovation and sustainable growth, and with it values which enforce such development. Regarding 'past experiences' and 'needs of potential users', our findings point to a close to perfect fit in terms of the solution, where many of the identified problems during the workshop phase of the project got addressed during implementation.

Convenience might also be linked with Rogers fourth characteristic, which is trialability. Rogers suggests trialability as a factor which has effects on the adoption of an innovation, that diffusion

of innovation and its adoption rate is faster if the innovation may be tested and experimented with on a limited basis. One of the main pillars of the 'Connected construction site' initiative was to establish several testbeds in which innovations such as the digital delivery container were to be implemented in small-scale and tested in order to acquire knowledge and best practice before any full-scale adoption. Here, we can see that the trialability characteristic of the digital delivery container was decisive weather or not to pursue it in the first place since it was a rather strategic prerequisite for the initiative as a whole. As Rogers himself puts it; "An innovation that is trialable represents less uncertainty to the individual who is considering it for adoption, as it is possible to learn by doing" (Rogers, 1983, p. 15). The testbed project had a defined timeframe which only had a 5 months duration, and thus a swift implementation was in their interest. Furthermore, there was less risk involved for the project who decided to be a part of the testbed and implement the solution. If it would prove to be inefficient, the project would not be stuck with a bad digital solution for longer than the previously defined time frame of the project. This made the project more willing to implement the solution. The fact that the digital delivery container had been implemented elsewhere beforehand made many of the implementation hurdles at production level manageable as previous experience facilitated by Qlocx (provider) could guide them through these phases. Other more practical issues like budget and human resources required to coordinate and develop the innovation were provided by the testbed project rather than the construction project having to take all these issues on in parallel with their daily tasks. This further emphasized the trialable characteristic of the innovation. Not only had the solution itself a considerable trialability characteristic, but the management structure of the initiative itself assisted the innovation's trialability.

Another aspect which Rogers discusses as relevant when looking at the innovation itself, is its complexity. When analyzing the data from this case, it became very apparent that many of those involved in the implementation thought that it had been so successful because of the simplicity of the innovation. It was easy to use; it had as previously mentioned already been developed somewhat in other places, so it was not difficult to understand how it would work in practice. We argue that perhaps this is also related to its perceived complexity in this case. It might have been positive for the implementation that the innovation had already been implemented in other social systems which are similar to NCC, i.e. in other construction companies, and if it could be implemented and used there, that might act as a catalyst at NCC as well. Rogers said "The complexity of an innovation, as perceived by members of a social system, is negatively related to its rate of adoption" (Rogers, 1983, p. 231). The innovation is therefore more likely to succeed if it is simple, according to Rogers' theory. We see this very clearly in our case as well, and how it was the digital factor of the innovation that made it possible, because it made it simple to use. As was discussed previously, there had previously been ideas about containers which could open up from both inside the construction site, as well as the outside, as to increase safety on site and make deliveries more efficient, but since physical keys were always going to be a trouble with this solution, it had never gained any ground. The digital application which all involved could now have in their phones enabled the solution to be feasible in a simple manner, eliminating the problem of physical locks and keys. We saw therefore in some different ways how the simplicity of the innovation was a success factor for its implementation in this case, supporting Rogers' theory.

Observability is a factor which Rogers discusses as something which effects the diffusion of an innovation. He defines observability as the question if the effects of the innovation being implemented will be noticed by others. As is evident by the data presented earlier, there were other actors involved in the supply chain which noticed the effects of the innovation. These were especially the suppliers and the transportation companies. The transportation companies saw the effects, that the deliveries took shorter time for their drivers, and also saw the potential for delivering outside of the construction site's opening hours. This was not something which had started while the testbed project went on, but something which many interviewees discussed and saw as big potential based on the effects of the innovation. Furthermore, the positive effects which the innovation had on the construction site were observed by the subcontractors on site, since they showed interest for, and started, to use the innovation on site during the testbed project. Not only did NCC implement it for itself but there were other contractors on site which were able to implement the innovation to their own systems. If not were for the observed positive effects of the innovation, we argue that it is unlikely that it would have happened that way. The positive effects were also confirmed with the quantifiable measurements taken during the testbed project, giving statistical data about the changes in work processes before and after implementing the solution. We therefore agree with Rogers and his theory of observability and its effect on diffusion of innovation.

Rogers' theory goes generally quite well with what we found about the effects of the innovation itself and on its adoption at NCC, but we also could see that those points that Shibeika and Harty (2015) had on the innovation itself were more evolving around the standardization of the innovation. This is something which we also could see in our empirics. Shibeika and Harty found that within a project-based organization, it is not only the simplicity and advantage of an innovation which matters, but rather the struggle between central management and the projects. The central management wanting to standardize innovations, while the projects wanting actual solutions to the problems they face. This was also touched upon by Benner and Tushman (2003) who discussed how standardizing routines has the potential to increase efficiency, which is arguable something which the central management sees as an overall goal of the organization, but that there is less room for innovation by doing so, which we could argue is restricting the solutions found for the projects. This is something which we saw in our empirics, first that the central really wants solutions to become a standard tool within the organization. Just as was presented in subchapter 5.8.1 above, that NCC is of such a size that it would never agree to developing and implementing solutions that are not compatible with multiple partners and can be a potential standard tool for other projects and contractors. But also, from the project's perspective, that the solutions implemented are often perhaps good, but the cost of the solutions is supposed to be the responsibility of the projects, which they often do not approve of. Continuing along the lines with standardization within the organization, was also the study by Mitropoulos and Tatum (1999) which very much goes in line with what Shibeika and Harty discussed. That there is a struggle between those managers in the central, and those in the projects, and which needs they are trying to solve for the organization. The central-managers are always looking for a solution which best fits the overall needs of the organization, while the project-managers are looking for solutions to solve the problems they face in the projects. But what we think was a major facilitator in this project, and goes well with what Shibeika and Harty (2015) discussed, was that the central part

got guidance and help from the projects through the workshop to identify those problems that would be the most beneficial to solve for the projects. Just as was said that the question asked during the workshop was: “what do we want to solve for the production?”, made it such that the potential solution would hopefully fit the standards of NCC’s central part, and something which they considered to be a potential tool for all projects to have, but also that it fit the needs of the projects using the solution. Thereby, this testbed project and its initial workshop allowed for the central part and the project side to come together, identify the problems the projects face, as well as fitting the more overall vision of the central part – making the solution a good fit for everyone.

6.2 Communication channels

Rogers‘ framework on diffusion of innovation (Rogers, 1983) discusses how the communication channels are crucial for members of the social system diffusing the innovation to communicate the innovation with each other. The diffusion naturally does not happen if knowledge of the innovation‘s existence is not there, making the communication of the innovation important.

In the case analyzed here, we recognized a few instances where the communication channels were enhanced and made more efficient for communicating, and thereby we argue, increased the rate of diffusion and the facilitation of the innovation. These are that there was a workshop held through the ‘Connected construction site’ project, which allowed for very efficient communication between multiple different partners involved in the supply chain. By creating this common platform for the various actors to come together and identify problems, and possible solutions, made the communication between the actors easier. Rogers further discussed that not only is there the need for communication channels to exist, but also that there is often a difference in knowledge between members of the social system, creating an imbalance between them and inefficiency in the communication. That is, that it may be challenging for multiple parties or actors to have the same understanding of any number of things, such as the problems which are being faced, the solution and its function or implementation, the effects it should have, etc. We argue that because there was a common workshop in the beginning of the ‘Connected construction site’ project, there was a common platform created, where the language of communication could become clearer, and balancing out the differences between those involved in the project. During this stage there was also a common goal set for the project, making it clearer to everyone involved in which direction the project should be moving. By communicating efficiently what the problems of the production were, the solution and its desired effects could be found efficiently and communicated back to the projects which would eventually use the solution. This, we argue, was one of the keys for the successful implementation of the digital delivery container, efficient communication between the different parties involved and a common language.

Furthermore, was NCC able to successfully make use of a novice communication channel to diffuse the innovation even further. Not only to reach the attention of the one project where the solution got tested, but also by using internal marketing on the internal digital platforms at NCC to reach multiple projects throughout the decentralized organization. Our results show that this effort was crucial in how the innovation got spread throughout the project organization in terms of getting an audience. One such finding in our empirics show that the innovation itself got communicated through this channel even before the test project (adopters) fully had gained

experience or knowledge about the innovation. This goes against Rogers rather linear process of information exchange stating the need for adopter experience and knowledge using the innovation. This could be seen as a bold move should the innovation be deemed inefficient, however, great interest among several other project managers was gained and thus diffused rapidly thereafter. Rogers further states that human communication occurs more effectively when two individuals are homogeneous. This positive factor can also be identified in our case as the initial communication effort was highly targeted at production participants of the social system, such as project managers, and that the whole marketing campaign revolved around one such member. Rogers states that diffusion investigations of interpersonal channels of communication often put little emphasis on scientific evaluations of perceived innovation benefits. Even though these objective statistics were present in the marketing campaign, the production member involved in the marketing campaign was later contacted by several potential adopters which would then seek confirmation, pointing more to the importance of subjective evaluation among a homogeneous network.

If we on the other hand look at what Shibeika and Harty (2015) found for communication channels in a project-based organization was that the channels of communication were changing throughout the process since, as we also pointed out above, the adoption and diffusion did not necessarily follow the more linear model that Rogers presented. Based on in which stage the adoption was at each time, there were different communication channels being used to spread the knowledge about an innovation within the organization. Just as we found, that some internal advertising, i.e. spreading knowledge, had already been done before the solution had been fully implemented, which made that the communication changed in later stages. It was presented in our empirical chapter that by doing so, the projects started enquiring about the solution, and thereby putting pressure on the central part having to meet the needs of the projects that were asking for the solution. This meant that later in the process, there was not necessarily the same need for this type of communication channels, but rather that it had then changed to a simple ‘word-of-mouth’ communication between the separate islands that the projects were described as.

What we furthermore found to be an interesting aspect to the communication channels in our case, was that the driven individuals that had an impact on the adoption were able to create a separate channel parallel to the more traditional communication channels within the organization. Just as was found by Nam and Tatum (1997) that there are individuals that if they were not involved, the project would have been delayed, we consider that the empirical data we gathered points to the fact that this specific case needed its innovation champions. These were also in a way their own communication channel, since as we presented in our empirical data had Qlocx presented the solution to NCC half a year prior without anyone wanting to implement the solution. But, since there was this ‘side team’ of innovation champions that were able to make decisions about this specific project, that allowed Qlocx to reach this parallel communication channel into the organization without going through the traditional hierarchy of the organization, and potentially get stuck there.

6.3 Time

Rogers (1983) discusses time as one aspect of how an innovation diffuses through a social system. This seems quite obvious, since the diffusion must happen over time. To clear up how time is

involved in the diffusion, Rogers defined five milestones through which an innovation must go through for its successful diffusion.

The first defined step in the time process, is the knowledge of the innovation. Those involved with the diffusion, and those that will use it, must have knowledge of the existence of the innovation. This is quite frankly a most basic step for a diffusion we argue. In the case analyzed here, there was knowledge from certain parts of the organization even before the 'Connected construction site' project started. As was discussed in the results section, Qlocx had pitched the idea of the digital lock on a digital delivery container to NCC half a year before this implementation happened. It was mentioned that it seemed like it mattered who the idea got pitched to, i.e. who within the organization possessed the knowledge of the innovation. After discussing with our interviewees it became clear that the person that the idea is pitched to, must be someone in a position which allows them to make a decision about the innovation, they also must of course see some value in the innovation, and they must have the potential to implement it at a construction site, i.e. find a project that is willing to try it. The Qlocx representative also discussed how it had now become very evident that it matters a lot which part of the organization the idea gets pitched to, a project must accept to try the solution, but the central part of the organization must be a part of it as well to give the necessary support.

The second step is the persuasion, which Rogers says is when the one which has gained the knowledge of the innovation forms an attitude towards it. This attitude can either be favorable or unfavorable towards the innovation. Very closely related is the third step, which is to make the decision to either adopt or reject an innovation. This, we argue, are the two tricky and crucial steps for the success of the implementation, as we saw in our data. We argue that in some ways, there never would have been a favorable attitude towards the innovation, if not were for the fact that the project got it for free. To be clear, we still recognize that since there were other potential partners which pitched ideas on solutions to NCC, but still the Qlocx solution got chosen by the central part of the organization. This means that the central part had a favorable attitude towards it from the start. However, the challenge here is that the construction site will be those actually using the innovation, so their favorable or unfavorable attitude towards a solution is the one that should, and perhaps even does, matter the most. The central part has the power to be persuaded and want to implement the digital delivery container, but it cannot force the solution upon the projects. The project must decide, and therefore make the decision to adopt or reject, based on either having a positive attitude towards the innovation and be persuaded to implement. As is evident by our data presented earlier, a big factor *why* the project Herrjärva got persuaded to implement the digital delivery container was that it was free for the project, and there was external support given throughout the implementation from the central part of the organization.

The fourth step is according to Rogers (1983) the implementation, that is to put the actual innovation to use. This goes hand in hand with the previously presented definition of innovation by Slaughter (1998), that there must be the *actual use* of a new product or process for it to become an innovation. As was shown in the case earlier, the innovation was put to use and implemented at one construction site for testing.

Finally, is confirmation which is the fifth step according to Rogers. That is when there is the opportunity for the user of an innovation to stop using it, and decide to reject it after discovering that it does not have the desired effects, etc. As we have presented with the case here, has NCC chosen to continue using the digital delivery container by Qlocx and create standardized routines around the innovation such that other construction sites may adopt it in an efficient manner. We argue therefore that the implementation of this innovation has been successful at NCC since the decision was made to take the solution further, and it got confirmed, rather than to review it and decide to dismiss it.

This framework shows a very linear process of how an innovation gets presented and until it gets implemented. But there are those that find this to be a too simple representation of the truth, specifically when discussing project-based organizations. First, if we look at what Shibeika and Harty (2015) said, was that there are multiple diffusion processes happening simultaneously within the organization. That is, that the stages which Rogers defined, are happening in multiple places and with multiple individuals within the organization at the same time. This is something which we were able to identify in our case as well, that there are different individuals, some from the projects and some from the central part specifically, which are at different stages and that it may be a collision if a representative from the central part is at the 'decision' stage and decides 'yes', while the manager in the construction site is also at the 'decision' stage, but decides 'no'. As was described in the empirical chapter, that the interests of the projects and the risks they must take on, are not always in line with what the central part wants to do, creates the potential for multiple diffusion processes, which can either end in the same implementation or not. Furthermore, if we view what Whyte (2003) found, we can see that the industry can also take solutions and re-innovate them. This is something which Sibeika and Harty (2015) also touched upon briefly, and we can see how it has the potential to create even more diffusion processes happening at the same time. That even after the linear process which Rogers presented has happened, and the implementation has happened within a project, that the projects, being the users of the innovation, can in a way re-innovate the innovation. That is, flip the innovation and use it in some other way than was initially thought. In our case, as was presented in the effects of the solution subchapter, the actors saw the potential for further development of the container. Not only did the solution solve the problems that 'were obvious', i.e. the disruptive environment and safety on site, but it also had some other benefits come along with it which the project could then facilitate even further and 're-innovate'. This was for instance what Ramirent did by starting to consider the container as a way of gaining a 'digital stamp' on its rental machinery. We therefore can see that even after the implementation, there are other implementation and diffusion processes going on, simply by modifying the solution and making it into a solution to other problems.

Another argument, as to why the 'linear' framework by Rogers perhaps is not as fitting for the construction industry specifically, is if we look at what Davidson (2001) discussed, that since the construction industry is so different from other industries, it naturally does not follow the 'logical' path of innovating. He discussed the 'logical' path do be how a solution is found, and then it gets patented, produced and managed. But if we remember what the construction industry is actually producing, we can see that it is natural that the logical, and perhaps linear like Rogers' framework are not as fitting. As was discussed in the literature review, is the construction site itself what is

being produced and the end product (Behera, et al., 2015). There is always some uncertainty involved with a new construction project (Vrijhoef & Koskela, 2000), and the projects are difficult to optimize (Bresnen & Marshall, 2001), showing that perhaps it is not a surprise that innovation can not follow the 'logical' or 'linear' path within this industry as we would expect for other more optimized industries. This is something which we could identify in our case, that the projects were very hesitant to implement a solution, simply because they are so restricted to pre-determined time- and budget plans. As one interviewee said that if a solution does not fit into an excel sheet, that just means that there is extra risk associated with implementing a solution. We argue that since there is so much uncertainty involved with the continuously unique, and non-optimizable construction projects to start with, that implementing yet another solution that might bring more uncertainty along with it is difficult.

6.4 Social systems

Finally, Rogers discusses the social system through which an innovation is diffusing as a factor on the rate of diffusion. Rogers defines a social system in his framework as: "a set of interrelated units that are engaged in joint problem solving to accomplish a common goal" (Rogers, 1983, p. 24). We argue therefore that there are somewhat two social systems involved in the case presented. First, the social system of NCC, the organization as a whole and all the different projects or construction sites, which are potential adopters of the innovation. Then there is also the other social system, which includes all the actors involved with the 'Connected construction site' project. Those are therefore, multiple players within the construction industry, as well as others within the supply chain, transporters, suppliers, etc. We argue that both of these, NCC and those involved in 'Connected construction site' each are a social system, since both of these are systems which are related and engaged in solving problems and achieving a common goal. What we found, that there are multiple social systems is supported by Shibeika and Harty (2015) even though they argue that these multiple social systems are within the project-based organization. We can identify this in our case as well, since the projects seem to be always restricted to act according to the restrictions of budget and time, while the central part perhaps has other focus points. What we saw in our case that was a successful 'answer' to this, was the testbed project which became its own social system in a way, where those in charge could make those decisions needed, and had a budget and resources available for the implementation to facilitate.

Therefore, we are discussing both a single decentralized project-based organization (NCC), as well as the multiorganizational setting of the construction industry as those social systems through which the innovation should diffuse. As was discussed in the literature review is this argued by Bresnen and Marshall (2001) to be what differentiates the construction industry from others. Furthermore, argued Holmen, et al. (2005) that the relationships between actors in this multiorganizational setting was one of the factors why it was difficult for the construction industry to innovate, that the relationships were too short-lived and not considered as long-term relationships which could become something beneficial for those involved and develop innovation. This is something which we argue was evident in this case as well. Since the external 'Connected construction site' project in a way created constraints by setting a common goal for the involved actors to look at the implementation of the innovation as a long-term commitment where they believed their organization could both benefit of the cooperation and make the best use of their

competences, and therefore ‘bring the most to the table’, so to speak. We argue that this allowed those involved to look at the implementation as a part of something bigger and more long-lasting, and in a way setting the differences between potential competitors aside. We therefore agree with Holmen, et al. (2005) and their conclusion about the relationships within the industry and its impact on innovation. Furthermore, is the conclusion by Blayse and Manley (2004) that construction companies could benefit greatly by using innovation brokers, i.e. companies that have other core competences to introduce new solutions and technologies to the industry. This is something which we consider to have been successful in this testbed project, since as was discussed, an idea of a container at the edge of the construction site which could open from both sides was not something ground breaking. Rather, was it the digital key, which was an enabler for the solution to actually become successful and work. We therefore see that this implementation was able to happen simply because of the use of innovation brokers, introducing technologies from other industries, i.e. the software industry.

Because of the organizational complexity of a decentralized project-based organization, we argue that a contribution to the implementation success in this case was that there were identified innovation champions. That is, there were driven individuals which were appointed to the implementation project specifically, and whose goal was to make the implementation and its diffusion successful. It was evident by the data that the workers in the regular projects, i.e. the workers and managers at the construction site do not have excess time or resources to spend on ‘side projects‘ such as implementing new solutions, since they are already very restricted by project plans and budgets. Therefore, we were able to identify innovation champions which were representatives from the central part of the organization which were able to drive forward the innovation throughout the organizational structure and spread it through the heterogeneous social structure which the organization is. This supports what the literature suggests, i.e. Nam and Tatum (1997) who found that innovation depends on individuals.

7 Conclusion and discussion

The findings of this case study may be discussed as suggestions for how a decentralized project-based construction organization may implement and diffuse an innovation. First, we will discuss the implementation, which factors were found to be those that resulted in the facilitated implementation of the digital delivery container, and then which actions should be taken to make the diffusion of this innovation successful as well.

The first research question, RQ1, we wanted to answer was:

> How can the process of implementing innovative solutions within a decentralized project-based construction organization be facilitated?

We present the answer in four separate factors which the data and analysis point to as the facilitators in the case studied here. They are:

First, we recognize that the simplicity and previous development of the innovation played a crucial role in this case. As was pointed out in the analysis, this is something which Rogers (1983) also had found, that the easier the innovation is for the users to understand, the better it is for the implementation and its success. As we saw with the digital delivery container, it had already been implemented in other organizations successfully, so the developer and owner of the innovation itself had some experience of how to implement the solution in a new organization.

Second, the testbed project was a positive factor for the implementation of this innovation. As was apparent by the data, the projects themselves had no excess resources to spend on trying new solutions, even though the positive benefits of these solutions could or could not be argued for. A new solution brings uncertainty, which creates hesitance. By creating this external testbed, which could act in a way on the side of the complex decentralized project-based organization, the solution was able to gain ground without going through the more traditional hierarchy of the organization. The projects were more willing to try the innovation, since external resources were available to assist with the implementation, and the providers of the solution had a clear way into the organization, past the hierarchy.

Third, and perhaps what we argue is the most important in this case, were the innovation champions, i.e. the driving individuals that pushed the innovation through the complex organization and made sure that it did not lose momentum. By making a team from the central part of the organization to be responsible for this project in parallel with the productions' daily operations, allowed them the opportunity to be more agile with the development and implementation of the innovation. We also argue that this led to the innovation being less likely to get stuck in just one project and thus be diffused throughout the project organization.

Finally, the internal advertisement that was conducted with help from the statistics of the positive benefits associated to the innovation, allowed for other projects within the organization to gain knowledge of the solution. This is the simple first step in diffusing an innovation, for users to gain

knowledge through communication channels of an innovation which has relative advantages for the user.

The second research question, RQ2, which we wanted to answer was:

> How is the process of implementing innovative solutions within a decentralized project-based construction organization hindered?

If we specifically look at what we conclude to be hindering implementing innovation, then we simply have one point that we consider to be highly hindering. That is, the internal politics and complicated organizational structure of the decentralized project-based organization. We do though also identify, that all except the first of those factors that we presented above to be facilitating and driving the implementation of innovation and flows parallel alongside the organizational structure of the firm. The individuals involved in the implementation project should have the power to make decisions about the implementation and its process, such that decision making gets easier and faster, i.e. moving past the traditional organizational structure. Testing and implementing innovation should also be done through a specific 'side' project, such as the testbed project was. With dedicated resources, both capital and human, to make sure that the construction project receives the support it needs to implement an innovation. The internal advertisement used is also a way to inform the projects of available innovations, and simultaneously informing them about solutions available but not forcing them to take on risk if they are unwilling.

7.1 Discussion

The above points are the factors which we have identified to be the most important to have facilitated the implementation of the digital delivery container at NCC based on our analysis. By conducting this single case study, we believe that we have been able to identify a potential way for the construction industry, and specifically these types of decentralized, project-based organizations, to further encourage innovation. As was discussed in the introduction to this paper, the construction industry is considered by many to be very conservative and non-innovating. This is something which we technically do agree with somewhat – since we saw hinders along the way that an innovation must overcome to be implemented – but we have also changed our view on the industry to a certain degree. As was discussed in the literature review, is there a uniqueness to every construction project, and this is something that was further confirmed by our interviewees, but that also means that each construction project is innovative in its own way since it means that it has to be optimized all over again. This, to us, shows that those people working within construction are to a certain extent very innovative, making the most out of the environment in which they are operating at each time, but it also furthermore shows that it can be difficult to introduce new and innovative solutions since that means that there is a new risk being introduced to the project.

We therefore believe that those working within construction should have the ability to implement innovative solutions. They are always working in new environments and attempting to do the most out of the situation in which they are, showing of innovative abilities. But, those factors that we

concluded to be the answer to our research question above, are those that we believe any decentralized project-based construction organization can influence. Since these factors are in a way manageable by the organization, we hope that they can assist these types of organizations to implement more innovations.

The 'Connected construction site' project is special on its own and is an initiative which had the goal of innovating. We therefore believe that it was a very good opportunity to conduct a research within these special circumstances, where the implementation of an innovation was supported. We could therefore extract those elements and factors which showed to be the most facilitating to learn from. That way, we hope, more decentralized project-based construction organizations can focus on these elements and thereby increase the likelihood of a successful implementation of an innovation within the construction industry.

7.2 Future research

After studying the single case of implementing the digital delivery container at the construction firm NCC we recognize that there are other factors that could potentially be beneficial for other implementation projects in similar organizations. Even though we only summarized our findings in four main points, that does not mean that it is a finite list of potential success factors that contributed to the implementation at NCC.

Some other interesting things that was apparent by our data that contributed to the success of the implementation and we want to take the opportunity here to mention. First, is the potential it has on positive development to bring in actors from other industries. Especially, we want to emphasize to bring in a developer which can be committed to the implementation process, just like Qlocx was in this case. Their small size and eagerness to spread the solution in the industry, made them a very committed partner which may not be overlooked as a contributing factor to this implementation. Both the size of the partner firm seemed to have effects, but the core competences of the partner firm may also not be forgotten. Qlocx being a software company brought in competence to NCC, and the construction industry, which lies outside of its expertise. Furthermore, making the development and implementation of new solution a common goal in the industry seemed to have positive effects in this case. It was very apparent by speaking to the representatives from Ramirent and Ahlsell that those new solutions being implemented must become some standard tool within the industry, and it must be compatible to multiple companies, so it has a chance to make a difference within the industry.

These aspects are something which we would recommend even further research. We did not have the means to do another study using another case, potentially in other companies, but that might be beneficial to see what effects the choice of partners has on implementing an innovation in such a conservative industry like the construction industry is.

7.3 Ethical implications

If we consider the broader ethical implications that this research could have, we certainly hope that it contributes to more successful implementations of innovations within the construction industry. Based on the introduction chapter to this paper, we also consider that if more innovations and digital solutions would be implemented to the construction industry, efficiency could hopefully be

increased, and costs could go down. This is something which could be of great benefit to the society at large, since housing prices are very important to the economy. If the construction industry, and production of houses could become more efficient and costs lowered, hopefully it would become more affordable for people to purchase real estate.

Another ethical implication which was actually brought up in one of the interviews during the study is that by introducing more digital tools, that means that we are eliminating some human contact. Increasingly are we interacting with machines and computers, rather than with other humans in our daily life, the construction industry not being an exception.

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Appendix 1

Interview guide in Swedish

1. Berätta lite om Qlocx som en organisation.
2. Beskriv eran relation till byggindustrin – hur/varför började ni med lösningar för bygg?
3. Beskriv kort vad Qlocx lösningen är - vad gör den, hur fungerar den?
4. Vad är en innovation för er? Om du skulle definiera innovation.
5. Hur ser ni på logistik i byggindustrin?
6. Hur började relationen mellan Qlocx och NCC?
    a. Hur kom att ni blev ‘valda’ för projektet?
        i. Var ni medvetna om initiativet ‘uppkopplad byggplats’ och ‘den sömlösa försörjningskedjan’?
    b. I vilket skede blev ni inkluderade i samarbetet?
    c. När skedde initiativet?
        i. När *vill ni* att ett sånt initiativ ska tas?
        ii. Får ni en förfrågan från beställare/entreprenör att ta fram en plan? Och då, har ni standardlösningar eller skräddarsyr ni?
7. I detta projekt, vilka fördelar finns det med att jobba med en stor entreprenad?
8. I detta projekt, vilka nackdelar/utmaningar finns det med att jobba med en stor entreprenad?
9. Vad vill ni att digitala leveranscontainern ska få för effekt?
10. Har ni relation med leverantörerna?
    a. Om ja, beskriv kort?
11. Vilka effekter tror ni att ett sånt här samarbete har för innovationsarbetet i stort inom byggindustrin?
    a. Då specifikt vilka (om några) fördelar/nackdelar/utmaningar ligger i att ha samarbete mellan start-ups och stora aktörer som NCC?
12. Vilka förändringar behöver göras för att förbättra logistiken inom bygg?
13. Vad har ni som digitaliserings/logistikpartner för vision om byggindustrin i framtiden...
    a. ...Som helhet?
    b. ...Från ert perspektiv?

Interview guide in English

1. Tell us a little bit about Qlocx as an organization
2. Describe your relationship to the construction industry – how/why did you start doing solutions for construction?
3. Describe briefly what the Qlocx solution is – what does it do, how does it work?
4. What is an innovation for you? If you were asked to define innovation.
5. How do you view logistics in construction?
6. How did the relationship between Qlocx and NCC start?
    a. How was it that you got 'chosen' for the project?
        i. Were you aware of the initiative 'connected construction site' and 'the seamless supply chain'?
    b. When was it that you got included in the cooperation?
    c. When did the initiative happen?
        i. When *do you want* that such an initiative should happen?
        ii. Do you get an inquiry from a purchaser/contractor to bring out a plan? And then, do you have standard solutions or do you customize?
7. In this project, which benefits are there with working with a big contractor?
8. In this project, which disadvantages are there with working with a big contractor?
9. Which effects do you want the digital delivery container to have?
10. Do you have a relationship with the delivery companies?
    a. If yes, please describe short.
11. Which effects do you think that this type of a cooperation can have on innovation within the construction industry in whole?
    a. Then specifically which (if any) advantages/disadvantages/challenges are there in a cooperation between start-ups and big organizations like NCC?
12. Which changes must be made to improve the logistics within construction?
13. What vision do you as a digitalization/logistic partner have for the construction industry in the future…
    a. … as a whole?
    b. … from your perspective?

Appendix 2

Interview guide in Swedish

1. Beskriv eran relation till byggindustrin – vilka produkter/services erbjuder ni till entreprenörer liksom NCC?
2. Vad är en innovation för er? Om du skulle definiera innovation.
   Nu specifikt om detta projekt:
3. Hur ser logistik inom byggindustrin ut för er, vad är bra och vilka är utmaningarna?
    a. Hur arbetade ni *innan* leveranscontainern kom?
5. Hur uppstod samarbetet med NCC?
    a. Beskriv eran relation till NCC i detta projekt
6. Hur ser eran relation till Qlocx ut?
7. Beskriv kort vad Qlocx innovationen (leveranscontainern) innebär. Vad gör den, hur fungerar den, osv.?
8. Hur kom att ni blev inkluderade i projektet?
    a. I vilket skede blev ni inkluderade i samarbetet?
    b. När skedde initiativet?
    c. När vill ni att ett sånt initiativ ska tas?
9. Vad bidrar ni med till projektet?
    a. Vilka är era kärnkompetenser?
10. Vilka är de största möjligheterna/framgångsfaktorer när ni har ett sånt här samarbete? NCC+Qlocx+Ramirent/Ahlsell
11. I detta projekt, vilka fördelar finns det med att jobba med en stor entreprenad?
12. I detta projekt, vilka nackdelar/utmaningar finns det med att jobba med en stor entreprenad?
13. Vilka effekter tror ni att ett sånt här samarbete har för innovationsarbetet i stort inom byggindustrin?
    a. Då specifikt vilka (om några) utmaningar/möjligheter ligger i att ha samarbete med start-ups och stora aktörer som NCC?
14. Vilka förändringar behöver göras för att förbättra logistiken inom bygg?
15. Vilka drivkrafter och hinder finns för en lösning som detta kan bli standardiserat verktyg i industrin?

Interview guide in English

1. Describe your relationship to the construction industry – which products/services do you provide to contractors like NCC?
2. What is an innovation for you? If you were asked to define innovation.

Now more specifically about this project:

3. How do you view logistics within the construction industry, what is good and which are the challenges?
    a. How did you operate *before* the digital delivery container?
4. How did the cooperation with NCC start?
    a. Describe your relationship to NCC in this project
5. How is your relationship to Qlocx?
6. Describe shortly what the Qlocx innovation (digital delivery container) contains. What does it do, how does it work, etc.
7. How was it that you were included in this project?
    a. During which stage did you join the cooperation?
    b. When did the initiative happen?
    c. When do you want such an initiative to happen?
8. What do you contribute with to this project?
    a. Which are your core competences?
9. Which are the biggest possibilities/success factors when you have this type of a cooperation? NCC+Qlocx+Ramirent/Ahlsell
10. In this project, which advantages are there with cooperating with a big contractor?
11. In this project, which disadvantages are there with cooperating with a big contractor?
12. Which effects do you think that this type of a cooperation can have on innovation within the industry, as a whole?
    a. Then specifically which (if any) challenges/possibilities are in having a cooperation with start-ups and big actors like NCC?
13. Which changes must happen to improve logistics within construction?
14. Which drivers and hinders are there for this type of a solution to become a standardized tool in the industry?

Appendix 3

Interview guide in Swedish:

1. Berätta lite om NCC som en organisation.
2. Vad är en innovation för er? Om du skulle definiera innovation.
3. Varför tror du att byggindustrin är "sämst på innovation"?
    a. Jämfört med andra industrier – var tror du skillnaden ligger?
4. Hur ser logistik inom byggindustrin ut för er, vad är bra och vilka är utmaningarna?
    a. Hur arbetade ni *innan* leveranscontainern kom?
5. Berätta lite om leveranscontainern från erat perspektiv. Hur fungerar den för er, hur jobbar ni med den?
6. Berätta lite om hur detta projekt började.
    a. Hur valde ni den här lösningen, och detta projekt till att testa den på?
7. Hur ser eran relation med Qlocx ut?
8. Hur ser eran relation med Ramirent/Ahlsell ut, specifikt i detta projekt?
9. Vilka är de största möjligheterna/fördelarna med ett sånt här samarbete?
10. Vilka är NCC:s kärnkompetenser?
11. Hur ser du/ni på digitalisering inom byggindustrin?
12. Det har varit lite internal samt external PR runt specifikt detta projekt, vilka effekter tror du att det har haft?
13. Vad skulle ni säga är en fördel (om några) med att jobba med ett startup, som Qlocx?
14. Vad skulle ni säga är en nackdel (om några) med att jobba med ett startup, som Qlocx?
15. Hur stor del har de andra aktörerna (Qlocx, Ramirent, osv.) i själva framtagningen av lösningen?
    a. Hur stor del vill ni att det ska vara?
16. Hur sker förbättringsarbetet runt lösningen?
17. Vad vill ni att digitala leveranskontainern ska få för effekt? Vad är det ni tror att innovationen ska bidra med?
    a. Lokalt och centralt?
    b. Ut i industrin?

Interview guide in English

1. Tell us a little bit about NCC as an organization.
2. What is an innovation to you? If you were asked to define innovation.
3. Why do you think that the construction industry is “worst at innovation”?
    a. Compared to other industries – where do you think the differences lie?
4. How do you view logistics within construction, what is good and which are the challenges?
    a. How did you work *before* the digital delivery container?
5. Tell us a little bit about the digital delivery container from your perspective. How does it work for you, how do you work with it?
6. Tell us a little bit about how this project started.
    a. How did you choose this solution, and this project to test it on?
7. What does your relationship with Qlocx look like?
8. What does your relationship with Ramirent/Ahlsell look like, specifically in this project?
9. Which are the biggest possibilities/advantages with this type of a cooperation?
10. Which are NCC’s core competences?
11. How do you view digitalization within construction?
12. There has been some internal, and external, marketing around this specific project, which effects do you think that it has had?
13. What would you say was an advantage (if any) in cooperating with a start-up, like Qlocx?
14. What would you say was a disadvantage (if any) in cooperating with a start-up, like Qlocx?
15. How big of a role did the other actors (Qlocx, Ramirent, etc.) have in bringing out the solution itself?
    a. How big of a role do you want them to have?
16. How does the improvement job around the solution look like?
17. Which effects do you want the digital delivery container to have? What is it that you think that the innovation should contribute with?
    a. Locally and centrally?
    b. In the industry

Appendix 4

Interview guide in Swedish

1. Berätta lite om hur ett ‘vanligt’ byggprojekt på NCC går till.
2. Vad är en innovation för er? Om du skulle definiera en innovation?
3. Hur ser logistik inom byggindustrin ut för er, vad är bra och vilka är utmaningarna?
    a. Hur arbetade ni *innan* leveranscontainern kom?
4. Berätta lite om leveranscontainern från erat perspektiv. Hur fungerar den för er, hur jobbar ni med den?
    a. Vilka är det största ändringarna som har hänt efter att den kom?
5. Berätta lite om hur detta projekt började [inledningen av leveranscontainern].
6. Hur ser du på relationen med Qlocx i detta projekt?
7. Hur ser du på relationen med Ramirent/Ahlsell i detta projekt?
8. Vilka är möjligheterna/fördelar med ett sånt här samarbete?
9. Vilka är nackdelarna med ett sånt här samarbete?
10. Hur har implementeringen av lösningen gått?
    a. Har det krävts mycket av era [byggprojektets] tid och resurser?
11. Vad tror du är skillnaden [om någon] med specifikt detta innvations-projekt, jämfört med andra som du har sett hända?
12. Vad vill ni att digitala leveranscontainern ska få för effekt? Vad är det ni tror att innovationen ska bidra med?
    a. Lokalt och centralt?
    b. Ute i industrin?

Interview guide in English

1. Tell us a little bit about what a ‘regular’ construction project at NCC is like.
2. What is an innovation to you? If you were asked to define innovation?
3. How does logistics within construction look to you, what is good and which are the challenges?
    a. How did you operate *before* the digital delivery container?
4. Tell us a little bit about the digital delivery container from your perspective. How does it work for you, how do you work with it?
    a. Which are the biggest changes that have happened after it came?
5. Tell us a little bit about how this project started [the implementation of the digital delivery container].
6. How do you view the relationship with Qlocx in this project?
7. How do you view the relationship with Ramirent/Ahlsell in this project?
8. Which are the possibilities/advantages with this sort of a cooperation?
9. Which are the disadvantages with this sort of a cooperation?
10. How has the implementation of the solution been?
    a. Has it required a lot of your [the construction project’s] time and resources?
11. What do you think is the difference [if any] with this innovation project specifically, compared to others which you have witnessed?
12. Which effects do you want the digital delivery container to have? What is it that you think the innovation should contribute with?
    a. Locally and centrally?
    b. In the industry