THESIS FOR THE DEGREE OF LICENTIATE OF ENGINEERING

If you want to go far, go with others

How using a collaborative project delivery model affects the project network in infrastructure construction projects

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Gothenburg, Sweden 2021

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Abstract

The growth of projects has elicited much interest in the last decades, both in academia and amongst practitioners. The increase in scale and complexity has further brought attention to the particulars of interorganisational collaboration: as projects grow, the relevance and impact of interdependencies between participating organisations rise to the surface. No organisation is an island and so a project becomes an archipelago of interconnected networks.

Current literature on interorganisational collaboration focuses on contract and procurement, both important aspects of project management. There is, however, less research pertaining to project realisation and how these changes in interorganisational collaboration shape the project process.

A field where this change has been especially noticeable is the infrastructure construction industry, where collaborative project management models have been introduced to reduce adversity and improve project outcomes. These new models necessitate a study of changes these new models bring with them to the conventional ways of work within the field, as they call for new processes and roles in the projects, thus changing how the actors engage with the project network. As such models are based on collaboration, the role of social ties within the project become an especially interesting question.

In this work, I expand on the theory pertaining to project networks in the empirical setting of infrastructure projects applying a collaborative project management model, with the aim of examining and gaining a deeper understanding of the collaboration between interorganisational project actors in a collaborative project delivery model. The methods used in this thesis are based in the qualitative research tradition and emphasise interviewing and observation. During this work, 44 interviews were completed in a pre-study and two case projects and observation of both project's shared office space was carried out. I also analysed project documents and analysed the social network between respondents in the case projects.

My results show the importance of social relations as enablers of the realisation of expected benefits of collaborative models. They moreover illustrate the changes necessary for the models to be effective, as well as study how the use of such project models affect the actors' engagement in the project network.

Keywords: project management, major projects, collaboration, project network, social ties, infrastructure construction, AEC industry

When you just do enough things together, you notice that the other party also knows their stuff and then you don't have to worry about the things you don't know so much about yourself.

— Design engineer

List of appended papers

Paper 1:

af Hällström, A., Bosch-Sijtsema, P. (2020): Collaborative governance models towards sustainable infrastructure projects: the case of resources, IOP Conference Series: Earth and Environmental Science, Volume 588, 1.15 – 1.19

The peer-reviewed paper was presented at the World Sustainable Built Environment Conference Beyond2020 in 2020 on the 4th of November 2020. The paper was co-authored with Petra Bosch-Sijtsema. The research design was developed by both authors. Data collection was conducted by myself, while analysis and writing was conducted jointly by both authors.

Paper 2:

af Hällström, A and Bosch-Sijtsema, P (2020) Collaboration and Relationships in Nordic Infrastructure Project Networks. *In:* Scott, L and Neilson, C J (Eds.), *Proceedings 36th Annual ARCOM Conference*, 7-8 September 2020, UK, Association of Researchers in Construction Management, 245-254.

The peer-reviewed paper was presented at the Conference of Association of Researchers in Construction Management (ARCOM) in 2020 on the 7th of September. The paper was co-authored with Petra Bosch-Sijtsema. The research design was developed by both authors. Data collection was conducted by myself, while analysis and writing was conducted jointly by both authors.

Paper 3:

af Hällström, A., Bosch-Sijtsema, P., Poblete, L., Rempling R., Karlsson M. (under review): The role of social ties in collaborative project networks: a tale of two construction cases.

This paper is originally based on paper 2 with extensive reworking done after comments during the ARCOM 2020 conference (7–8 of September). The paper was co-authored with Petra Bosch-Sijtsema, León Poblete, Rasmus Rempling and Mats Karlsson. The idea for the article was jointly developed by af Hällström, Bosch-Sijtsema and Poblete. The research design was developed by af Hällström and Bosch-Sijtsema, in collaboration with co-supervisors Rasmus Rempling and Mats Karlsson. Data collection was conducted by myself, while analysis and writing was conducted jointly by af Hällström and Bosch-Sijtsema.

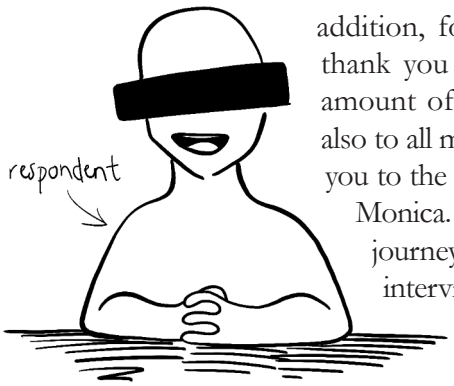
You want to build as you've always built, in a way.

— Contractor

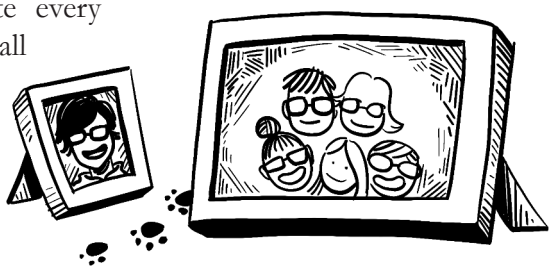
Acknowledgments

When I write this, March of 2021 has just begun and it's almost exactly a year from the day the world changed forever. Of course, life is in a constant state of flux and the largest change in my life so far actually hasn't been the global lockdown. When this journey began in 2018, it was really difficult for me to visualise this point. Halfway between beginning and end; the licentiate. Maybe because some of my friends had already defended their doctorate (and that the licentiate is almost unheard of where I come from), THAT was somehow clearer; you write a bunch of articles or a monograph, dress up in a tux* to discuss your work with an opponent and that's it. I have since then understood how very wrong I was in my assumptions; the process is infinitely more fun (and challenging) than I assumed. But when it came to the licentiate, I was lost. And thus, this work would not have been possible without a lot of support.

I want to thank my supervisors; Petra, Rasmus and Mats, I wouldn't be here without you. Literally. Thank you for taking on a Finnish urban planner to look at collaboration in construction! Your input has been invaluable and I always look forward to our Friday meetings; I know I'm going to learn something new each and every time. Thank you also to León, our latest addition, for your insightful and constructive thoughts regarding theory. And thank you Pernilla, my examiner, for constructive feedback and an unlimited amount of patience and always having an encouraging word to share. Thank you also to all my wonderful colleagues at TME in general and SML in particular. Thank you to the worlds best roomies, Stina and Daniel, and the worlds best past roomie, Monica. A special shoutout to Stina for being my lic-zoomie and sharing in this journey with me; you made me power through! Thank you also to all my interviewees; without you, this thesis wouldn't be here. Thank you to my case projects for participating and sharing your data and knowledge with me! I would also like to thank SBUF, Trafikverket and CMB for financing this research into infrastructure collaboration.



And of course, thank you to friends and family for always being there for me and bearing with me when I go on tangents about collaboration and relationships in projects and get lost in concepts you usually have no idea about. I appreciate every encouraging message in the chat groups and every phone-call where you remind me that I can do this. Thank you for the endless calls and out-of-context photos and music recommendations and encouraging comments and virtual game nights and just… being there and sharing your life with me. I appreciate and love you all! And a special, great, heartfelt thanks goes to Fredrik. Thank you for being you (and for remembering to feed the cat)!



But there's yet more to come! Although this part of my #coolhatproject is done, there's still a lot to do and even more to learn. I'm looking forward to the next part of the journey and where I will be then. After two+ years of being immersed in research and the academic community, I'm more convinced than I ever was before; this was a leap worth taking.

Tack, kiitos & thanks!

* In Finland, the dresscode is white tie

Either we have been very bad at explaining that what it was we wanted out of this, or, for some reason, the contractor interpreted it not as we expected them to.

— Client

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Abbreviations

CPDM	Collaborative project delivery model
SNA	Social network analysis

1. Introduction

The recent increase in project size and complexity (Flyvbjerg, 2014; Lundin et al., 2015) is compounded by the amount of organisations partaking in the project, as this involves negotiation among multiple organisations with their own goals, making projects requiring interorganisational collaboration especially challenging (Gann & Salter, 2000; Jones & Lichtenstein, 2009; Lundin et al., 2015; Sydow & Braun, 2018). Major projects, a class of their own, whose lifespan is counted in decades and budgets surpassing 100 million dollars (Flyvbjerg, 2014), often involve multiple stakeholders and involve the coordination of different project participants, stakeholders and sub-projects (Flyvbjerg, 2014; Gann & Salter, 2000) and are particularly affected by challenges related to interorganisational collaboration. Moreover, the interorganisational relationships born in such projects often persist after the project is delivered (Hellgren & Stjernberg, 1995; Sydow & Braun, 2018). The interorganisational and relational dimensions are thus important dimensions to take into consideration when discussing projects, and especially major ones.

Projects are, moreover, a special kind of organisation, bound in time and with a defined goal. The increase in complexity, combined with the particular characteristics of projects as organisations require a novel approach, both in practical as well theoretical terms. The growth of projects (Flyvbjerg, 2014), coupled with the increasing share of them that span organisational boundaries (Lundin et al., 2015; Sydow & Braun, 2018) has led to the introduction of new management models in an effort to minimise uncertainty and risk to the client (Chen, Manley, Lewis, Helfer, & Widen, 2018; Hastie, Sutrisna, & Egbu, 2017; Lahdenperä, 2012; Scheepbouwer & Humphries, 2011), as well as calls for further theoretical approaches (Pryke, Badi, & Bygballe, 2017; Steen, DeFillippi, Sydow, Pryke, & Michelfelder, 2018).

One of the suggested academic approaches include a network-based perspective on projects (Pryke et al., 2017; Steen et al., 2018) as a network view can help conceptualise the temporality of projects and "enables a better understanding of projects as organizational forms" (Steen et al., 2018, p. 14). One way to theorize networks is the application of network theory. Network theory focuses on actors, who are connected by ties: "[t]he pattern of ties in a network yields a particular structure, and nodes occupy positions within this structure" and "it is the researcher— by choosing a set of nodes and a type of tie— that defines a network" (Borgatti & Halgin, 2011, p. 1169). Wang et al (2018), building on work by Jones and Lichtenstein (2008) among others, argue that the behaviour of network actors is defined by the informal institutions, such as the aspects governing social relations, highlighting social ties as an interesting object of study. Thus, the definition of both actors, ties and the project network itself depend on how the network is demarcated.

The classical view in project network research places emphasis on the individual actor. As there are multiple levels at which project networks interact with their environment, arguments have lately been raised for a multi-level approach to project network research (Sydow & Braun, 2018). Sydow and Braun (2018) mention the project, network, organisation and field as separate levels to consider. The patterns of these levels are shaped by slightly different ties, which impact their structure and interactions. In this work, I am looking at two of the levels mentioned by Sydow and Braun (2018): the project organisation and the individuals participating in the project.

In the setting of projects, the project network becomes an object of analysis. There are two main ways of looking at the project network, as discussed in further detail by e.g. DeFillippi and Sydow (2016): as (1) the network formed around the individual project through interorganisational relationships; or (2) as the network created by the relationships created between organisations partaking in a series of projects. Although both projects and interorganisational relationships are embedded within a larger organisational and institutional environment (DeFillippi & Sydow, 2016; Sydow & Braun, 2018), the relationships in a single project can broaden our understanding of how interorganisational relationships affect the project as well as of the patterns of interaction in a specific setting (Hellgren & Stjernberg, 1995), and make it easier to identify possible causes and

effects. I will follow the idea of the network created around an individual project, as discussed by e.g. Hellgren and Stjernberg (1995), Adami and Verschoore (2018) and Pryke et al (2018) and use the term "project network" to denote the network shaped by a single project as this view can help us understand project dynamics and projects as organisations.

Moreover, the challenges of interorganisational collaboration can be further studied in the empirical setting of infrastructure construction. The construction sector has traditionally been regarded as adversarial (Hansen-Addy & Nunoo, 2014), prone to conflict and costly disputes (Rahman & Kumaraswamy, 2004) and a lack of cooperation between actors (Franz, Leicht, Molenaar, & Messner, 2016). Larger projects have exacerbated these problems (van Fenema, Rietjens, & van Baalen, 2016) and large infrastructure projects are seldom finished on time or within budget (Flyvbjerg, 2011, 2014). One solution to solve these problems has been the introduction of *collaborative project delivery models* (CPDM) which focus on collaboration between project participants rather than hierarchical relationships (Bygballe, Jahre, & Swärd, 2010; Bygballe & Swärd, 2019; Chen et al., 2018; Eriksson, 2015; Walker & Lloyd-Walker, 2014). In this work, 'collaboration' is defined as a process that "occurs when a group of autonomous stakeholders of a problem domain engage in an interactive process, using shared rules, norms, and structures, to act or decide on issues related to that domain" (Wood & Gray, 1991, p. 146).

CPDMs involve early inclusion of key actors as well as resource sharing and a joint decision-making process (Lahdenperä, 2012). In traditional project organisations the responsibilities have been defined in the contract of the project, but with the introduction of earlier actor involvement and deeper integration between project actors into infrastructure projects due to the increasing use of CPDMs, there is a need to examine the traditional division of actor roles and responsibilities.

The introduction of CPDM has resulted in an increase of both research focusing on interorganisational collaboration (cf. Chen et al., 2018; Lahdenperä, 2012; Walker & Lloyd-Walker, 2014) as well as studies looking specifically at certain management models such as alliancing (cf. Hietajärvi & Aaltonen, 2018; Walker, Harley, & Mills, 2015), early contractor involvement (cf. Eadie & Graham, 2014; Laryea & Watermeyer, 2016; Walker & Lloyd-walker, 2012) and partnering (cf. Gadde & Dubois, 2010; Hansen-Addy & Nunoo, 2014). This increase highlights a growing trend of collaborative approaches to project management in construction research. Furthermore, infrastructure construction shows several of the aspects discussed earlier: projects have grown larger and more complex (Flyvbjerg, 2014) and there is a call for new management models (Bygballe & Swärd, 2019) and perspectives on construction projects, especially from a network perspective (Pryke et al., 2017).

Hitherto, literature on CPDMs has mainly focused on the procurement stage (cf. Chen et al., 2018; Eriksson, 2013; Eriksson et al., 2019; Volker, Eriksson, Kadefors, & Larsson, 2018) and how the contract impacts the project. Less attention has been paid to how different types of ties impact the project network and thus project delivery.

The larger projects grow, the greater numbers of people and organisations they involve, creating ever larger interpersonal and -organisational networks. There have been some forays into this area (cf. Adami & Verschoore, 2018; Pryke, Badi, Almadhoob, Soundararaj, & Addyman, 2018) but there is still little known about the interplay between social relations, project networks and the formal project structure and contracts in the context of interorganisational projects.

1.1. Purpose of the thesis

The lack of literature pertaining to the area, coupled with the new empirical phenomena of CPDM, results in multiple interesting research possibilities. In this thesis, I will strive to answer the call for further research into the impact of project networks in the construction sector (Pryke et al., 2017)

and interorganisational collaboration (Sydow & Braun, 2018), combined with the impact of relational ties (Adami & Verschoore, 2018; Wang, Lu, Söderlund, & Chen, 2018).

This thesis focuses on interorganisational collaboration in infrastructure construction projects in a Nordic setting. The purpose of this thesis is **to examine and gain deeper understanding of interorganisational collaboration in a project network created in a collaborative project delivery model.**

1.2. Research questions

When reflecting on the aim of the thesis – to examine and gain deeper understanding of the collaboration between interorganisational project actors in a collaborative project delivery model – in conjunction with the existing body of knowledge concerning project management and the theoretical framework of a project network perspective, two research questions were formulated:

- How does the use of a collaborative project management model affect actors' engagement with the project network?
- What is the role of social ties created in a project managed by a collaborative project delivery model?

The research presented in this thesis provides new insights into the impact of social relationships on actor interaction and collaboration, which can broaden our understanding of the project network in interorganisational projects. An approach based on project network theory (Hellgren & Stjernberg, 1995; Pryke et al., 2017; Steen et al., 2018) is used to inform the research.

1.3. Structure of the thesis

The thesis starts with an introduction to the research field, as well as problem formulation and research purpose. After this, an overview of previous research on collaboration in the construction industry, the changing ways of managing infrastructure construction projects, project networks, and a frame of reference for the study are presented. After the theoretical framework is presented, the research methodology and design are expanded upon. This chapter also includes a deeper description of the empirical setting. This is followed by a summary of the included papers and a discussion on the theoretical implications thereof. The thesis is concluded by conclusions covering both theory and practice, as well as suggestions for future research.

2. Previous research: the realm of projects

2.1. Interorganisational collaboration

An interorganisational project involves "two or more organizational actors from distinct organizations working jointly to create a tangible product/service in a limited period of time" (Jones & Lichtenstein, 2009, p. 234). The larger the project, the greater the number of participating organisations and thus the level of interorganisational collaboration.

The traditional approach to project studies, examining the individual project actor and their actions in an intra-organisational setting, has drawn critique due to the lack of focus on collaboration between multiple actors and how the temporal nature of projects affect these interactions (Jones & Lichtenstein, 2009; Sydow & Braun, 2018); issues which have grown larger and more complex in tandem with the growth of projects in general (Flyvbjerg, 2014; Lundin et al., 2015; Sydow & Braun, 2018).

Sydow and Braun (2018) identify three dimensions of complex interorganisational projects: (1) the need to account for multiple levels in the project, taking into consideration the interaction between separate levels; (2) adopting a dynamic perspective on the project, with a focus on the practice perspective and actors' behaviour in the project and a processual understanding of the relationships created; and (3) different modes of interorganisational governance, as interorganisational relationships are governed by a form of governance differing from both those found in permanent organisations but also from 'arm's length' market transactions.

These three perspectives can be seen in collaborative project management delivery models (CPDMs), recently introduced in the infrastructure construction industry. The models were introduced to put more focus on collaboration between project actors rather than the hierarchical relationships characteristic of the industry (Bygballe et al., 2010; Bygballe & Swärd, 2019; Chen et al., 2018; Eriksson, 2015; Walker & Lloyd-Walker, 2014).

2.2. Collaborative project delivery models

An infrastructure construction project consists of multiple organisations acting together to achieve a pre-determined goal. Many such projects are large in scope and scale, and can be classified as major projects: they take decades to realise, involve multiple stakeholders and their total costs exceed 100 million dollars (Flyvbjerg, 2014). Major projects are furthermore often complex due to their scale and the inherent risk of coordinating specialists from different organisations and fields (Gann & Salter, 2000).

As the nature of major infrastructure projects have changed, so has the nature of their management. In large projects, there is a great variety and inherent risk, as well as multifaceted processes related to coordination and control (Adami & Verschoore, 2018; Gann & Salter, 2000; Hughes & Murdoch, 2003), increasing the level of difficulty of managing such projects and making them complex (Adami & Verschoore, 2018). Further complications arise from both the collaboration between different organisations arising in such a project, as large-scale infrastructure projects usually include several different organisations due to their scale and demands for specialist knowledge (Gann & Salter, 2000), and from the complexity of coordinating multiple stakeholders (Hellgren & Stjernberg, 1995; Jones & Lichtenstein, 2009; Sydow & Braun, 2018).

Collaborative project delivery models (CPDMs) have been increasing in popularity as a possible solution to the management challenge of large infrastructure projects (Chen et al., 2018; Lahdenperä, 2012; Schepker & Poppo, 2014). Research into the area has identified benefits of such models, including increased project quality (Bygballe, Håkansson, & Ingemansson, 2015; Eadie & Graham, 2014; Scheepbouwer & Humphries, 2011), less adversity in the project

organisation (af Hällström & Bosch-Sijtsema, 2019; Song, Mohamed, & AbouRizk, 2008) and reduced costs (Eadie & Graham, 2014; Song et al., 2008). These models have been used in private construction projects for several decades, for example in housing and industrial construction, but their introduction to the public infrastructure sector is a relatively recent phenomenon (Lahdenperä, 2012).

Collaborative project delivery models (CPDMs) are characterised by differing degrees of "early involvement of key parties, transparent financials, shared risk and reward, joint decision making, and a collaborative multi-party agreement" (Lahdenperä, 2012, p. 57). The sharing of resources and risks as well as joint decision-making establish CPDMs as relational management models (Tadayon, 2018). Thus, the anticipated success of CPDM-based projects relies on the relationships that either enable or constrain the level of sharing activities and involvement of actors.

2.2.1. How the use of CPDM changes the project

Although each construction project is unique, they follow a standard project process, divided into pre-project, project definition and design, project execution, and use (Sears, Sears, Clough, Rounds, & Segner, 2015). See figure 1 for a process overview.

Once a client identifies a need, a pre-project phase of planning and definition commences. This phase is the responsibility of the client, although expertise from both the contractor and design engineer might be called upon to provide specifications and technical advice.

The pre-project phase is followed by the activity of architectural and engineering design, depending on the project's requirements. During this phase the client details their needs together with design specialists, either in-house or as contracted services. There might be some overlap between design, procurement and initial construction.

Project execution includes detailed engineering, procurement and physically realising the project. The activity of construction is often undertaken by a specialised construction firm, with the client giving minimal input during the process. The beginning of this phase may overlap with project definition and design, and the design engineers may be involved in the detailed design. The execution phase is followed by the client taking charge of the project and starting the use phase.

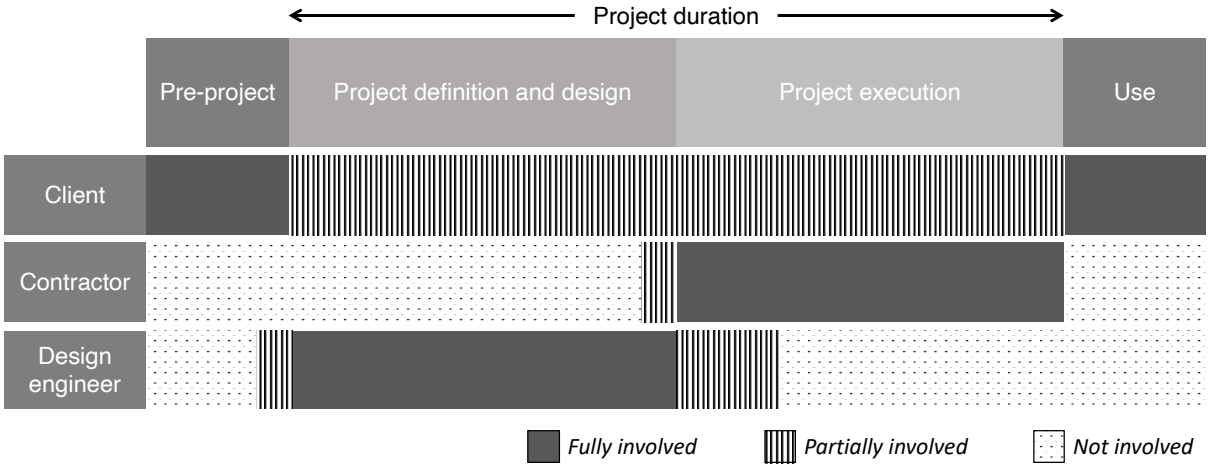

Figure 1: *Traditional project life cycle and actor involvement (building on Sears et al., 2015)*

Although the construction industry is project-based (Lundin et al., 2015) and knowledge-intensive (Hastie et al., 2017), there are also indications of a lack of learning between projects (Gann & Salter, 2000), which could lead to challenges when implementing the novel model of CPDM. As there

are several CPDMs, this section does not focus on the contractual aspects but on the project process and operations. When utilising a CPDM, there are some changes in this traditional process (see figure 2).

The pre-project phase is similar to a traditional project process, in that the client identifies a need and commences planning and project definition. In a CPDM, however, the process of choosing a service provider and shaping the CPDM may involve partial involvement from the contractor and the lead designer, as the selection process often involves workshops and assessments to evaluate how all actors work together.

As per the CPDM model, phase 1 involves early inclusion of all key actors (Lahdenperä, 2012). During this phase, the client is fully involved in the process and works in close collaboration with the design engineer to design the project. The contractor is also partially involved; they are called upon to give their expert opinion on the design, although no construction work is ongoing (paper 2).

Phase 2 continues the demands for close client and designer involvement as unknowns often appear when construction work starts, and the design may require changes (paper 2), which requires input from both the client and the design engineer. As construction work progresses, the design engineer's role diminishes, before construction has reached a stage where no more design changes are possible.

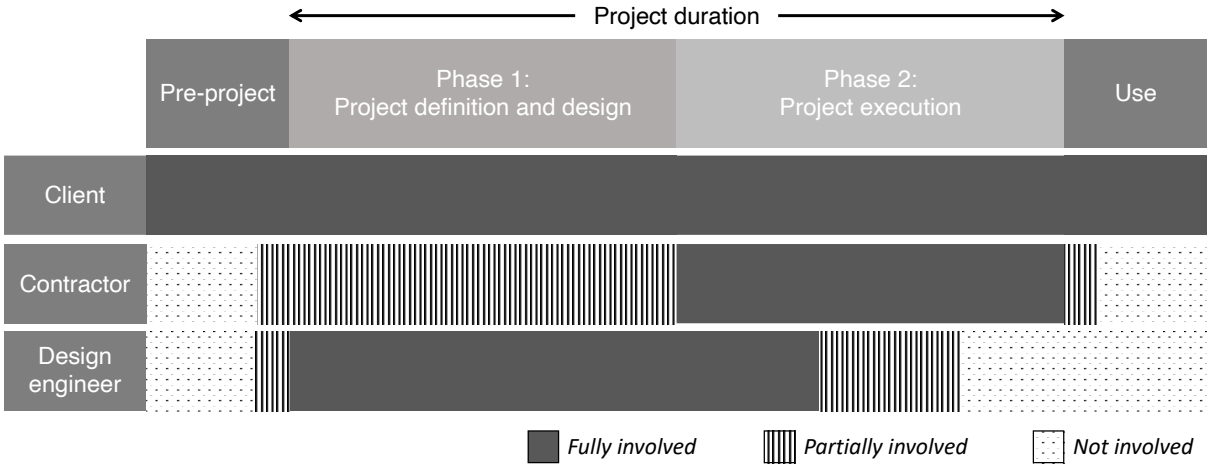

Figure 2: *Project life cycle and actor involvement when using a CPDM*

Although there are several CPDMs applied in the construction industry today, such as alliancing, early contractor involvement, integrated project delivery and partnering, the organisation of CPDMs follow a similar structure and emphasise the importance of early inclusion of all key actors, communication and sharing of resources (Lahdenperä, 2012). These changes lead to changes in traditional roles and responsibilities since they require new skillsets from project actors, as can be seen in the analysis of a partnering project by Bygballe and Swärd (2019): "Partnering represented a fundamental change for the participants in this project and implied the discarding and replacement of existing ways of organizing and managing the construction process" (p.2). Since change of organizing leads to changes in the project process, the actors' roles also change. Past research into construction projects has focused mainly on operational issues of work allocation, rather than analysis of required actor roles and responsibilities (Hughes & Murdoch, 2003).

In this thesis, I follow the definitions of roles presented by Hughes and Murdoch (2003) as being "the relationship between a participant and an operation" (Hughes & Murdoch, 2003, p. 25), with an operation being defined "a package of work that can be undertaken by one organizational unit

without interruption by decision points" (Hughes & Murdoch, 2003, p. 22). This relationship is interesting, as those who participate in a project organisation belong, simultaneously, to multiple organisational settings (Hughes & Murdoch, 2003; Lundin et al., 2015; Sydow & Braun, 2018). There is therefore a need to coordinate decision-making and responsibilities between the separate organisations that make up the infrastructure project, as no one organisation can make decisions on behalf of other organisations (Hellgren & Stjernberg, 1995). This may present a challenge for successful implementation of a CPDM, as many such models build on unanimous decision-making (Lahdenperä, 2012) and highlight the importance of defining roles and responsibilities in a project.

Furthermore, large infrastructure projects have project-specific goals. The organisations involved in the project also have their own objectives in engaging in the project (Hellgren & Stjernberg, 1995; Sydow & Braun, 2018), as do the individuals creating the organisations. In order for a project to fulfil its goals and objectives, role descriptions for performing, controlling and managing the tasks and responsibilities are needed to coordinate the work of actor organisations as well as individuals (Hughes & Murdoch, 2003). Following Hughes and Murdoch's (2003) ideas of roles being dependent on defined packages of work and Lahdenperä's (2012) thoughts on defining roles and responsibilities, the novelty of CPDM the change in roles necessitates clear role descriptions in order to facilitate the role change.

2.2.2. The role of social ties in CPDM

Close social relationships, also known as ties, within a project network can help shape goals and behaviours as well as coordinate actor adaptation and adjustment (Uzzi, 1996) and support the formation of collaborative relationships where "a group of entities enhance the capabilities of each other" (Camarihna-Matos & Afsarmanesh, 2011, p. 311). This shifts the focus away from short-term gains to cultivating long-term relationships (Uzzi, 1996).

It is argued that close social ties build on three main components: trust, close information transfer and joint problem-solving arrangements (Uzzi, 1997). All aspects are also part of a CPDM (Lahdenperä, 2012), highlighting the importance of social relationships to the success of the model. This becomes especially pertinent as CPDM requires the early inclusion of all actors, extending the collective time spent in the project and thus increasing the opportunities for social ties to form.

CPDM is built on collaboration and sharing in the project process; risk and rewards are shared, as is decision-making and financial details. All key parties are involved early in the process and the model builds on the relationships enabling interaction within the project setting (Lahdenperä, 2012). As CPDMs often are used in major interorganisational projects, the issue of coordinating decision-making and governance also becomes important; although one of the tenets for CPDM is shared decision-making, the practicalities surrounding it rely on both the project organisation and process, as determined in the contract, but also on the social ties between actors (Kadefors, 2004; Uzzi, 1997). The nature of ties within the network are therefore imperative for the implementation and success of the model.

The project organisation created by CPDM is shaped by the three aspects of interorganisational collaboration, in all of which social ties play a key role: (1) *the nature of relationships*, as the CPDM requires early inclusion of all actors; (2) *the issue of coordinating decision-making and governance*, as the nature of these changes due to the implications of 'sharing' essential to CPDM; and (3) *the ambiguous nature and demarcation of projects*, as infrastructure projects last for years, if not decades, and the actors participating in the project, both organisations and individuals, may change during the process. The issues pertinent to a better understanding of these factors shaping interorganisational collaboration are thus also key to understanding the impact of CPDMs in the construction industry.

3. Theoretical frame of reference

Network theory is "about the consequences of network variables, such as having many ties or being centrally located" (Borgatti & Halgin, 2011, p. 1172), or how the structure formed by a set of actors connected by specified ties enables or constricts actions. A network consists of actors (or nodes), connected by ties (Borgatti & Halgin, 2011; Pryke, 2012b). The actors in the project network can be both the organisations as well as the individuals, depending on how the network is defined.

Network theory has recently become popular in both the field of project research (Pryke, 2012a; Steen et al., 2018) as well as within the construction community (Pryke et al., 2017). When taking the rising interest in interorganisational collaboration as well (Sydow & Braun, 2018), the rise in network applications in project research can be interpreted as a growing interest in the relational aspects of projects and networks in the academic community.

3.1. Project networks

For project organisations, the organisations and individuals create, besides a project organisation, also a project network. As discussed earlier, I will here use the definition of Hellgren and Stjernberg (1995), Adami and Verschoore (2018) and Pryke (2018), among others, and use the term "project network" to denote the network, created by ties connecting actors within a single project. This view can assist in understanding project dynamics. Furthermore, how project organisations are created as relationships in a single project can deepen our understanding of how interorganisational relationships affect the project and patterns of interaction in a specific setting become visible (Hellgren & Stjernberg, 1995), making it easier to identify possible causes and effects.

As project networks are formed by ties between actors participating in the project, project network boundaries become difficult to determine (Hellgren & Stjernberg, 1995). One reason for this fluidity might be the dynamic nature of project membership, as participating organisations allocate individuals to the project according to identified needs and the project participants thus belong to multiple organisations, or network settings, simultaneously (Hughes & Murdoch, 2003).

A project network is governed by responsibilities, routines, roles and relationships (Steen et al., 2018). The efficiency of the project network is contingent on the performance of the entire network, which in turn depends on how well individual goals of the organisational actors involved are aligned with the project goal (Hughes & Murdoch, 2003), as well as the flow of resources within the network (Borgatti & Halgin, 2011).

Project networks, the relational network formed around a project by the actors partaking in the project process, rely on different governance models than traditional organisations (Hellgren & Stjernberg, 1995; Steen et al., 2018; Sydow & Braun, 2018). Steen et al (2018) further discuss the importance of relational governance and mutual trust as discussed in literature, as well as the impact of different actor roles on the network. These actors strive to fulfil both their own goals as well as project goals, while engaging in role-determined activities (Adami & Verschoore, 2018; Manning, 2008).

3.1.1. Actors

Network theory focuses on the interaction between actors (or nodes). An actor is linked to other actors in the network through specified types of ties (Borgatti & Halgin, 2011; Pryke, 2005). In this work, I define the infrastructure development project network actors on the organisational level as client, design engineer and contractor, and on the individual level as the individuals partaking in the project as directed by their parent organisation.

In a project network, the dynamics between actors are of importance, as each participating organisation has their own power dynamics, creating a need for internal coordination (DeFillippi & Sydow, 2016; Hellgren & Stjernberg, 1995). DeFilippi and Sydow (2016) reflect on Provan and Kenis (2008) in their identification of three main forms of authority coordination: (1) shared governance; (2) appointing a lead coordinator from among the participating organisations; and (3) appointing a dedicated network administrative organisation. The effectiveness of these approaches depend on the level of trust and goal consensus (DeFillippi & Sydow, 2016), important aspects of the theory behind CPDMs.

3.1.2. Ties

A tie is, in its simplest form, anything that connects two actors. In order to understand and analyse ties, it is nevertheless useful to distinguish types thereof, as their definition creates the network (Borgatti & Halgin, 2011). There are several different approaches to defining ties and their characteristics. Granovetter (1973) discusses the strength of ties, which has become one of the main definitions of the quality of ties, and Burt (2001) focuses on the structural holes left between actors in a network. Borgatti and Halgin (2011) define ties as 'state' or 'event', depending on their duration, while Wang et al (2018) among others discuss the formality thereof. In this work, I am focusing mainly on the formal and informal ties, as both states and events, but will also touch upon aspects of tie strength.

A state tie is a long-term connection, while *an event tie* is transitory. Borgatti and Halgin (2011) note that a state tie can be measured "in terms of strength, intensity, and duration" (p.1170), while an event tie is measured as occurrences over a period of time. An example of a state tie is a role-based relation in a project network, such as the one between the project managers from the client, the design engineer and the contractor, or a social connection, such as between two old school acquaintances who happen to work in the same project. An example of an event tie is a project meeting or a spontaneous discussion taking place at the coffee maker in the office.

Ties can furthermore be formal or informal. *A formal tie* is often observable and measurable, such as a contract or organisational structures (Papadonikolaki, Verbraeck, & Wamelink, 2017; Wang et al., 2018). Formal ties are also often state ties (Wang et al., 2018). *An informal tie* is often a relation between two actors (Papadonikolaki et al., 2017) and can influence actor behaviour (Wang et al., 2018). Recent research has postulated that the alignment of the formal network, shaped by formal ties, with the informal network of relations could result in a positive correlation with project performance (Wang et al., 2018).

Bridging ties (Borgatti and Halgin 2011, referencing Granovetter), connect network clusters. This is of particular interest in a collaborative project network which consists of separate clusters, formed by the participating actor organisations. The bridging ties are both the contract, linking organisational actors together, but also meetings where both individuals meet in a social setting, but organisations meet through the moderating ties of role-based attendance, as well as social ties connecting individuals from separate clusters. Social ties, however, can only form between individuals as 'social' relates to the way people interact. Organisations are unable to form social connections.

3.1.3. The multiple levels of project networks

I am here demarcating the project network to two levels, following Sydow and Braun's (2018) proposal of taking a multi-level approach. One network is formed between the organisations participating in the project, held together by state ties in the form of legal contracts. A second network forms between the individuals taking part in the project, as ordained by their parent organisations. They have a state tie in the form of their employment to their parent organisation while event ties within the project create new state ties (relationships) to other individuals, from other organisations, also engaged in the project. This structure is pictured in Figure 3 which depicts

the dynamics between individual project actors and the ties influencing their roles within the project.

When participating in a project, the parent organisation coordinates its resources, e.g. employees, in order to fulfil its internal goals as well as those defined by the formal state tie (contract) linking the organisation with the project. This formal state tie restricts the parent company's ability to utilise its resources by, for example, instituting a certain level of experience for the participating individuals.

The individual actors have certain roles in their parent organisation and in the project organisation. Their participation in the project is defined by both the formal state tie (contractual relationship) between their parent company and the project organisation, but also by their own formal state tie (employment contract) with their parent company. The individual actors are further connected to each other through formal event ties, such as project meetings, but also through informal social ties.

It is the dichotomy between project and parent organisation and the actor's role in both contexts which is a source of conflict within the project organisation. The project manager does not have the authority or formal tie of an employer to manage the individual actors from other organisations, while the individual's role in the project is shaped by both the project context and network created by the project, but also by their relationship to their parent organisation.

Coordination of the project network is paramount in accomplishing the objectives of the project (Hellgren & Stjernberg, 1995; Sydow & Braun, 2018). As Gann and Salter (2000) observe, "Success often depends upon the knowledge that people at every level of the organisation bring to bear in new, semi-autonomous and often temporary, cross-functional teams" (p.967).

There are several theories looking at the structure of networks in general, such as Granovetter's strength of weak ties (1973) and Burt's structural holes (2001), but few investigate the characteristics of the network structure. There is furthermore even less literature on network structure in the construction field, although there has been a growing interest in this field (cf. Bygballe & Swärd, 2019; Pryke et al., 2017; Zheng, Le, Chan, Hu, & Li, 2016).

3.2. The intersection of Interorganisational collaboration and project networks

The characteristics of interorganisational projects make project networks (focused on the single project) especially relevant, as the fields share many key ideas. Three main overlapping dimensions are (1) *the nature of relationships within a project network*, described as either 'the temporality and continuous reconstruction of projects' (Hellgren & Stjernberg, 1995) or 'a processual understanding of relationships' (Sydow & Braun, 2018); (2) *the issue of coordinating decision-making and governance*, discussed under and 'legitimate authority' by Hellgren and Stjernberg (1995) and 'modes of interorganisational governance' by Sydow and Braun (2018); and (3) *the ambiguous nature and demarcation of projects*, leading to discussions on the difficulty of describing and analysing networks when their boundaries are undefined (Hellgren & Stjernberg, 1995) as well as the need for a multi-level approach to their study (Sydow & Braun, 2018).

The nature of relationships within a project network is a central theme, as interorganisational relationships "have their own kind of governance which is typically different from hierarchies that are found in permanent organizations" (Sydow & Braun, 2018, p. 9) but that also are different from arms-length transactions commonly found in markets (Sydow & Braun, 2018). This is partly because interorganisational ties often connect organisations outside the scope of the project and they thus are linked to some degree, regardless of project duration. Hellgren and Stjernberg (1995) describe this as how "[a]n opponent in the short run, may in the longer perspective be seen as a potential partner. Similarly, the partner in the short run may be a competitor in future projects. This possible

dual relationship between actors is an important feature of interorganizational relations in project networks" (p.382). The management of projects thus requires a different approach than what traditionally is prescribed (Hellgren & Stjernberg, 1995; Sydow & Braun, 2018).

The nature of relationships is further elaborated by the concepts of "relational and structural embeddedness", as defined by Jones and Lichtenstein (2009), who show how low levels of so-called "relational embeddedness" result in an increase in the use of hierarchy as a tool to facilitate collaboration. They further note that "when structural embeddedness and thus density of relations is higher, shared knowledge about how to perform roles and who should coordinate with whom is more widely dispersed among field or industry organizations, obviating the need to formalize these relations" (p.237). "Relational embeddedness" is defined as the relationship between interacting parties and the degree of knowledge they have about each other's needs and goals and how much they take these into account in their actions (Jones & Lichtenstein, 2009). "Structural embeddedness", on the other hand, relates to the structure of the larger network and how the actor's contacts are related to each other and it "facilitates shared understandings and rules for collaboration that distinct organizations bring to their joint activities, reducing transactional uncertainty and facilitating coordination" (Jones & Lichtenstein, 2009, p. 239). This indicates that a project with low relational embeddedness would lean more on formal relationships and hierarchies, while a tightly connected network would share understanding of the project process, thus enabling collaboration. Therefore, the nature of the ties connecting the network can have a great impact on the structure of the project network and the outcome of project delivery.

The discussion about the relationships in a network continues in *the issue of coordinating decision-making and governance*. Hellgren and Stjernberg (1995) argue that "no single actor may act as a legitimate authority for the network as a whole" (p.380) and that the management and coordination of a network of organisations should be understood as a decision-making process based on politics. Organisations partaking in a project are beholden to the project organisation, while individuals have a dual role: project results are to be delivered to the project organisation, while the responsibility for long-term resource management and development lies within their parent organisations (Lundin et al., 2015). This view is also held by Jones and Lichtenstein (2009) who discuss the need for structural embeddedness to coordinate project activities, as well as Sydow and Braun (2018), who note the importance of informal ties in the modes of interorganisational management. When discussing project network management, the question of efficient coordination of non-hierarchically linked actors and the reciprocity this is based on (Sydow & Braun, 2018) must be taken into account.

Project network management is also affected by *the ambiguous nature and demarcation of projects*. As networks are defined by the beholder (Borgatti & Halgin, 2011; Hellgren & Stjernberg, 1995), the undefined border of project networks makes understanding and analysing networks difficult (Hellgren & Stjernberg, 1995). The combination of an undefined network border and the nature of major infrastructure projects calls for a multi-level approach (Sydow & Braun, 2018), enabling a deeper understanding of the network and how it is structured. This calls for a qualitative approach, in order to understand the nature of the network.

3.3. Summary

A combination of concepts and theories previously described allows for an exploration of how the utilisation of CPDM in a project affect actor's engagement with the project network and the role of social ties in such a project. This can be presented as the interconnectedness of project networks (see figure 3). The actors within the project network created by a project are linked by relationships, either as ties between organisations or ties between individuals, depending on the level of examination. There is furthermore interaction between the separate levels within the

network (Sydow & Braun, 2018), and the engagement within the project network affects the ties created between actors, both organisational and individual. As the use of a CPDM changes the traditional roles of the construction project (Bygballe & Swärd, 2019), the engagement further determines the level of social ties and how the role change is realised.

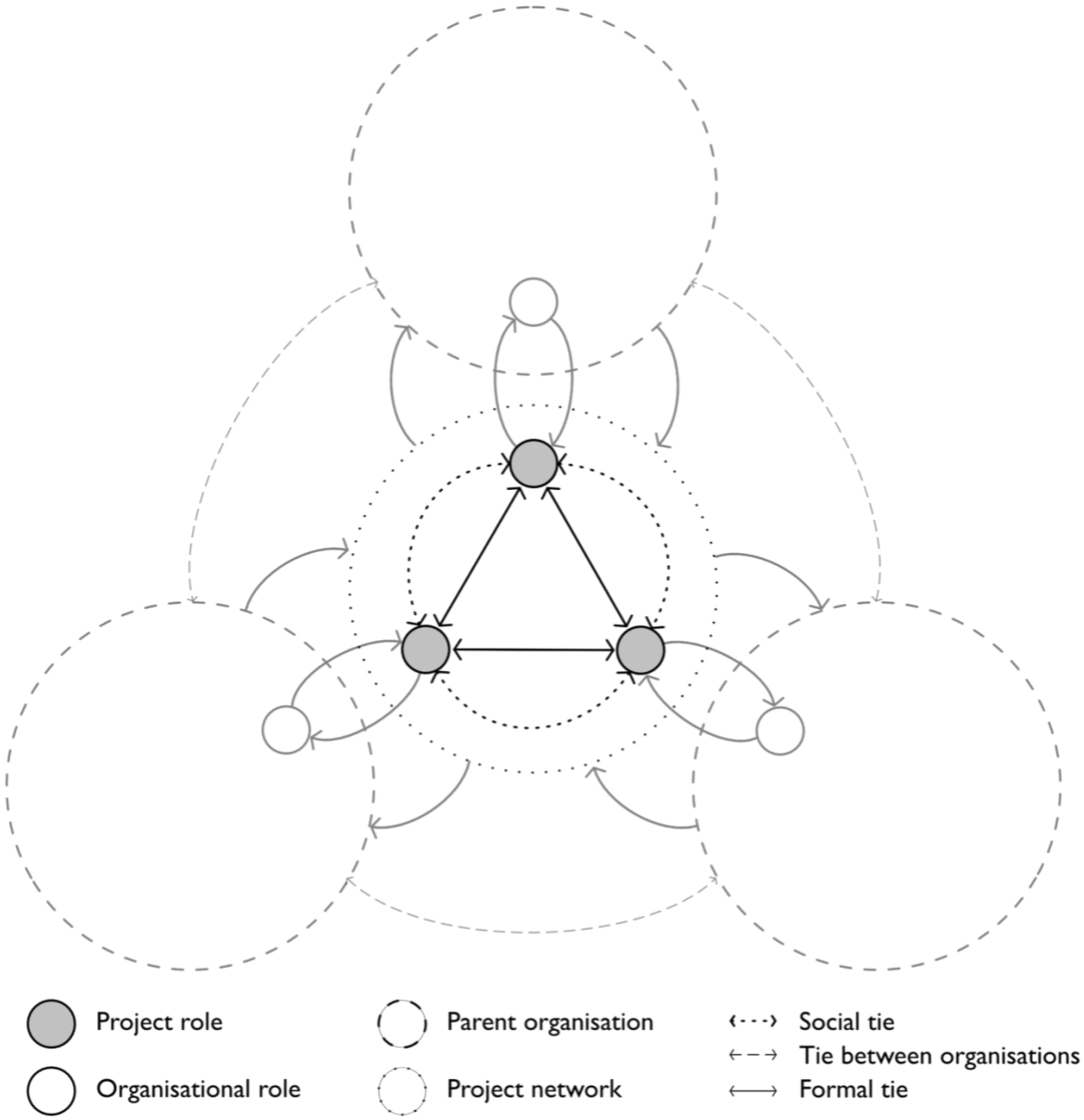

Figure 3: *The interconnectedness of project networks*

4. Methodology

This chapter outlines how the research questions can be answered through the design of the included studies, as well as the methods chosen for data collection and analysis. It closes with reflections on research quality.

The fundamental purpose of this study is to understand reality. Therefore, the definition of reality becomes and important facet to consider when we "determine *what* it is that we seek to understand through research" (Bell, Bryman, & Harley, 2019, p. 26).

The project field is pluralistic, which enables multiple approaches and viewpoints. The theoretical framework used in this study does come with some implicit assumptions about the world, the nature of knowledge and science that have implications for further analysis and the discussion on the findings.

With a project network perspective, projects and the networks created within are seen as objects of study. As humans interpret the situation they find themselves in (Anagnostopoulos, 2004) and project networks are a set of relations (Hellgren & Stjernberg, 1995) and a network is defined by the researcher (Borgatti & Halgin, 2011), the definition and view thereof depends on the viewer.

I have based my research on analysing the organising process of project networks, following Gioia and Pietre's (1990) seminal paper where they state that "the goal of theory building in the interpretive paradigm is to generate descriptions, insights, and explanations of events so that the system of interpretations and meaning, and the structuring and organizing processes, are revealed" (Gioia & Pitre, 1990, p. 588). People are, after all, the foundation and creator of their realities (Lincoln & Guba, 2000).

4.1. Empirical setting

Interorganisational collaboration has been highlighted as an relevant setting for further research in the project community (Sydow & Braun, 2018) and the infrastructure industry is an interesting empirical setting for research into the phenomena. The projects within this field are often large-scale, comprising of multiple organisations and the growth of collaborative project models within the sector (Chen et al., 2018) indicates a need for further research in this area.

The construction project life cycle consists of requirement specifications and procurement before the project starts, project definition and design, project execution, use and end-of-life. The life cycle of a CPDM follows this general division, but often defines project definition and design as *phase 1* and detailed design and project execution as *phase 2*, as the idea is to involve all key competences in an early stage and thus continue with the same team from design to execution (Hietajärvi, 2017; Lahdenperä, 2012; Walker & Lloyd-walker, 2012). Following a more conventional model, the client oversees project definition and design, and then chooses a contractor for the execution stage separately (see figure 4). In this work, I will focus mainly on the two phases particular to CPDMs: project definition and design and project execution, although I will also touch upon the initial stage of client need specification. This delimitation is done as there might be other network dynamics at play during the initiation phase (need specification and procurement) and the last phases (use and end-of-life) which fall outside the scope of this thesis.

An infrastructure project moreover comprises of many organisations, ranging from client and governance specialists to construction companies, design engineering firms and subcontractors. As existing literature on CPDM focuses on the relationships between the client, contractor and design engineer, with a skew towards the relationship between the client and the contractor, I have focused on these three actors.

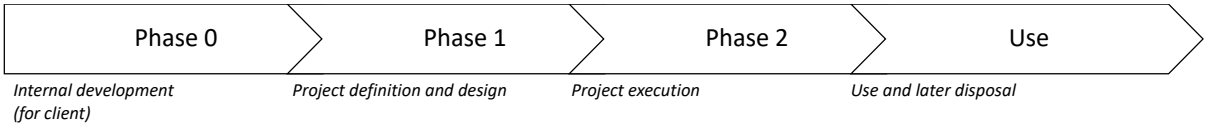

***Figure 4**: The project life cycle of a project employing a CPDM (adapted from Walker and Lloyd-Walker, 2012)*

4.1.1. CPDM life cycle

Pre-project (phase 0 in figure 4), or requirement specification and procurement, is well covered in literature (cf. Chen et al., 2018; Eriksson, Lingegård, Borg, & Nyström, 2017; Eriksson et al., 2019; Jefferies, Brewer, Rowlinson, Cheung, & Satchell, 2006; Volker et al., 2018). During this phase, the client formulates their requirements so as to be able to decide on a governance model for the project and procures the necessary services as determined by the governance model chosen. The contractor and design engineer will often be involved with a smaller planning team in the end of this phase, when the project organisation and process is designed.

Phase 1 includes concept development and pre-engineering (Hietajärvi, 2017; Walker & Lloyd-walker, 2012). This is also the main adjustment from traditional infrastructure projects, as most CPDMs include expertise and input from both the client and the contractor in this phase (Chen et al., 2018; Lahdenperä, 2012) while traditional project models either keep each separate project phase in the client's control, as in design-bid-build where each step is decided upon separately, or design-build, where the client outsources the whole process (Antoine, Alleman, & Molenaar, 2019). The inclusion of the main stakeholders is due to the expectation that a collaborative approach can include client specifications in the design better as well as counteract a potential need for rework due to the contractor's expertise. As rework can cost over 10 % of the original contract value and is due mainly to design errors and quality defects (Lee, Park, & Won, 2012) this can lead to great cost increases in large-scale infrastructure projects. Moreover, literature on CPDMs emphasises the need for involving all actors already during project design definition and design in order for the project to benefit from their expertise regarding construction solutions (Chen et al., 2018; Lahdenperä, 2012; Walker, Davis, & Stevenson, 2017). The phase includes partial input from the contractor, as the goal is to incorporate industry-specific knowledge, but not actual construction work. Phase 1 commonly ends with a target price for phase 2. Due to the size of infrastructure projects using CPDM, they are often divided into sub-projects for management purposes. Such sub-sites are called sub-sites, segments or blocks. In this thesis I will use the term 'block' to denote a sub-project within the larger project.

Phase 2, implementation, encompasses project production (Hietajärvi, 2017; Walker & Lloyd-walker, 2012). This phase can overlap with phase 1 to a certain extent, as it often encompasses detailed design and engineering, thus necessitating partial input from the design engineer.

Post-project, including use and end-of-life, the client has full ownership of the end result. This phase may incorporate a warranty period (Hietajärvi, 2017).

4.1.2. Actors in a CPDM

An infrastructure construction process is initiated by a public client who has a specific need they want to satisfy. The need is therefore tied to the client's overall purpose and goal and the construction project is "an instrument or a technology for meeting a purpose" (Ryd, 2014, p. 136) – the purpose of public projects is often a goal for society. The client is a part of the whole project process.

The design engineer's role is to develop the plan to build the intended construct. Current literature focuses on the contractual relationships of designers with either client or contractor, but in a project process the contractual relation is of secondary importance to the actions the actor takes

and role they fulfil. The design engineer can be part of the pre-project phase if the client has contracted them to help develop needs and governance models as well as the detailed engineering in the implementation phase, but their main role is during phase 1.

The contractor's role is to build the project according to the specifications drawn up by the design engineer and accepted by the client. In a CPDM, the contractor's role starts in phase 1 as construction expertise is needed in order to develop the design and continues in phase 2, where the majority of their input is.

These are the three main actors in infrastructure development, as defined earlier. They are comprised of individuals with roles derived from both the project goal as well as their parent organisation role in the project (Wang et al., 2018) and can be further divided by contractual lines or their individual roles in the project, according to their expertise, but in this work, I will focus on these three main actors.

4.1.3. Ties in a CPDM

State ties in a CPDM are long-term connections between actors (Borgatti & Halgin, 2011). These include for example role-based relationships, such as between project managers from different organisations or specialists within a block; contracts between organisations; and social perceptions, such as recognising the skills of another actor. *Event ties* are transitory and can be measured in number of occurrences. In a CPDM, such ties can for example be strictly work-related, such as e-mail exchanges, conversations in the project office and meetings, or social interactions, such as taking lunch together.

Formal ties in a CPDM are often measurable, such as contracts and the project hierarchy and organisation. *Informal ties* are the interactions between actors not captured by the formal procedures, such as casual meetings in the project office and social exchanges.

Some of these ties can be *bridging ties*, connecting network clusters (Borgatti & Halgin, 2011), of special interest in the CPDM as collaboration between separate organisations and actor clusters are the foundation for the project model.

4.2. Research design

Interorganisational collaboration, as exemplified by the rise of collaboration in infrastructure development projects, is an emerging empirical phenomenon (Sydow & Braun, 2018). Qualitative research, combined with an explorative approach was deemed most useful due to the novelty of the use of CPDMs, as qualitative research is particularly suited to study social relations and attain rich data about the object of study (Flick, 2018). The research is also empirical, or "knowledge based on real world observations" (Flynn, Sakakibara, Schroeder, Bates, & Flynn, 1990, p. 251).

In this context, most value can be gained from deep and probing studies rather than a more quantitatively driven research, focused on multiple data originators, as my research questions will best be answered by the depth provided by qualitative methods. There is also the complexity of my topic to take into account, which is challenging to approach from a quantitative angle. I therefore rely heavily on the real-life insight from practitioners. To achieve this, I have based my data collection on *contrasting case studies*, where I gather detailed information from several similar project sites (Flynn et al., 1990).

4.2.1. Case research

The cases were selected based on size, contract form and availability. CPDM requires a project complex enough to warrant activities across organisational boundaries, which, coupled with my empirical setting of infrastructure development, led to an interest in large-scale projects due to the inherent scale of most infrastructure projects. As collaborative procurement forms have increased

in the infrastructure sector, the contract form was also of significance. There are few projects utilising a CPDM in Nordic countries, which led to the last selection criteria: availability. I had access to one project utilising such a contract form through the reference group created by the institution funding the research project and one project through my previous experience in the industry.

As the research was inductive in nature, theorizing about a new phenomenon from the data gathered (Fisher & Aguinis, 2017; Whetten, 1989), insight into contrasting characteristics developed alongside the data gathering process with the insights garnered from the data. Following recommendations by Flynn et al (1990), I gathered detailed information at each case site and made notes about possible differences and similarities as they emerged.

As the research design is based on multiple case studies, it is necessary to mention the main benefits and drawbacks of the case study as a basis for research. Case studies can give in-depth knowledge about the investigated phenomenon (Dubois & Gadde, 2002; Flynn et al., 1990). This methodology is especially suited to research complex organisational structures with a multitude of interrelated variables and actors in areas where little previous research has been conducted (Dubois & Gadde, 2002).

A weakness in research based on case studies, is the temporal boundary determined by the research project. As the process is continuous, special care must be taken to frame the context of the research's conclusions (Dubois & Gadde, 2002). Another concern is the risk of losing one's sense of proportion when working with rich and detailed case data (Eisenhardt, 1989).

Access to the case projects and organisations has helped me further specify my theoretical definitions and concepts. As I have close cooperation with industry partners in my project, this gives me access to cases as well as input from industry, enabling a deeper understanding of both industry realities and the academic aspects.

The case projects also enable the analysis and examination of possible other influencing variables, such as project size, time span, or size of participating organisations, to name a few. Systematic research on such variables in the field can both create insights on the current state of the field as well as create more generalisable data on longitudinal changes (Flynn et al., 1990).

4.2.2. Case studies

The study includes two case studies, as well as a pre-study, focused on projects in the Nordics where a CPDM model is used. These cases were chosen as my research focus was on the collaboration and project network rather than just the governance model. These cases were stated to work with a high level of collaboration based on their contracts and the stated wish from the Client.

The pre-study is focused on a small-scale renovation project of a bridge. The first case study is a remodelling of a railway station, which is done in relation to a major rail expansion and refurbishment project. The second case study focused on a light rail construction project. These studies were chosen for their governance models, as all chosen projects are using a CPDM model. As the utilisation of CPDM models is relatively new, there is still a lack of large-scale infrastructure projects using such a model in Nordic contexts. The cases are presented in table 1.

Table 1: *Overview of the case studies*

Project	CPDM	Budget	Construction project timeframe	Country	Client
Pre-study	Design-build	-	2005-2013	Sweden	Public organisation
Case 1	Early Contractor Involvement	4,7 bil. SEK	2018-2026	Sweden	Public organisation
Case 2	Alliance	4,6 bil. SEK	2017-2024	Finland	Several public organisations

The initial empirical basis for this study was developed from a pre-study examining a bridge renovation project. The project site is situated near Stockholm, Sweden, and was a part of the main traffic system of the region, as well as a national construction heritage site, which placed special requirements on the project execution. This study can be characterized as a retrospective study, ranging from the start of the planning and procurement through to the completion of the bridge. Data has been collected through interviews and document analysis.

The first main case is a railway project in Sweden. It is managed with an ECI model, through a design and build contract between the client and the main contractor who subcontracted all other work throughout the process. The case is currently in the production stage. Data was collected through interviews, document analysis and observation.

The second main case is a light-rail project based in Finland and is managed through an alliance model and a multi-party contract. The case is currently in phase 2, production. Data was collected through interviews, document analysis, and observation. We also received the results for the project's own questionnaire related to the actors' perception of the project.

4.3. Methods

As "qualitative research is of specific relevance to the study of social relations" (Flick, 2014, p. 11), a qualitative approach is a good base for developing a set of methods to study project management, a field based on social interaction (Flynn et al., 1990). I have used mainly qualitative methods in my research thus far. The main methods have been *interviews*, *observation*, and *document analysis*. I also included a trial of a *kinesthetic methods* during interviews, as there is a connection between working with your hands and shaping knowledge (Pallasmaa, 2009). My approach to this method was to ask all interview respondents to draw their organisational structure as part of the interview situation. This method could help in clarifying network structures, perceptions of the network, as well as the individual's understanding of their position in the project organisation. The method helped in visualising how the respondents saw the project organisation. We have thus far not used the results of this method in our publications.

Data collection in the case studies were mainly based on *semi-structured interviews* (Bell et al., 2019) with representatives from the organisations involved in the project. I conducted 44 interviews between June 2019 and February 2020, including individuals on all levels of the organisations, from project managers to collaboration coordinators, members of the steering group to experts and block chiefs. The respondents were determined through a snowball sampling method, applied to the cases separately. The interviews ranged between half an hour to three hours in length, with a mean duration of 70 minutes. I interviewed similar roles in both cases. The topics centred on the respondent's perception of both collaboration and the project, and their immediate network. I also took notes during the interview. Most interviews were conducted in person, but a few took place

over the phone. All the interviews were tape recorded and transcribed. Some of the data gathering through interviews resulted in retrospective data, as my research questions pertained to the whole project process and the interviews were done during phase two, necessitating a recall of events in the respondents. Table 2 shows an overview of the respondents.

I have also used *observation* (Bell et al., 2019). Observations focused on the way collaboration is realised in the project by observing structured moments of collaboration, such as planned collaboration meetings, as well as unstructured collaboration, such as what spontaneously arises in a shared space. I have observed a number of collaborative planning meetings in which many of the network actors are involved, as well as the daily processes at the project offices of both main cases. In case 1, observation was carried out over two separate days, totalling 18 hours. In case 2, observations were conducted during a week, totalling 40 hours. During the meetings, I focused particularly on participant's activity levels. During the project office observation, my attention was directed especially towards seating arrangements and social interaction. The data was collected by taking notes at pre-determined intervals of the observation day, noting the position of actors as well as activities taking place in the space. Pictures were taken of artifacts in the space, such as schedules and meeting places. The recent introduction of relational management models was seen in the low portion of respondents with experience in CPDM.

Furthermore, I have used *document analysis* (Bell et al., 2019). Documents analysis was carried out on materials provided by the organisations and project participants, as well as publicly available information.

Table 2: *Respondents with their respective roles*

No.	Work role	Actor affiliation
5	Block manager	contractor, client
2	Collaboration coordinator	client, design engineer
8	Design coordinator	client, contractor, design engineer
9	Manager	contractor, client
4	Project manager	contractor, client
12	Specialist	contractor, client

4.4. Analysis and coding

Using a combination of qualitative methods can improve our understanding of the gathered data, as it helps balance out the limitations of the different methods (Bell et al., 2019). Qualitative data was taped, transcribed and coded according to a thematic approach as well as saved to a secure online platform.

The collected data was saved both on- and offline. Online, the recordings, transcripts, and notes were saved in a secure cloud storage service. Offline, the recordings, transcripts, and notes were saved on my computer as well as on an external hard-drive. The interview notes were further physically saved.

Data was inductively coded in NVivo. When looking at the separate sources, aspects related to network engagement and social ties were sought, whereafter these were coded in relation to emergent themes; as such, the themes were inductively created during the analysis and coding (Bell et al., 2019).

The coding template grew organically as themes emerged from the data. The process included identifying e.g. roles, events, relationships, objects, tools, and the interviewees interpretation thereof. Discovered concepts were then classified according to the theoretical framework and overarching themes found during the coding phase.

Analysing the data through a project network lens shaped the coding process, as focus was placed on ties and actors. Thus, the identification of specific themes related to project network engagement and social ties was a result of an inductive thematic analysis.

4.4.1. Social network analysis

Social network analysis (SNA) is a useful approach to fulfilling my aim of understanding how actors utilise the project network and how social ties affect collaboration within the network, as it helps us understand "the myriad of systems, typically freestanding rather than integrated, involved in the planning, design and delivery of our increasingly complex [construction] projects" (Pryke, 2012a, p. 10). As SNA is little used in project research thus far, a short introduction is in order.

SNA offers a framework for understanding relationships between network actors and flows of resources within the network and has enjoyed a rise in popularity in the social sciences over the last decades (Borgatti & Halgin, 2011). Recent work has introduced the method to project management (Blackburn, 2002; Pryke, 2005; Steen et al., 2018) and construction research as well (Adami & Verschoore, 2018; Pauget & Wald, 2013; Pryke, 2012a; Pryke et al., 2018; Zheng et al., 2016). Although SNA has been widely used in social sciences, its use in project management and construction research has hitherto been limited. There have been recent calls for further investigation into especially the relationships connecting network actors (Adami & Verschoore, 2018) as well as aspects of collaboration (Sydow & Braun, 2018), indicating a need for research in this area.

Applying qualitative methods to network theory are in line with recent calls for more qualitative approaches within project research (Steen et al., 2018) and can give a deeper understanding of the network and its ties as it allows for a contextual understanding of the network (Hersberger, 2003). As network theory mainly focuses on quantitative aspects of networks, such as the directionality and strength of ties between network actors (cf. Borgatti & Halgin, 2011; Granovetter, 1973; Hersberger, 2003; Pryke, 2005), there is a dearth of contextualisation. A deeper understanding of how networks are structured will also allow for a deeper understanding of the nature of the network and to identify themes overlooked by quantitative methods (Hersberger, 2003).

As SNA is a traditionally quantitative approach (Pryke, 2005; Zheng et al., 2016), a possible conflict of methodologies and philosophies could arise, but following recent calls for more mixed methods and further qualitative applications of project network research (Steen et al., 2018), there is much insight to be gained from analysing the social network through qualitative lenses.

The network information was gathered by asking respondents about the colleagues they worked the most with. The SNA analysis was performed by adding the relationships as reported by the interviewees in SocNetV, a software for visualising and analysing social networks. After several iterations of the network presentation, the Fruchterman-Reingold visualisation was chosen due to the clarity of the algorithm's result (Fruchterman & Reingold, 1991).

4.5. Quality of data

Research must be both of a high standard and trustworthy to be able to contribute to the scientific discussion. To ensure the quality of research, I follow the commonly accepted five criteria of

quality, as discussed by Treharne and Riggs (2015): credibility, confirmability, authenticity, transferability and dependability.

Credibility, i.e. that the findings represent the experience of the object of study, has been ensured by engaging a reference group consisting of experts from both industry and academia. The data collected is, however, always affected by the methods employed and to a certain shaped by the researchers inherent biases and the boundaries defined by the research project. (Dubois & Gadde, 2002; Flynn et al., 1990; Gould, 1996; Van Maanen, Sørensen, & Mitchell, 2007). The reference group helped in establishing *confirmability*, i.e. the impact of my own biases and perceptions, as well as credibility. The reference group has furthermore helped with *authenticity* and to evaluate the usefulness of the findings. To maintain *transferability*, the participant's responses and my observations of the project offices have been documented by note-taking comparable to journaling. Methods to ensure transferability included keeping diligent records regarding the data gathered, having an open book policy with our respondents and ensuring anonymity for them in order to solicit honest and truthful answers. By interviewing people from different levels of the project hierarchy as well as from separate participating organisations, in addition to document analysis, the triangulation of data and thus *dependability* of the research has been fortified.

As trustworthiness is a sign of the authenticity of the findings (Lincoln & Guba, 2000), I have furthermore strived for a high level of transparency in reporting my findings (Treharne & Riggs, 2015), both in article format as well as this thesis, within the bounds of anonymity guaranteed to the respondents. As a part of the transparency of my research, I have participated in several scientific conferences within my field and presented the research conducted in accordance with established academic practices and my supervisors' commendation.

4.5.1. Ethics

I have followed Chalmers' guidelines regarding ethical conduct as well as general codes of ethics, such as the ones presented in Flick (2014). My research has been based on informed consent, I have avoided causing harm to participants during the data collection, and I have maintained confidentiality. As my study consists of a limited number of cases, this third aspect is especially important, as the context is narrowly defined, and it may thus be easier to identify respondents from the data. The anonymity of interviewees and projects is therefore paramount.

Table 3 details factors impacting research quality and how I have striven to mitigate them.

Table 3: *Factors impacting research quality*

Factor	Risk	Mitigation strategy
Trustworthiness of data	Data gathered is not authentic or trustworthy; not able to contribute to theory	• Diligent record keeping • Open book policy with respondents • Ensuring anonymity to solicit truthful answers • Prepare analysis guidelines • Identify and analyse own biases
Transparency	Research method unclear; Unable to communicate findings	• Clear descriptions of methods employed • Clear, rich descriptions of data • Engage reference group to ensure clarity • Participate in conferences and seminars to share and discuss findings
Credibility	Findings not representative of object of study	• Triangulate data • Engage reference group to ensure clarity
Confirmability	The findings are unduly influenced by the researcher's perspective	• Triangulate data • Engage reference group to ensure clarity
Authenticity	The findings do not represent the whole of the object of study	• Triangulate data • Engage reference group to ensure clarity
Transferability	Study results not applicable in other contexts	• Clear descriptions of methods employed • Clear, rich descriptions of data • Engage reference group to ensure clarity
Dependability	Study results not reproducible	• Audit process and findings with other researchers and reference group

5. Appended papers

The papers appended in this licentiate dissertation are introduced by title, methods, findings and main contributions (see figure 5). All three papers are collaborations, two of them co-authored with my main supervisor and the third co-authored with my supervising team. As the papers used differing names for the cases, we are here presenting them as case 1 and case 2, with a note about their designation in the publication for clarity.

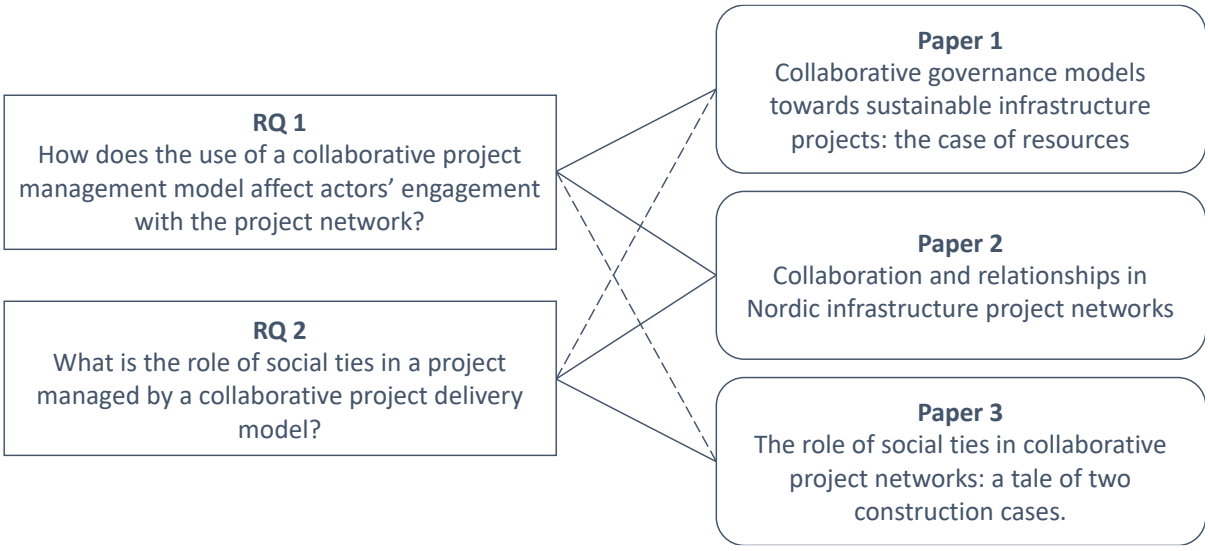

Figure 5: *The relationship between the research questions and the appended papers*

Research question one is explored mainly in paper 1, which focuses on the impact of CPDM on resource efficiency and indicates a change in actor, and especially the client, role. This is further elaborated on in paper 2, a study into the project process and the benefits of changing actor roles. Paper 2 also observes difficulties in changing roles to allow for the full advantages of using CPDM to emerge. Paper 3, furthermore, answers research question two and elaborates on the social ties in a project network, a subject touched upon in paper 1 and 2 and further investigated in paper 3.

Paper 1: Collaborative governance models towards sustainable infrastructure projects: the case of resources

The purpose of the study presented in paper 1 was to study how actors involved in CPDMs collaborate and share resources in order to understand how actors involved in such projects interact. The use of collaborative project management models has increased the last two decades, but much research has focused on the contract while leaving the social connections between project participants to the side.

Collaborative project management models (CPDMs) were studied through network theory, focusing on the actors in an infrastructure project and the ties connecting them. The empirical setting of two complex infrastructure project case studies has been investigated through interviews, document analysis and observation.

The main findings relate to the relevance and change of the client's role in the project, the unified view of the possible benefits of applying a CPDM and the importance of the contractual framework for furthering innovation.

Client's role: The client's role differed between the cases. In case 2 (presented as case two in the paper), the client was engaged and proactive in both phase 1 and 2, which was perceived as a

reason for success. In case 1 (presented as case one in the paper) the client was less active throughout the whole process and had less resources allocated to active participation in the project process. Active and engaged client participation was likewise seen as a benefit, as it could have a strong impact on scheduling and resource use. An active client was especially important in phase 1, as it was seen to enable less bureaucracy in the planning process. Actors in both projects perceived a need for the client's role to change due to the collaborative project model, but only case 2 had realised such a change.

Perceived benefits: Both cases saw clear benefits of a CPDM and in the early inclusion of the contractor in the project process, mainly related to time savings, an expediated decision-making and resource savings through a more iterative design process. The design planning phase was furthermore integrated in the project process, especially in case 2, enabling resource savings as the schedule was shortened. Moreover, collaboration between all actors was seen as beneficial for the decision-making process and keeping the schedule in both cases, indicating the importance of social ties enabling collaboration.

Contractual framework: The biggest difference between the cases could be found in the contract and how it shaped the project. In case 1, the client had a bilateral contract with the contractor subcontracting the design planning, while a multi-party contract was used in case 2, involving all main organisations and focusing on the sharing of resources, risk and responsibilities. In case 1, the two parties had different expectations on how the contract should be perceived and executed/implemented. The difference in expectations had negative implications for how the two actors collaborated. Furthermore, the contract was seen as a driver for innovation, especially in relation to environmental and sustainability issues in case 1. In case 2, the multi-party contract was seen as a driver for successful collaboration and it enabled the actors to focus on technical solutions rather than conflicts. In case 2, the contract was seen as freeing the actors to focus on the project and not being caught in interorganisational conflicts.

The paper offers insight into the significance of and changes in the role of the client, how actors engage in the project network (or not) and how they engage in activities. The paper furthermore provides further clarity on the importance of social relationships between the network actors in contrast to the focus on contracts/procurement.

Paper 2: Collaboration and relationships in Nordic infrastructure project networks

Paper 2 studies the changing actor roles in complex, large-scale, collaborative infrastructure construction projects in order to describe how the roles of the actors in a project network change and how this role change impacts the network. The paper builds on the theory of project networks, the concept of collaborative project management models and two case studies, investigated through interviews, document analysis and observation.

Client role change: In traditional infrastructure projects, the client's role encompasses defining requirements, supervising the project, and checking that the requirements are met. The findings show the necessity of a change in this role in projects applying a CPDM, as identified by respondents. The need was identified in both cases. In case 1 (presented as case A in the paper), the client maintained their traditional role, although respondents mentioned the necessity of a role change. The client also discussed the difficulty in the project and respondents mentioned the lack of expected collaboration and how especially the client and contractor had diverse expectations on each other's role and had different interpretations of the governing contract. Respondents in case 2 (presented as case B in the paper) identified that the model affects especially the client's role and a transition in the role of the client was perceived as a success factor.

Design engineer role change: In traditional infrastructure projects, the design engineer is engaged only part-time in the project, as their traditional way of working splits their time between different

projects. As a CPDM requires close collaboration, a need for change was perceived in the role of the design engineer, especially in case 2. The design engineer moreover needs to develop their relationship, especially with the contractor as the design engineers are used to working with the client in iterative, early project phases, while lacking the single project focus the contractor has. In case 2, the change from working on multiple projects to focusing on the CPDM had been made to an extent. In case 1, the design engineer saw their role as a traditional design role as they were subcontracted by the main contractor and did not see any changes due to the collaborative model of the project.

Contractor role change: In a traditional project, the contractor starts working in phase 2, often encountering planning problems revealed only when the construction process starts. In a CPDM, the contractor's role was perceived as somewhat changed. The depth of the change depended on the respondent, although clear differences could be seen between the cases. In case 1, the contractor saw themselves as engaged in a more collaborative way of working than they traditionally did and they noticed clear benefits with their early inclusion in the project, while the client perceived the contractor's behaviour as traditional and adversarial. In case 2, the contractor was frustrated with the iterative nature of phase 1, as planning as a process is less defined than construction and can go through several iterations before a final solution is decided upon but recognised a need for changed roles and behaviour patterns and mentioned these as aspects of their role and participation to develop in future CPDM-projects.

The paper gives insight into the relevance of social relations, the interaction between network actors and the development thereof, as well as the need for a change in actor roles and relationships if a CPDM is to be successful. This transition is not always easy in a rather institutionalized industry as the architecture, engineering and construction industry. Our findings show that a lack of client involvement, especially at an early stage, can have far-reaching consequences for the project organisation and process.

Paper 3: The role of social ties in collaborative project networks: a tale of two construction cases

The purpose of the study presented in the paper is to explore the role of social ties in project networks, where social ties —as opposed to institutional and contractual relationships— at the interorganisational level have not yet been examined systematically in the construction literature on project networks. This paper applies a social network approach, viewed through a qualitative lens, on two case studies through interviews, document analysis and observation.

The findings show how the level of social ties, both formal and informal, affect the project network and therefore project delivery, when the project is viewed through a network lens. The findings discuss the following aspects that affect the creation and development of social ties.

Initial set-up and project identification: The initial project set-up on the social network created in the project was found to have an impact in both cases. Both cases showcased how early exclusion of one actor led to weak social ties later on within the network. The project organisation followed the contractual stipulations in case 1 (presented as case Bilateral in the paper), but the contractor and subcontractor had formed a strong initial network and ties to the client, who came in later, were lacking. In case 2 (presented as case Multiparty in the paper) the contractor came onboard later and weaker ties were also perceived, even though the project managed to create a denser network over time. The initial set up and implications for the social network created was also found in how members identified with the project, with a lower project identification in case 1 and a higher identification with the project for case 2.

Perception of actors: The importance of the actor's perception of other actors' roles, responsibilities and behaviour was seen as relevant in both cases. In order for collaboration to work, the parties

should have a shared understanding of the roles and responsibilities of other actors within the network, as well as the project goals, as this enables a shared perception about the whole project. In case 1, the actors had ambiguous perceptions about roles and responsibilities and lacked a shared perception of the project, which led to distrust and conflicts and actors falling back to more traditional roles, while case 2 managed to create a shared understanding and over time developed a transformed interpretation of the different actor roles, enabling collaboration.

Resource sharing: The sharing of resources is one of the cornerstones for collaboration and benefits of CPDM, founded on mutual trust and social ties. The findings in case 2 highlight the need for aligned tools and standards to enable sharing within the project, which they managed to an extent. While there was an absence of resource sharing in case 1 due to several reasons, such as parent organisation policy, and the presence of weak social ties.

Shared space: CPDM literature often mentions the shared office space as a prerequisite for collaboration, but our findings show that the mere presence thereof is insufficient for social ties to form. In case 1, the space was divided by organisation, with people from the same organisation sitting together, the space was further used mainly by the client and the contractor, as the design engineers were seated primarily at their home office. The shared space in case 2 was divided by geographical planning division, seating representatives from separate organisations together. A similar seating arrangement as seen in case 1 was mentioned as a challenge in case 2 when phase 2 began and the resource infrastructure at the block did not allow the design engineers to work from the block offices.

The paper provides a deeper understanding of the interplay of formal and informal ties in a project network, exploring how a formal tie in the shape of a project contract, especially one supporting collaborative project practices, can enable the creation of informal social ties within the project network. Formal ties are especially important in shaping the network in initial phases of the project, while informal ties gain in importance as the project progresses and social ties have had time to develop.

This paper expands on findings in paper 2, focusing on the role of social ties between actors in a project network utilising a CPDM. Results indicate the importance of the project initiation phase to build strong social ties within the project network, enabling collaboration and the expected benefits of CPDMs.

6. Discussion

6.1. How the use of collaborative project management models affects actors' engagement with the project network: CPDM-caused changes

When the project model changes, so does the project network, routines, responsibilities and behaviour within the project organisation (paper 2). This change is especially visible in the construction industry and recent efforts to introduce collaborative project management are visible in an increased literature related to the procurement of such projects: less is known about the project process and delivery phases, partly due to the novelty of the field.

CPDM emphasises the importance of including all main actors in an early stage of the project as well as communication and sharing of resources (Lahdenperä, 2012). The rising use of CPDMs as a way to manage major infrastructure projects has introduced several changes in the project process compared to traditional models of managing projects. In a traditional model, the project process is divided into clearly separate phases, governed with unconnected contracts (figure 1). The roles and responsibilities of actors are also clearly defined with the client supervising the work, the design engineer procuring plans and designs, and the contractor building in accordance with predetermined designs. In a CPDM, there are three main changes to take into account: first, the early inclusion of actors; second, the changing roles and perception arising from the changes; and third, sharing within the project organisation (figure 2).

First, the central change in a CPDM is the inclusion of all actors early in the process (see figure 2). The main benefit thereof is based on the introduction of contractor knowledge in the planning stage as well as a clearer picture of client needs, which is thought to improve planning outcomes and design implementation (Lahdenperä 2012, paper 1, paper 2). This proved to be a challenge in the observed cases, however, as the actors are unaccustomed to working in close contact with each other (paper 2).

Second, as actors are involved earlier and are expected to change their familiar processes, their own roles change, but also the perception of other actors (paper 3). Using a CPDM enables role changes necessary for a high level of collaboration to emerge (paper 2), facilitating resource sharing (paper 3), aligning actor and project goals (paper 3) and minimising the need for interorganisational conflict resolution (paper 1). From an organisational perspective, the use of a CPDM shapes their tie to the project through the chosen contract form (paper 1). A CPDM also appears to enable project identification (paper 3), contributing to a shared identity and alignment with project goals.

The client's role changes from the role of an overseer to an active participant (paper 2). As clients are normally unaccustomed to working in projects, the project being a unique one-off endeavour for them (Hughes & Murdoch, 2003), there was also a need to assure enough resources for the client to engage in the process (paper 1). This was especially important early in the project process, since the client's involvement in early stages of the process was seen as necessary by the respondents as noted in paper 3. This role change helps client's access the knowledge base of both design engineer and contractor early in the process, if they are engaged in the planning phase of the project, as discussed in paper 2. It also impacts the activities they engage in during the process, as the traditional model of overseeing the project life cycle gives way to a more involved role, especially in phase 1.

In the design engineer's role, the changes were focused mainly on the individual designer's work balance (paper 2). The design engineers were accustomed to work both iteratively and collaboratively, as prescribed by CPDM, as well as within project networks, but their usual work process included working on multiple projects at once (paper 2). This became a problem in a CPDM where frequent and instant iteration was assumed and a prerequisite for a successful application of the model; the design engineer's resource use and activity engagement thus changed

mainly due to the external demands regarding their internal resource management and work allocation.

The contractor's role changes related to their involvement in the early planning process and iterative design processes (paper 2). Several contractor representatives mentioned how they "just wanted to get to the real work" (paper 2, p.8) in the early, iterative planning stages, indicating a difficulty in adapting to the role change related to deeper involvement in the planning as required in phase 1. As the inclusion of contractor expertise in the planning stage is one of the key aspects of CPDM, there is therefore a need to redefine their role in the early phases of construction projects and how they see as "real" work. The contractor's activity engagement was thus affected the greatest, especially in phase 1 as they had to engage in previously unfamiliar activities. These changes in the project network could, however, lead to a more efficient resource usage in phase 2, both from the contractor's but also the whole project's point of view, through expediated decision-making and an iterative design process (paper 1).

The changing roles place further demands on the social ties within the project. The perception of each other's roles and responsibilities can shape actor behaviour; a vague understanding of project roles could lead actors to fall back into traditional roles, while a shared understanding of the changed roles and responsibilities can help create and stabilise a new understanding of the project roles (paper 3). Differing expectations relating to the way project actors should communicate with the surrounding environment, for example, were not collectively agreed upon (paper 2) and such a lack of common understanding creates a risk for conflict.

Third, a successfully implemented CPDM enabled resource sharing within the project network. In case 2, respondents from all organisations spent approximately three days a week at the shared project office during phase 1, which was instituted as part of the CPDM. The office was arranged according to project blocks. During phase 2, the contractor representatives moved to block offices, which was noted to be challenging for the design engineer due to resource constraints. In case 1, the project office was used mainly by the contractor and to a lesser degree by the client during both phase 1 and 2. There was a clear division between seating arrangements. The design engineer attended the project office for meetings. During phase 2, the contractor moved to block offices, but the client mainly stayed at the project office. The design engineer visited the block offices. This difference in the application of a CPDM affected the casual meetings in the project office and thus the creation of informal social ties and the sharing of resources (paper 3). Resources were hardly shared in case 1, while a unified view of the project in case 2 enabled trust and resource sharing to occur within the limits of current technical boundaries (paper 3).

Applying a qualitative lens, we can gain deeper understanding of the properties described by network theory (Hersberger, 2003; Steen et al., 2018). The findings presented here give greater insight into how the use of a CPDM affect actors' engagement with the project network and can help project managers plan for more efficient network development.

6.2. The role of social ties in a project managed by a collaborative project management model

As the project organisation shapes the project network, the participating organisations and individuals become involved as actors in the network. Project networks do, however, rely on different governance models than traditional organisations (Steen et al., 2018; Sydow & Braun, 2018) and draw their process from the interaction of responsibilities, routines, roles and relationships (DeFillippi & Sydow, 2016). An especially important part of this is the interaction of ties and role of social ties.

The idea of collaboration in CPDMs is based on social ties in the form of non-contractual aspects of the project process, partly connected to the early inclusion of actors in the project and the creation of trust within the project (Bygballe & Swärd, 2019; Chen et al., 2018; Kadefors, 2004; Lahdenperä, 2012). When such a network is closely connected with multiple ties, there is a higher probability of a shared understanding as the actors get the same information simultaneously (Borgatti & Halgin, 2011; Pryke, 2005). The chosen CPDM affects actors' engagement with the project network, both on the organisational and individual level. These levels also interact as the project progresses. Furthermore, differing levels of social ties affect the project process (paper 2, paper 3). The engagement that is created by this interplay further shapes the social ties within the project network; either the social ties become close and collaboration is achieved, or they stay distant, keeping the actors at arm's length. This process is visualised in figure 6.

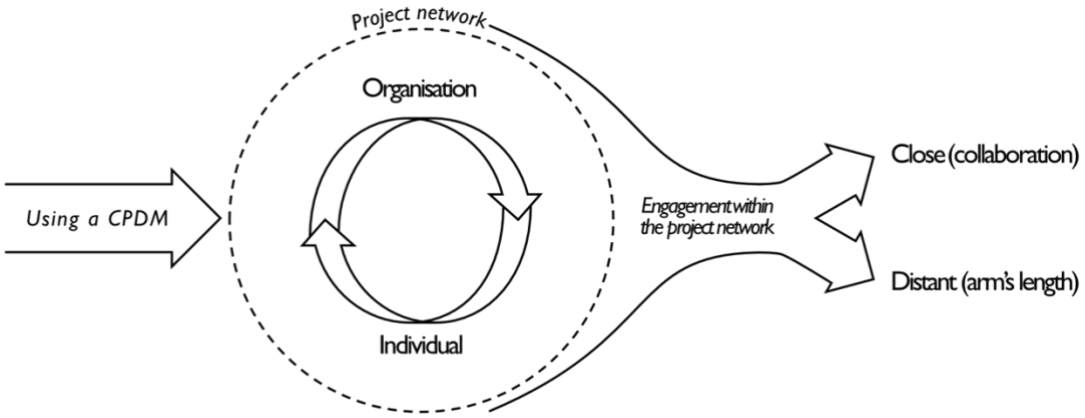

Figure 6: *The CPDM process and how it affects the project network*

In the network without close ties, there was a discrepancy between the client and the contractor as the lack of close ties led to differing understandings of the project process and a state of conflict and falling back on traditional roles and their parent organisations, heightening the importance of the formal ties, such as contracts and meetings, and reducing the level of social ties, decreasing trust. This project structure is depicted in figure 7. In the network with close social ties, the project network shared an understanding of the project process (paper 2, paper 3). The actors also identified more with the project network and created a tighter social network (paper 3), thus enabling a deeper level of collaboration. This project structure is depicted in figure 8.

The importance of the initial project set-up and initiation in the enabling of social ties to form later on in the project process as evidenced by the problems faced by both cases further highlight the role of social ties (paper 3) and the lack of or presence of trust, a key component of collaboration (paper 2). The focus on the initial set-up and project identification, perception of other actors, as well as the prescribed sharing of resources such as office space (paper 3) all contribute to trust and a unified view of the project's goal: key prerequisites for a successful CPDM according to literature (Chen et al., 2018; Lahdenperä, 2012). These factors are also key contributors to the formation of social cohesion and ties within the project network.

Moreover, the sharing of resources is emphasised as an essential tenet of CPDM (Chen et al., 2018; Lahdenperä, 2012) and a signal of the success of social cohesion and tie formation within the project (paper 1, paper 3). This includes, depending on the CPDM in use, sharing knowledge, risk, time and ideas. Close social ties in a CPDM thus enable resource sharing within the project network.

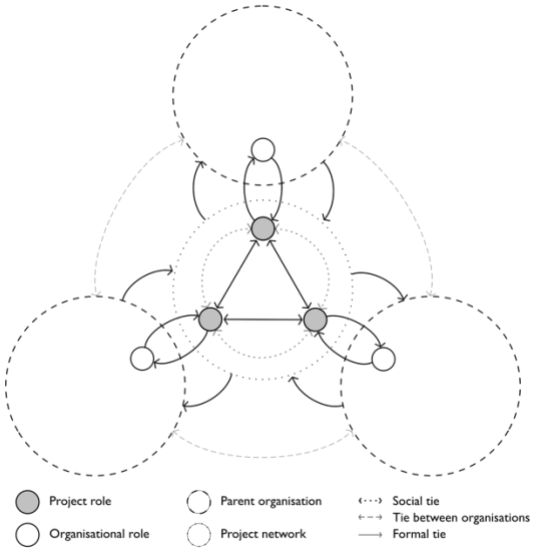

Figure 7: *The interconnectedness of case 1*

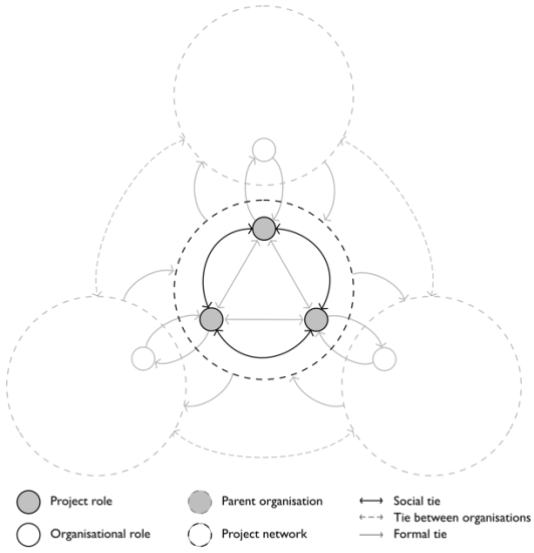

Figure 8: *The interconnectedness of case 2*

Social ties would therefore seem to impact the levels of collaboration within a project network as their presence enable the flow of resources and the building of trust between actors, or alternatively, a lack of social ties hinders the formation of trust and therefore prevents collaboration in the project network.

6.3. Interorganisational collaboration in a CPDM

Factors impacting actor collaboration in interorganisational settings can be understood through insight in three areas: (1) the nature of relationships withing the project network; (2) the issue of coordinating decision-making and governance; and (3) the ambiguous nature and demarcation of projects (Hellgren & Stjernberg, 1995; Sydow & Braun, 2018). These dimensions are all highlighted by the use of CPDMs due to the importance of interpersonal relationships in the project model and early inclusion of key actors, the challenges posed by coordinating several participating organisations with their own goals and objectives and the shifting nature and long life-spans of major projects. These three areas are therefore in a key position to facilitate the examination of interorganisational collaboration and help us gain a deeper understanding thereof.

The nature of relationships withing the project network: A project network is only as strong as the ties between the actors of the network and as large-scale projects often involve multiple organisations, the strength and nature of the ties between them become important for successful project delivery. Interorganisational relations are often different from structures found in permanent organisations due to their bridging nature, connecting organisations across project boundaries (Hellgren & Stjernberg, 1995; Sydow & Braun, 2018), but also requiring new management forms in the single project. The management model introduced by CPDM emphasises this aspect due to the increased collaboration required during all project phases (paper 3). Formal ties in an early stage of the project can help support the creation of informal ties (paper 3), enabling the tight connections and collaboration as described by Jones and Lichtenstein (2009) which are linked to the bridging ties discussed by both Hellgren and Stjernberg (1995) and Sydow and Braun (2018). The differences between network structure between case 1 and 2 explain the difference in levels of social ties within the project networks (paper 3). In case 2, the respondents reported being more focused on the project rather than the contract, while respondents in case 1 emphasised the role of the contract

(paper 1, paper 3). Close social ties can therefore contribute to interorganisational collaboration and a greater alignment with the project.

The issue of coordinating decision-making and governance: Project participants belong to multiple organisational settings (Hughes & Murdoch, 2003; Lundin et al., 2015; Sydow & Braun, 2018), which indicates that the management of project networks is divided between the responsibilities actors have towards their parent organisation and the project organisation (Lundin et al., 2015). This results in decision-making based on politics (Hellgren & Stjernberg, 1995) and non-hierarchically linked actors (Sydow & Braun, 2018), which in turn influences the perception of the roles and responsibilities of other actors (paper 3), affecting the shared understanding of the project network. CPDMs are based on sharing resources, responsibilities and decision-making, among others (Lahdenperä, 2012), but as no organisation can make decisions on behalf of other organisations partaking in the project (Hellgren & Stjernberg, 1995), informal ties become important to enable collaboration and coordinate decision-making (Jones & Lichtenstein, 2009, paper 3). The high level of connections and informal ties in case 2 enabled changes in roles and responsibilities as well as a common understanding of the project model and goals (paper 2, paper 3).

The ambiguous nature and demarcation of projects: Major projects involve multiple stakeholders (cf. Gann & Salter, 2000; Hellgren & Stjernberg, 1995; Jones & Lichtenstein, 2009; Sydow & Braun, 2018) and the life cycle of an infrastructure project can span decades (Eriksson, 2015; Flyvbjerg, 2014), leading to a high probability of actors participating in the project network to change during the process. Organisations may also change personnel in the project depending on their goals, compounding the issue of determining project boundaries. This was highlighted by the changing roles brought by the CPDM; as the actors are required to participate in the project process in new ways, the nature of the project was also changing (paper 2). However, the contract was also identified as a driver for collaboration and the implementation of a successful CPDM, helping ease the ambiguities inherent in the project and enabling the actors to focus on project delivery (paper 1). Furthermore, as the researcher defines the network (Borgatti & Halgin, 2011), the issues discussed previously concerning the nature of relationships and coordinating the project network become dependent on the definition thereof. The management of major infrastructure projects is complex, involving several separate disciplines, making the demarcation of projects and the project network difficult in a CPDM, as seen in case 1 where the understanding of the project differed between the client and contractor and resulted in interorganisational conflicts (paper 1).

7. Conclusion and future research possibilities

Along with the recent growth of projects, in both size and scope, interorganisational collaboration within projects has risen as a topic of interest within the project community, as has a call for research into network properties of projects. By using a qualitative approach to network theory in an empirical setting of infrastructure projects, the development of a project network structure becomes clearer and a deeper understanding is gained of the role of ties. With the papers presented in this thesis, I show that project network roles change due to a more collaborative project management model affecting actors' network utilisation, resource management and activity engagement, and that the success of this change depends on the social ties as the level of social ties affect collaboration between actors in the network.

A project network approach enables a broad view of interorganisational collaboration, since it takes into account the ties between both participating organisations as well as individuals. The appended papers explore how CPDM affect actors' engagement within the project network, as well as the changes in project process that arises from the application of new management models.

The three factors impacting collaboration in an interorganisational project network are the relationships withing the project network, coordinating decision-making and governance and creating a shared perception of the ambiguous nature and demarcation of the project. CPDMs furthermore modify the traditional construction approach to projects by including all key actors in the early stages of the project, thus changing both the project process and actor roles. The client's role changes from the role of an overseer to an active participant (paper 2), as the collaborative model requires constant input and interaction with the client. The design engineer's role changes were focused mainly on the individual designer's work balance (paper 2), changing from a fractured multi-project approach to focusing on one project at a time. The contractor's role changes from purely executive to include more multi-faceted tasks and responsibilities related to planning and knowledge sharing, necessitating an adjustment in their role and how they see "real" work.

These role changes can enable a high level of collaboration to emerge (paper 2), facilitating resource sharing and minimising the need for interorganisational conflict resolution (paper 1). From an organisational perspective, the use of a CPDM shapes the organisational tie to the project through the chosen contract form (paper 1). A successful CPDM furthermore helps align actor and project goals (paper 1), decreasing the risk of interorganisational disputes. A successfully implemented CPDM also appears to enable project identification (paper 3), contributing to a shared identity and alignment with project goals. The use of a CPDM can further facilitate resource sharing and align actor and project goals, decreasing the risk of interorganisational conflicts and enabling social ties to emerge. If you want to go far, go with others.

7.1. Future research

Possible future venues include, but are not limited to: the importance of the initiation phase in shaping the network; the impact of social ties in project networks as CPDMs becomes more prevalent and actors move from one CPDM to another; an understanding of collaboration an cooperation as CPDMs become more common; and the interplay between the state tie that is the contract and the rest of the ties in the network.

Especially the difference between collaboration and cooperation is an interesting topic and deserving of future research as there seems to be little definition of the two terms in current literature on collaborative project management models. There are also some signs of a so-called "dark side" of collaboration: although collaborative practices improve information flow and resource utilisation, they also constrict the network and actors. As most of current literature portrays a very positive view of collaboration and focus on benefits to collaborative practices

rather than possible negative outcomes of such practices, the question about this "dark side" arises. Are there downsides to increasing collaboration, and if so, what are they?

When considering project networks and how ties shape collaboration in interorganisational project networks, an especially interesting topic to investigate is the influence of the parent organisation on the project network. Projects, especially large-scale and complex ones, often bridge decades and the project organisation has to be designed in order to allow for the exchange of participating people. The influence of the parent organisation and its culture on the project organisation and, in extension, the project network is an unexplored field which could help us understand tie dynamics of project networks.

In order to gain further insight in these project network aspects, I will adopt on mixed methods in the next phase of my PhD. This will enable me to validate some of my initial findings, especially related to the view and definition of collaboration as well as the importance of the initial phase through quantitative triangulation.

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