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**Improving Suppliers' Position in Construction
Project Networks**



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Improving Suppliers' Position in Construction Project Networks

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Abstract

Construction projects are typically delivered by networks consisting of multiple organizations. Attention to such project networks, in terms of their structures, activities, and more specific inter-organizational relationships, is increasing. Often, research in the construction sector places clients and contractors at the center of the project network and focuses on their strong dyadic relationships. These are highly relevant actors and relationships, but it is argued that inter-organizational relationship research should also consider the other parties, such as suppliers and designers, that are involved in construction project networks. Little empirical research focuses on non-central actors whose interests might be to improve their positions in project networks.

The objective of this thesis is to increase our understanding of improving the position of non-central actors in project networks. This thesis focuses on suppliers of materials and components (as non-central project actors in construction project networks) and their relationships with contractors and designers. Suppliers are one of the most neglected research categories in the construction industry, although materials and components account for 50–60% of construction project costs and suppliers are regarded as key sources of construction innovations.

This thesis employs a mixed method research strategy in which both qualitative and quantitative research approaches are used as a complementary complication. It includes a summary and four publications (Articles I–IV). Articles I–III explore the improvement of the position of suppliers from the perspective of designers, and Article IV explores the issue from the perspective of contractors. Articles I and IV employ a qualitative research approach and the data is collected through interviews. Article II employs a conceptual research approach and the data is collected through a literature review. Article III employs a quantitative research approach and data is collected through a questionnaire.

This thesis argues that suppliers can improve their position in construction project networks by influencing purchasing decisions and enhancing their relationships with contractors and designers. To influence purchasing decisions, suppliers need to market their potential to both contractors and designers at the business level. At the project level, they should identify the actor with the most influential role in making purchasing decisions and focus their marketing activities on that actor. This thesis reveals that contractors and designers expect activeness, technical capability, and cooperation from suppliers. Based on these expectations, this thesis suggests project- and business-level practices to enhance suppliers' relationships with contractors and designers. This research contributes to project network research by differentiating between business-level practices that are implemented outside a single project context and project-level practices that are implemented within a single project context. The thesis argues that suppliers can improve their position in a single project network by implementing project-level practices, but they need to develop business-level practices to improve their position in the underlying project business network. This thesis also contributes to construction innovation research by indicating that suppliers need to actively seek out development ideas from contractors and designers and develop their marketing capabilities to overcome barriers that hinder the innovation potential of suppliers.

Tiivistelmä

Rakennusprojektit toimitetaan normaalisti useiden osapuolten muodostamissa verkostoissa. Tutkimus kiinnittää lisääntyvässä määrin huomiota projektiverkostojen rakenteisiin, toimintoihin ja yritysten välisiin suhteisiin. Rakennusalan tutkimus on keskittynyt pääosin tilaajiin ja pääurakoitsijoihin projektiverkostojen keskeisinä toimijoina sekä niiden välisiin vahvoihin suhteisiin. Nämä ovatkin erittäin oleellisia toimijoita ja suhteita, mutta rakennusalan tutkimuksen tulisi ottaa huomioon myös muut projektiverkoston osapuolet kuten toimittajat ja suunnittelijat. Vain eräät empiiriset tutkimukset keskittyvät ei-keskeisiin toimijoihin, joilla voi olla kiinnostusta parantaa asemaansa projektiverkostoissa.

Tämän tutkimuksen tavoitteena on lisätä ymmärrystä ei-keskeisten toimijoiden aseman parantamisesta rakennusalan projektiverkostoissa. Tutkimus keskittyy rakennusalan projektiverkostojen ei-keskeisistä toimijoista materiaalien ja komponenttien valmistajiin sekä niiden urakoitsija- ja suunnittelijasuhteisiin. Tällaiset toimittajat ovat jääneet hyvin vähäiselle huomiolle rakennusalan tutkimuksessa, vaikka niiden toimittamat materiaalit ja komponentit muodostavat jopa 50–60% rakennusprojektien kustannuksista. Lisäksi toimittajia pidetään yhtenä merkittävimmistä rakennusalan innovaatioiden kehittäjistä.

Tässä väitöskirjassa käytetään mixed method -tutkimusstrategiaa, jossa hyödynnetään sekä laadullisia että kvantitatiivisia tutkimusmenetelmiä. Väitöskirja kostuu yhteenveto-osuudesta ja neljästä julkaisusta (Julkaisut I-IV). Julkaisu I-III tutkivat toimittajan aseman parantamista suunnittelijoiden näkökulmasta, ja julkaisu IV tutkii aihetta pääurakoitsijan näkökulmasta. Julkaisuissa I ja IV käytetään laadullista tutkimusmenetelmää ja data on kerätty haastatteluiden avulla. Julkaisu II on konseptuaalinen tutkimus, jossa data on kerätty kirjallisuuskatsauksen avulla. Julkaisu III hyödyntää kvantitatiivista tutkimusmenetelmää, jossa data on kerätty kyselyn avulla.

Tutkimus väittää, että toimittajat voivat parantaa asemaansa rakennusalan projektiverkostoissa vaikuttamalla hankintapäätöksiin sekä kehittämällä suhteita pääurakoitsijoiden ja suunnittelijoiden kanssa. Vaikuttaakseen hankintapäätöksiin toimittajien täytyy markkinoida osaamistaan pääurakoitsijoille ja suunnittelijoille liiketoimintatasolla. Projektitasolla toimittajien tulee tunnistaa se verkoston toimija, joka pystyy vaikuttamaan voimakkaimmin hankintapäätöksiin, ja keskittää markkinointitoimenpiteet kyseiseen toimijaan. Tutkimus paljastaa, että pääurakoitsijat ja suunnittelijat odottavat toimittajilta aktiivisuutta, teknistä tietämystä ja yhteistyötä. Näiden odotusten perusteella tämä tutkimus suosittelee projekti- ja liiketoimintatason käytäntöjä, joilla toimittajat voivat kehittää suhteitaan pääurakoitsijoiden ja suunnittelijoiden kanssa. Tutkimus kontribuoi projektiverkostojen tutkimukseen erottelemalla liiketoimintatason käytännöt, joita käytetään yksittäisen projektikontekstin ulkopuolella, ja projektitason käytännöt, joita käytetään yksittäisessä projektikontekstissa. Tutkimus väittää, että toimittajat voivat parantaa asemaansa yksittäisessä projektiverkostossa projektitason käytäntöjen avulla, mutta parantaakseen asemaansa taustalla vaikuttavassa liiketoimintaverkostossa toimittajien täytyy kehittää liiketoimintatason käytäntöjään. Tutkimus kontribuoi myös rakennusalan innovaatiotutkimukseen osoittamalla, että toimittajien täytyy aktiivisesti kysyä kehitysideoja pääurakoitsijoilta ja suunnittelijoilta sekä kehittää markkinointitaitojaan ylittääkseen esteet, jotka heikentävät toimittajien innovaatiopotentiaalia.

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This dissertation has been an amazing journey. The journey began about five years ago when I started my master's thesis in the Future Industrial Services (FutIS) research program. At that time, I was interested in academia but I did not plan to write a dissertation. I planned to finish my master's thesis and take part in a student exchange program before graduation. This plan changed during the writing of my master's thesis, as my supervisor Professor Miia Martinsuo suggested that we should write a conference paper together. She later offered me an opportunity to take part in a research exchange instead of a student exchange. I am very grateful to Professor Martinsuo because our first conference paper and the research exchange at Esade Business School in Barcelona inspired me to write this dissertation. I am also grateful to Assistant Professor Ivanka Visnjic who invited me to Esade Business School and guided me as I began writing the dissertation.

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Helsinki, March 10th, 2018.

Rami Sakari Sariola

List of publications

This thesis is based on the following original publications which are referred to in the text as Articles I–IV. The original articles have been reproduced with the kind permission of the publishers.

- Article I: Martinsuo, M. and Sariola, R. (2015). “Developing a supplier’s third-party relationships and cooperation in project networks”. *International Journal of Managing Projects in Business*, Vol. 8, No. 1, pp. 74-91.
- Article II: Sariola, R. and Martinsuo, M. (2015). “Framework for enhanced third-party relationships in project networks”. *International Journal of Managing Projects in Business*, Vol. 8, No. 3, pp. 457-477.
- Article III: Sariola, R. and Martinsuo, M. (2016). “Enhancing the supplier’s non-contractual project relationships with designers”. *International Journal of Project Management*, Vol. 34, No. 6, pp. 923-936.
- Article IV: Sariola, R. (2018). “Utilizing the innovation potential of suppliers in construction projects”. *Construction Innovation*, Vol. 18, No. 2, pp. 167-182.

Author’s contributions to the co-authored publications

In the following, the researcher’s personal contributions to the research processes underpinning those publications that involved multiple authors are explicated.

As the second author of Article I, I researched the literature, collected the data, conducted the data analysis, and participated in the writing of the article. Miia Martinsuo was the first author. She guided me in the research process and led the writing of the article. Together we discussed the key findings and contributions. Feedback from the anonymous reviewers and guest editors of *International Journal of Managing Projects in Business* influenced the final version of the article. My approximate contribution to the article was 50%.

As the first author of Article II, I was responsible for the research design. I did the systematic literature review and led the writing process of the article. Miia Martinsuo commented on the research design and participated in the writing of the article. Together we developed the conceptual framework and propositions. Comments from the anonymous reviewers and the editor of *International Journal of Managing Projects in Business* influenced the final version of the article. My approximate contribution to the article was 80%.

As the first author of Article III, I was responsible for the research design, data collection, data analysis, and writing process. Miia Martinsuo guided me in implementing the quantitative research methodology and she participated in the writing of the article. She was especially involved in developing the questionnaire and the hypotheses. Together we discussed the key findings and contributions of the article. Comments from the anonymous reviewers and the editor of *International Journal of Project Management* influenced the final version of the article. My approximate contribution to the article was 80%.

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Tiivistelmä

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1. Introduction

1.1. Background and motivation

The construction industry is a typical example of project-based organizing, where projects are delivered in networks that contain multiple actors. Project networks are sets of intra- and inter-organizational relationships between individuals and organizations that interact within the scope of one or several projects (Manning, 2005; Pauget and Wald, 2013). Construction projects are delivered to clients through networks of contractors, their suppliers and subcontractors, and various other supportive stakeholders. Examples of these supportive stakeholders are designers, consultants, and advisors, who are widely used in construction projects (Bresnen and Marshall, 2000; Cova and Hoskins, 1997). Such project networks are attracting increasing attention from researchers in terms of their structures, activities, and, more specifically, their inter-organizational relationships. Frequently, attention is directed at the value-adding function of dyadic supply chain relationships, namely the cooperation between the contractor and the client (Crespin-Mazet and Portier, 2010; Gustafsson et al., 2010), or the contractor and subcontractors (Bemelmans, 2012; Eriksson et al., 2007; Frödell, 2011). Such dyadic relationships are highly important as they can be considered to represent the contractual core of a project. Still, it is argued that research on inter-organizational relationships should consider all the parties involved in the construction project networks (Akintoye and Main, 2007; Eriksson and Szentes, 2017). Few empirical studies focus on other relationship types adopted by less central actors in project networks.

Centrality refers to an actor's position in the project network relative to others. An actor's centrality in a network is measured by the number of direct ties they have with other actors, independent access to others, and control over other actors (Rowley, 1997). Each actor tries to achieve their aims by improving their position in the network in relation to the positions of other actors (Håkansson and Ford, 2002). The improvement of actor's position in a project network is considered advantageous because it provides the actor with opportunity to influence other network actors and makes the actor visible (Pauget and Wald, 2013; Sedita and Apa, 2015). Previous literature has frequently focused

on firms at the center of the project network and their strong dyadic relationships, whereas less attention has been paid to the non-central firms whose interest might be to improve their position in project networks by creating new relationships or strengthening their existing relationships.

The manufacturers of construction components and products are the suppliers in construction projects. Sometimes the term supplier also refers to service suppliers. In this dissertation, service suppliers are referred as subcontractors, in accordance with practice. Suppliers are non-central actors in construction project networks because their only direct relationship in a project network is with a contractor, and they have little communication with other project actors (Rundquist et al., 2013). To improve their position in construction project networks, suppliers need to enhance their relationships with other network actors and develop practices to influence decisions made in construction projects. The suppliers are product-oriented companies that deliver products and components to contractors working on construction projects. Their product and component sales are dependent on the purchasing decisions made by the construction projects. The suppliers represent one of the most neglected research categories in the construction industry (Larsson et al., 2006). This is illogical, since components and materials account for 50–60% of project costs, and the project schedule is dependent on material and component deliveries (Ibn-Homaid, 2002). The suppliers have the best knowledge of their field, so they are capable of developing designs and suggesting alternative solutions that could yield significant cost savings. Furthermore, since the suppliers operate in more stable markets than the other project actors, they can maintain research and development (R&D) programs and develop new solutions (Blayse and Manley, 2004). Therefore, suppliers are regarded as key sources of innovation in the construction industry (Bygballe and Ingemansson, 2014; Gambatese and Hal-lowell, 2011).

The construction industry is often blamed for being conservative and lacking innovation (Bygballe and Ingemansson, 2011; Hemström et al., 2017). Earlier literature has identified several factors that hinder the innovativeness of the construction industry. The construction industry is largely project-based and fragmented, which means that innovations are developed by the project networks and project-based firms tend to invest less in R&D (Aouad et al., 2010). This short-term project-level focus is hindering long-term development in the construction industry (Eriksson and Szentes, 2017). Another hindrance to progress is the fact that inter-organizational relationships are mainly adversarial in nature and often strained by conflict and mistrust (Eriksson et al., 2007; Laan et al., 2011). Lack of trust is a major barrier in the formation of cooperative relationships and the production of construction innovation (Akintoye and Main, 2007; Manu et al., 2015). The success of the supplier's innovations is influenced by the strength of their relationships with project participants and end users (Manley, 2008). Recent research highlights the role of suppliers, designers, and contractors in construction innovation because product and process innovations often come from them and from the collaboration between them (Bygballe et al., 2010; Hemström et al., 2017). However, there is a lack of research into the relationship between the adopters of new products (e.g., designers and contractors) and the suppliers (Emmitt, 1997; Larsson et al., 2006).

This research is motivated by the fact that suppliers have huge innovation potential, but neither they nor their relationships to other project actors have attracted the research attention they deserve. It is acknowledged in previous research that the position of suppliers in project networks is not ideal for influencing purchasing decisions and diffusing their innovative ideas (Rundquist et al., 2013). Their only contractual relationship to a construction project is through a contractor. Contractors are particularly resistant to change (Hemström et al., 2017) and they tend to select suppliers and subcontractors through competitive tendering based on price (Miller et al., 2002). This is a problem for suppliers and subcontractors because they are not able to influence designs before tendering, and their innovation potential is wasted (Eriksson et al., 2007). Therefore, suppliers need to seek innovative ways to market their new products and solutions for contractors before tendering. Contractors are not solely responsible for purchasing decisions in construction projects. Clients can set requirements and supportive stakeholders can influence purchasing decisions. Designers in particular play a central role in project networks since they are involved in the project from very early on and participate all the way through the project (Hemström et al., 2017; Jalkala et al., 2010). These designers participate in the decision making in the early project phases as well (Cova and Salle, 2008; Kolltveit and Grønhaug, 2004), and they are responsible for designing the construction and specifying the materials and components used in the project (Emmitt, 2006; Hemström et al., 2017). From the suppliers' perspective, designers are third parties who can influence the contractor's and client's purchasing decisions and the supplier-contractor relationship.

The suppliers are not usually directly linked to the clients in construction project networks (Briscoe and Dainty, 2005). The intermediaries between the two are the contractors and the designers (Winch, 1998). Contractors and designers play an important role in the project network, since they possess knowledge about the needs of both the client and of the actual building process (Larsson et al., 2006). They also have a huge influence on purchasing decisions and the diffusion of construction innovations (Hemström et al., 2017), so contractors and designers are the most influential actors in construction project networks from the suppliers' perspective. It is argued that dyadic relationships do not really capture the particularities of a network, because relationships are interconnected with other relationships (Choi and Wu, 2008; Ritter, 2000; Vedel et al., 2012). Recent research suggests that a triad is the smallest unit of a network and it captures the essence of a network and allows for its behavior to be studied (Choi and Wu, 2009; Finne and Holmström, 2013; Vedel et al., 2012). The triad means a relationship between three network actors that are connected to each other. A triadic perspective allows to study companies' interaction in dyadic relationships and the interconnection between these relationships (Vedel et al., 2012). Therefore, this research considers suppliers' dyadic relationships with contractors and designers from the triadic perspective (Figure 1).

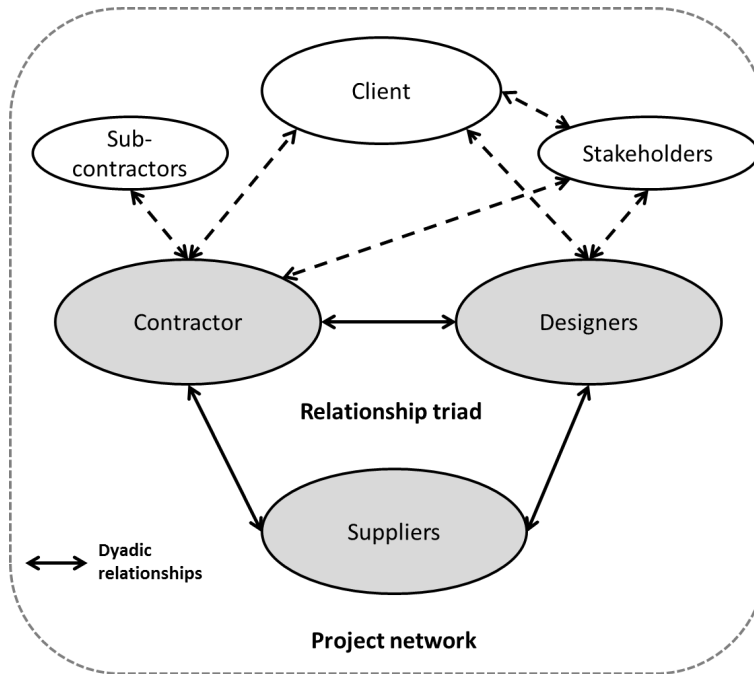


FIGURE 1. Research setting in a construction project network.

As shown in Figure 1, the research is delimited to suppliers, contractors, and designers in construction project networks. Other project network actors are not taken into account, although the clients' role in purchasing decisions and construction innovation is considered. Further research is encouraged to study suppliers' relationships to other network actors in construction project networks.

1.2. Research objectives and research questions

This research focuses on suppliers as the project network's non-central actors whose aim is to improve their network position. Suppliers are interested in improving their network position for the following reasons. First of all, they want to escape the trap of competitive bidding by influencing purchasing decisions and designs before tendering (Cova and Salle, 2007). The second reason is access to information. The suppliers are not able to utilize their innovation potential fully because they do not have sufficient knowledge of client needs, product development needs, and potential areas for innovation (Wandahl et al., 2011; Larsson et al., 2006). Improving suppliers' network position could bring benefits to other project network actors because it enables the utilization of suppliers' knowledge before tendering and means that suppliers are able to develop better products. Earlier research has concentrated on firms at the center of the project network (e.g., contractors and clients)

and their strong relationships. Less attention has been paid to non-central actors in project networks (e.g., suppliers) and their relationships. Therefore, the overall objective of this dissertation is:

To increase understanding about the improvement of non-central actors' positions in project networks.

To meet the objective of the dissertation, this research explores purchasing decisions in construction projects and suppliers' inter-organizational relationships with contractors and designers, who are considered to be the most influential network actors from the suppliers' perspective. This research topic is approached by studying contractors' and designers' behavior in the purchasing process and by identifying practices for enhancing suppliers' relationships with contractors and designers. In particular, the research concentrates on the expectations that designers and contractors have for suppliers, and the improvement of the suppliers' non-central position in construction project networks. Therefore, the following research questions were formulated:

RQ 1: How can suppliers influence purchasing decisions in construction projects through contractors and designers?

RQ1 is designed to analyze the current research and practice to increase understanding of purchasing decisions made in construction projects. This is highly important for suppliers because their involvement in a project network is dependent on the purchasing decisions made in the construction projects. Purchasing decisions have been researched in the construction literature, but knowledge of the influence of contractors and designers on supplier selection is scant (Emmitt, 2006; Frödel, 2014). Articles I and IV are designed to answer RQ 1 by investigating two perspectives: those of the designers (Article I) and of the contractors (Article IV).

RQ 2: How can suppliers enhance their relationships with designers and contractors?

RQ 2 focuses on practices for enhancing suppliers' relationships with designers and contractors. Each actor's position in a project network depends on their capability to create new relationships and to strengthen existing ones (Pauget and Wald, 2013). To improve their position in construction project networks, suppliers need to use different kinds of practices to create and enhance their relationships in construction project networks. Enhanced relationships and cooperation between project network actors are also a way to facilitate construction innovations (Hemström et al., 2017). The enhancement of relationships has been a major concern in construction projects, but suppliers' relationships have received little attention in existing research (Bemelmans et al., 2012a; Larsson et al., 2006). Article II is designed to develop a framework and propositions on enhanced relationship strength through an extensive literature review. The purpose of Article III is to develop these propositions to hypothesize and test hypotheses in a hypothetico-deductive research design with a questionnaire as the primary source of data. Whereas Articles II and III focus on practices for enhancing the relationship between suppliers and designers, Article IV focuses on identifying practices for enhancing suppliers' relationships with contractors. Article IV also consider construction innovations

and practices for utilizing the innovation potential of suppliers. Chapter 4.5 supplements Article IV and explores the potential of triadic cooperation between suppliers, contractors, and designers.

1.3. Research process and dissertation structure

This research has been conducted within the Service Business Capabilities project as part of the Future Industrial Services research program, funded by Finnish Technology and Innovation Agency Tekes, companies, and research institutes, and coordinated by the Finnish Metals and Engineering Competence Cluster (FIMECC). The Service Business Capabilities project included three case companies that produce and supply high-quality material-based intermediary components to construction projects. At the beginning of the research project (2011–2012), preliminary interviews were conducted in each component manufacturing firm. These interviews revealed the need of these three supplier firms to understand designers' role in making purchasing decisions, and to improve their position in construction project networks (Martinsuo et al., 2012). This need worked as a starting point for the dissertation.

The dissertation research was carried out in four steps. In the first step (2013), the role of designers in construction projects' purchasing decisions and their expectations towards suppliers were explored. A review of the literature on inter-organizational relationships and third parties in project networks was conducted. The data was collected through semi-structured interviews with structural engineers and architects. As a result, Article I was written and published in the *International Journal of Managing Projects in Business*.

In the second step (2014), the ideas and actions that occurred as a result of the designers' expectations were developed further through an extensive literature review. The actor's position in a project network depends on their capability to create new and to strengthen existing relationships (Pauget and Wald, 2013). Therefore, previous literature on business relationships, project networks, and relationship strength were explored to take stock of the current state of knowledge in enhanced third-party relationships. Based on the literature review, a framework and propositions on enhanced relationship strength between suppliers and designers as third parties was developed. As a result, Article II was written and published in the *International Journal of Managing Projects in Business*.

In the third step (2014–2015), Article II's propositions were developed into hypotheses and tested in a hypothetico-deductive study. Empirical data was collected through questionnaires to test the hypotheses. The questionnaire was developed based on prior literature on designers' and other third parties' experiences, as well as earlier interviews with designers. Based on the survey results about enhancing the suppliers' non-contractual project relationships with designers, Article III was written and published in the *International Journal of Project Management*.

In the fourth step (2015), the needs and expectations of contractors regarding suppliers, and the utilization of suppliers' innovation potential by contractors were studied. The need to study the contractors' perspective emerged from the designer interviews and from a review of previous literature. Designers described how contractors have a central role in construction project networks and how the interest of contractors significantly influences their purchasing decisions and supplier-designer relationships. A preliminary literature review revealed that suppliers have huge innovation potential (Bygballe and Ingemansson, 2014; Gambatese and Hallowell, 2011) and that contractors are the most influential actors in the construction project network in determining the commercialization success of construction innovations (McCoy et al., 2009). Therefore, suppliers need to understand the contractors' perspective in order to improve their position in construction project networks. To help meet this requirement, the previous literature about construction innovations and contractor-supplier relationships was studied. Empirical data was collected through semi-structured interviews with contractors. As a result, Article IV was written and published in the journal *Construction Innovation*.

It became evident during the research process that contractors, designers, and suppliers should work together more often, but currently these actors work rather independently. Therefore, the potential of triadic cooperation between suppliers, contractors, and designers in construction project networks was also explored. The triadic cooperation was studied from the contractors' perspective because contractors are regarded as drivers of new concepts in construction projects (Bygballe et al., 2010) and they are constantly interacting with suppliers and designers. This analysis used the same interview data that was used in Article IV. The exploration specifically concentrated on the motives and expectations of contractors in triadic cooperation and considered the adoption of triadic cooperation in construction projects. These results are reported separately in Chapter 4.5 (also Satriola, 2015), which is included in the thesis because it highlights the connections between the network actors, provides a new perspective for studying inter-organizational cooperation in construction project networks, and opens up relevant avenues for further research.

This summary of the dissertation is organized as follows. The first part is an introduction that presents the backgrounds, aims, research processes, and summaries of the original articles. The second part is a theoretical background that summarizes the relevant literature and theories about project networks in the construction industry, project marketing, and inter-organizational relationships in construction project networks. The third part describes the research context and presents the methodologies of each article. The fourth part summarizes the key results and contributions of the original articles. The final part presents the conclusions, including a discussion of the theoretical and managerial implications, limitations of the research, and suggestions for further research.

1.4. Outline of the original articles

The first article explores the expectations of designers as third parties for their relationships with suppliers, and the creation and management of such relationships in construction projects. Very often, research is directed at the dyadic relationship between buyers and suppliers, or the direct delivery chain between clients, contractors, and subcontractors. Few studies look into third parties that affect the purchasing decisions in projects and their relationships to suppliers in the construction projects. The goal was to gain increased understanding of the emergence of mutually beneficial relationships between suppliers and designers and their interaction practices in the project and potential new services. As key contributions, the article discusses project suppliers' third-party relationships as a potential source of bargaining power in their contractor relationships, and as key drivers for strengthening the suppliers' network position. The article offers insight into the practices that third parties use and expect when suppliers seek a more central role in the construction project.

The second article investigates third-party relationships between suppliers and designers in construction project networks and seeks increased understanding of how such relationships can be strengthened. Creating new relationships and strengthening existing ones are ways for suppliers to improve their network position (Pauget and Wald, 2013). The approach in this article was conceptual: previous empirical research about relationship strength is reviewed systematically. Prior research on practices toward strengthening the relationships in networks is somewhat scattered. This article collects cooperative practices from different research streams, namely inter-organizational relationships in project networks, supply chain management in construction, and relationship-based procurement in construction projects. The purpose of this study was to develop a framework and propositions on enhanced relationship strength between suppliers and designers as third parties. Based on the literature review, the framework for enhanced third-party relationships was developed and seven propositions concerning cooperative practices that enhance the relationship strength between suppliers and designers were stated. The developed framework contributes to the field by offering knowledge on how these less salient, non-contractual relationships in project networks can be strengthened.

The third article develops and tests a framework of relationship strength and its antecedents in the non-contractual relationship between suppliers and designers in construction projects. Previous research on relationship strength has mainly been conceptual and concentrated on contractual client-supplier relationships (Bove and Johnson, 2001). This study brings empirical evidence regarding non-contractual relationships between suppliers and designers to research regarding relationship strength. The findings revealed that the designer's experience of the supplier's activeness, the supplier's technical capability, and designer-supplier cooperation beyond the project's boundaries are positively linked to their perception of the relationship strength between the supplier and designer. Prior literature acknowledges that the relationship between suppliers and designers is essential for construction innovation, but calls for more research (Emmitt, 2001; Manley, 2008). This article answers the call and helps to explain this important link in construction project networks.

The fourth article focuses on practices for enhancing contractor-supplier relationships and practices for utilizing suppliers' innovation potential in construction projects. It is argued that suppliers can make significant contributions to innovation, but that this talent is wasted through adversarial relationships with contractors (Håkansson and Ingemansson, 2013). The enhancement of the contractor-supplier relationship has not attracted the attention it deserves, although it has been suggested that inter-organizational relationship research should consider all the parties involved in construction projects (Akintoye and Main, 2007). This article offers important information about the part that both the suppliers and the contractors play in construction innovation and its facilitation. Based on the findings, it is concluded that contractors perceive that suppliers have innovation potential, and that suppliers are often sources of construction innovation. As a key contribution, the article identifies business- and project-level practices for enhancing the contractor-supplier relationship, and for overcoming barriers that hinder the suppliers' innovation potential.

2. Theoretical background

2.1. Project networks in the construction industry

This thesis builds upon previous research on project networks (including social networks), project marketing, inter-organizational relationships, and construction innovation. These streams of research jointly reveal the need to study the positions and roles of non-central actors in construction project networks.

2.1.1. Key concepts

Complex products and systems, such as those in the construction industry, are typically delivered in networks of multiple organizations. Such project networks, in terms of both their structures and activities, are the subject of an increasing amount of research. Project networks are temporary sets of intra- and inter-organizational relationships between individuals and organizations that interact within the scope of one or several projects (Manning, 2005; Pauget and Wald, 2013). The network aspect emphasizes that no single actor has total control over the network (Powell, 1990), there are no definite boundaries for the network (DeFillippi and Sydow, 2016), and project networks are formed to achieve predefined project targets (Artto et al., 2008). Projects evolve through separate phases during their lifecycles. Generally, three main phases can be recognized in investment projects: investment preparation, project execution, and post-project operations (Aaltonen and Kujala, 2010). The composition and structure of the project network varies during the project lifecycle (Pauget and Wald, 2013).

One stream of research covering the structure of the project network concerns project stakeholder management. Project stakeholder management typically divides the project network actors into internal stakeholders and external stakeholders. Internal stakeholders are formally members of the project coalition, whereas external stakeholders are not formal members of the project coalition (Aaltonen and Kujala, 2016). The external stakeholders, such as local residents, landowners, environmentalists, regulatory agencies, and governments are trying to influence the project throughout the project lifecycle but their influence strategies vary (Aaltonen and Kujala, 2010). In the investment preparation phase focusing on the feasibility study and preliminary investment design, the number of internal stakeholders is relatively small as it is only the client, designers, consultants, and advisors who are involved in preparing the project (Kolltveit and Grønhaug, 2004). Depending on the project contracting strategy, the contractor may already be involved in this phase. In construction projects, the execution phase is usually divided into design and construction phases. In the construction phase, the number of internal stakeholders grows rapidly as the contractor, subcontractors, and suppliers get involved through procurement decisions. The project moves to the operations phase when the client accepts the project deliverables. In this post-project phase, most of the internal

stakeholders have moved on to other projects and the project network includes only actors that are responsible for the warranty period (Figure 2).

Lundin and Söderholm (1995) state that the planned isolation of the project minimizes disturbances and enables better efficiency. However, projects are always linked with history and context so that “no project is an island,” as argued by Engwall (2003). Single project networks are embedded in a more durable project business network where the stakeholders’ interests may be more oriented toward the long-term rather than toward a single project (see Figure 2).

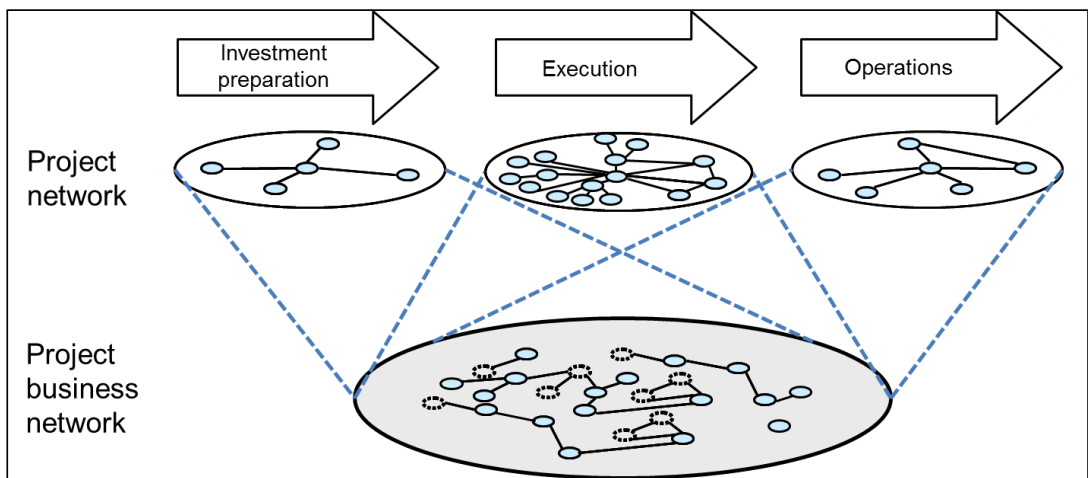


FIGURE 2. The project network and the underlying project business network (adapted from Arto et al., 2008).

Figure 2 illustrates the project network structure in different project lifecycle phases and the underlying project business network. According to Arto et al. (2008), “The project business network combines the past, present and future into a network of business actors that are, or could potentially be, involved in mutual business activities in current or future projects.” Actors are selected into a project network from the underlying project business network.

Project marketing literature (Cova and Salle, 2008; Jalkala et al., 2010; Skaates and Tikkanen, 2003) highlights the importance of identifying actors, their relationships, their roles, and their influences in the project network. They use slightly different terms to refer to the project network and the project business network. Cova et al. (1996) developed the concept of a project “milieu” to help understand and analyze the project network context. Milieu is the network of focal actors, and a distinction is often made between the project-specific milieu (cf. project network) and a more stable project milieu across different projects (cf. project business network). A project milieu consists of different companies that may create a project-specific milieu for a certain client, or discontinue and recreate the same or a new project-specific milieu for a later project (Cova et al., 1996; Dubois and Gadde, 2000).

The logic behind studying networks is the notion that firms operate in the context of interconnected relationships that form networks. The relationships in networks influence the nature and outcome of firms' actions (Gadde et al., 2003). This dissertation uses concepts from social network analysis that are transposed onto a project context, in line with Brookes et al. (2006), to analyze construction project networks.

- **An actor** is an individual firm participating in activities that enable the project to achieve its goals.
- **Ties** connect actors to one another. A tie in a project context is an **inter-organizational relationship** that is an interaction that exists between two actors and shares resources (e.g., information, knowledge) between actors to achieve the project's goals.
- A **subgroup** can be defined as any subset of actors and all the ties among them. A **triad** is a subgroup that is formed by three project actors. This dissertation explores triads that are formed by suppliers, contractors, and designers.

2.1.2. Actor's position in project networks

The actor's position in networks has been researched through the lens of centrality. Centrality refers to an actor's position in the network relative to the positions of others (Rowley, 1997). The potential to influence others depends on the actor's network position (Gadde et al., 2003). The actor's position in a project network can be an advantage or disadvantage. Holding a non-central position limits access to other actors, so it is considered disadvantageous. Holding a central position in a project network is considered advantageous because it provides the actor with direct access to other network actors and makes it visible (Pauget and Wald, 2013). Network analysis traditionally distinguishes between three different concepts of centrality (Freeman, 1978; Rowley, 1997):

- Degree centrality measures the direct ties of an actor in a network.
- Closeness centrality measures the shortest paths to other actors in a network. Closeness centrality takes into account the indirect ties of an actor.
- Betweenness centrality considers the potential of an actor to control communication. An actor has high betweenness centrality if the actor integrates otherwise non-connected actors.

Based on these three concepts, an actor's centrality in a network is measured by their number of direct ties to other actors, indirect ties to other actors, and control of communication over other actors (Rowley, 1997). Each actor tries to achieve their aims by developing their position in the network relative to other actors (Håkansson and Ford, 2002). Improving an actor's position in a project network depends on their capability to create new and to strengthen existing relationships (Pauget and Wald, 2013). The actor in a network can often influence how loose or tight their relationships and connections are to certain specific other actors in the network (Artto et al., 2008).

The position of an actor is also determined by other actors in the network. An actor's position in a network is perceived differently by the various other actors. Their perceptions are reflected in their

actions and reactions, which determine an actor's position in the network (Gadde et al., 2003). Therefore, an actor can also develop their network position by influencing the knowledge and understanding of other actors (Håkansson and Ford, 2002). Actors might have their own motives and interests for their participation in a project network. Each actor has long-term business interests that could influence their behavior in the project networks, since the organizations involved in one project may have better chances of participating in the next project (Artto et al., 2008). Therefore, actors can try to shape their position in the underlying permanent project business network (Hellgren and Stjernberg, 1995).

2.1.3. Inter-organizational relationships in construction project networks

Research on inter-organizational relationships emerged from the recognition that organizations operate in a relational context of environmental interconnectedness and that an organization's performance is dependent on its linkages to other organizations (Oliver, 1990). The roots of inter-organizational relationship research can be traced back to the 1960s when researchers began conceptualizing relations between organizations in order to study them (Evan, 1965). According to Oliver (1990), inter-organizational relationships are the relatively enduring transaction flows and linkages that occur among or between an organization and one or more other organizations in its environment.

Inter-organizational relationships have received a great deal of attention in various business research settings, featuring different theoretical backgrounds and different terminologies (Autry and Golobic, 2010; Jelodar et al., 2016). Inter-organizational relationships have been characterized, for example, as weak or strong (Donaldson and O'Toole, 2000), arm's-length or embedded (Uzzi, 1997), adversarial or cooperative (Eriksson et al., 2007), and transactional or relational (Dubois and Gadde, 2000). Although inconsistent terminologies have been used to describe various inter-organizational relationships, a common thread is the idea of a continuum of relationships ranging from transactional and adversarial relationships to committed, strategic relationships with various cooperative relationships in between (Autry and Golobic, 2010).

In construction project networks, inter-organizational relationships are mainly transactional and adversarial, that is, located at the beginning of the continuum (Bankvall et al., 2010; Jelodar et al., 2016; Kadefors, 2004; Laan et al., 2011). Public procurement regulations and traditional procurement methods have been claimed to maintain transactional and adversarial relationships in the construction industry (Blayse and Manley, 2004; Bygballe et al., 2010). This is problematic since adversarial relationships and a lack of cooperation in construction project networks hinder the improvement of productivity in the construction industry (Fulford and Standing, 2014).

2.1.3.1 Evaluation of inter-organizational relationships

Earlier literature has used constructs such as relationship strength, relationship quality, and relationship closeness to evaluate inter-organizational relationships. Measurement of these closely related

constructs has varied, even when the same terms have been used (Bove and Johnson, 2001). A large variety of measures—such as commitment, trust, satisfaction, information sharing, joint problem solving, relationalism, loyalty, and transaction volume—have been included in these constructs (Bove and Johnson, 2001; Hausman, 2001; Smyth and Edkins, 2007; Uzzi, 1997; Walter et al., 2003). Relationship strength is usually measured by trust and commitment (Bove and Johnson, 2001). Relationship quality often takes trust and commitment into account, but it also includes various other measures, such as satisfaction, opportunism, cooperation, power, and atmosphere (Athanasopoulou, 2009; Jelodar et al., 2016). Relationship closeness emphasizes an emotional bond between the parties in a close relationship (Barnes, 1997). Bove and Johnson (2001) argue that trust and commitment are the central dimensions in inter-organizational relationships, and that other dimensions function as antecedents or consequences of trust and/or commitment. Morgan and Hunt (1994) support this view by concluding that trust and commitment are the key constructs in inter-organizational relationships.

Based on the discussion above, the construct of relationship strength is used to characterize the depth of inter-organizational relationships in construction project networks. Relationship strength characterizes an inter-organizational relationship in terms of trust and commitment (in line with Bove and Johnson, 2001; Hausman, 2001; Morgan and Hunt, 1994). The greater the degree to which trust and commitment are perceived to be present, the stronger the relationship is (Bove and Johnson, 2001). Various aspects of relationship strength have been associated with such business benefits as loyalty (Storbacka et al., 1994), access to information (Björkman and Kock, 1995), performance improvement (Smyth and Edkins, 2007), and competitive advantage (Ahola et al., 2013).

Trust has been studied in different disciplines such as sociology, psychology, anthropology, economics, and management (Lau and Rowlinson, 2009). There is no widely recognized definition of trust (Meng, 2012). This study focuses on trust in project business, particularly in construction projects, which has recently been gathering increasing research interest (e.g., Buvik and Rolfsen, 2015; Manu et al., 2015). Inter-organizational trust in construction projects is linked to time and cost savings and better information sharing (Manu et al., 2015). According to Smyth et al. (2010), trust in project business is a current conviction that another party is willing to take into account individual and organizational interests within the context and under possible events.

Commitment has been defined as an enduring desire to maintain a valued relationship (Ulaga and Eggert, 2006). Commitment relates to what counterparts will do for each other, for example, the extent to which they prioritize each other (Snehota and Hakansson, 1995) and the desire to continue a relationship (Morgan and Hunt, 1994). This is important when actors are developing a long-term relationship. Commitment helps to stabilize the relationship and it is key to achieving valuable outcomes for both parties (Ulaga and Eggert, 2006). Valuable outcomes could be new innovations, better design solutions, and more effective working methods. Commitment is primarily important to assess future actions and, because the future is always circumscribed by uncertainty, trust may be a necessary condition for commitment (Snehota and Hakansson, 1995). There are empirical findings

that show that trust and commitment are significantly positively related; more specifically, the greater the level of trust, the greater the level of commitment (Bove and Johnson, 2001; Buvik and Rolfsen, 2015; Kwon and Suh, 2004).

While the nature of inter-organizational relationships and the market position of project-based firms in general are receiving increasing attention, particularly in project research (e.g., Ahola et al., 2013), clearly less is known about business relationships and their strength among the less central players in project networks (Eom et al., 2015).

2.1.3.2 Intreconnectedness of inter-organizational relationships

Supply chain management literature has acknowledged that dyads do not really capture the particularities of a network (Choi and Wu, 2008); instead, triads are increasingly proposed as the fundamental building blocks in complex networks. A triad refers to a relationship between three network actors that are connected to one another (Choi and Wu, 2009). The triad can be viewed as the smallest network unit allowing the study of network effects (Ritter, 2000; Vedel et al., 2012). The main focus of triadic research has been on the direct delivery chain between clients, integrators, and manufacturers (Choi and Wu, 2008). For example, the intent of manufacturers to alter their supply chain position may require triadic operational models between the supplier, an integrator, and end clients (Finne and Holmström, 2013) and other ways of collaborating upstream and downstream in the supply chain (Nordin et al., 2010). Besides the direct supply chain, triads may involve companies with an indirect role in the business network. For example, a manufacturer's interest in expanding its service base towards clients may require triadic cooperation involving competitors, in case the manufacturer intends to maintain or modernize its competitors' products (Raddats and Easingwood, 2010).

Inter-organizational relationships in construction project networks have been mainly studied from the dyadic perspective, particularly regarding the dyads formed between clients and main contractors (e.g., Bresnen and Marshall, 2000) or between contractors and their subcontractors (e.g., Beldmians et al., 2012a). The dyadic perspective focuses on the interaction between two actors and the outcomes of these interactions (Håkansson and Snehota, 1995). However, relationships do not exist in isolation because they may influence other relationships, or in other words, because of the interconnectedness of relationships (Ritter, 2000; Vedel et al., 2012). The dyadic perspective is not enough to study interconnections between relationships, whereas a triadic perspective includes at least two dyadic relationships and enables the study of the interconnection between relationships (Vedel et al., 2012). The interconnection between relationships might be negative, neutral, or positive (Ritter, 2000; Vedel et al., 2012). Furthermore, the framework proposed by Ritter (2000) describes 10 possible impacts among inter-organizational relationships.

This research focuses on suppliers' relationships with contractors and designers. Together these actors form a triad in the construction project network and the relationships in this triad might influence each other. Therefore, a triadic perspective is applied to study the suppliers' relationships with designers and contractors in construction project networks (Figure 3).

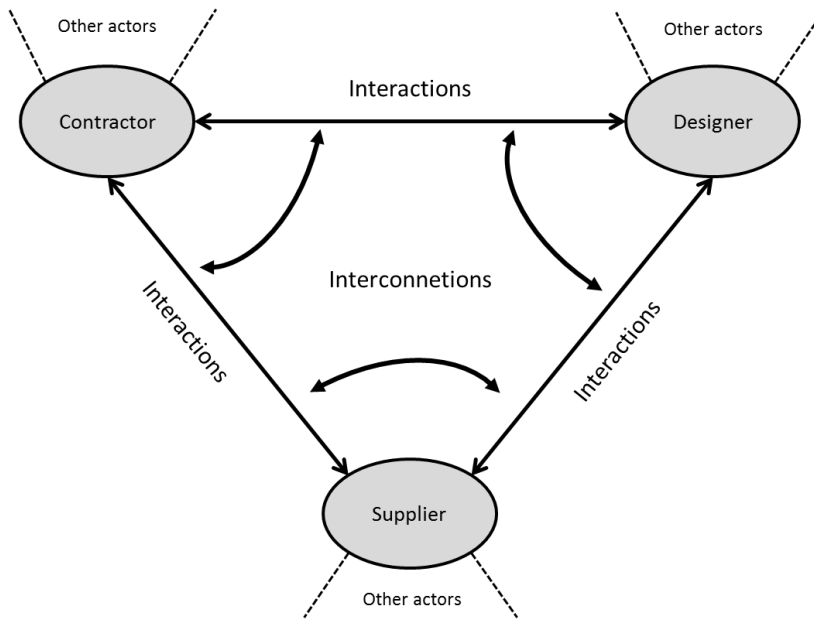


FIGURE 3. The triadic perspective for studying supplier's relationships in construction project networks (adapted from Vedel et al., 2012).

To conclude, current research is directing increasing attention to project networks in terms of inter-organizational relationships. Supply chain research is increasingly oriented toward triadic supply relationships (Choi and Wu, 2008, 2009) whereby the interconnectedness of relationships needs to be understood to steer the network appropriately (Ritter, 2000). This dissertation focuses on suppliers' relationships with contractors and designers from the triadic perspective illustrated in Figure 3. Despite its advantages, triadic analysis has not been widespread in network research (Vedel et al., 2012). Furthermore, suppliers' relationships in construction project networks have not been studied from a triadic perspective. These gaps justify this research.

2.1.4. Actors' roles in construction project networks

The construction industry is a typical example of project-based organizing where multiple actors are linked into the same project deliveries in a project network. Construction projects are delivered to the clients through networks of contractors, their suppliers, and various other supportive stakeholders. In construction project networks, the project client is usually the investor and user of the project outcome. The use of supportive stakeholders, such as designers, consultants, and advisors, is very

typical in construction project networks (e.g., Bresnen and Marshall, 2000; Cova and Hoskins, 1997). Designers, consultants, and advisors in particular are engaged in the projects through contractual relations either with the client or the contractor, which differentiates them from “secondary stakeholders,” such as environmentalists, who are not contractually associated with any focal firm in the project (Aaltonen and Kujala, 2010). Designers have been recognized for holding a fairly central position within the construction project network (Yang et al., 2011). Especially architects have established their role in specifying the building design and components in the early phases of the construction projects (Hemström et al., 2017). They may, however, take an obedient and operational role as their position in project networks has changed in recent decades. Winch and Schneider (1993) recall that architects have historically been mainly responsible for the entire construction project on behalf of the client, but that clients now increasingly appoint professional project managers, thereby undermining the architect’s centrality in the project network. Jalkala et al. (2010) support this by saying that structural engineers and architects have a key role in the project networks but they have become less active in the early project phases than before. Architectural practice is knowledge-based work where the distinctive competence deals with creativity, whereas the distinctive competence of consulting engineers (such as structural engineers) relates to technology. Structural engineers provide solutions to technical problems, which makes them particularly important in discontinuous projects where the level of competence cannot be maintained by the constructors themselves and their services are needed only occasionally (Winch and Schneider, 1993).

Contractors play a central role in project networks since they deliver the projects to the clients and they have direct relationships with the majority of the other project actors in the project execution phase. The contractors are increasingly dependent on suppliers and subcontractors for project delivery, as they do not have all the required expertise and resources to deliver the entire construction project on their own. Nowadays, as much as 75–80% of a project’s turnover is spent buying materials and subcontracting services (Dubois and Gadde, 2000). Traditionally the main contractor is selected only after the investment preparation phase when the main designs are already completed. Nowadays, the design process is increasingly being led by the main contractor and the client in cooperation (Jalkala et al., 2010). Therefore, contractors have more often a central role already in the investment preparation phase.

The manufacturers of construction components and materials are the suppliers in construction projects. The suppliers are product-oriented companies that sell products and components to contractors working on construction projects. They represent one of the most neglected research categories in the construction industry (Larsson et al., 2006). This is illogical, since components and materials account for 50–60% of project costs, and the project schedule is dependent on material and component deliveries (Ibn-Homaid, 2002). Suppliers typically hold a non-central position in project networks since they most often have weak relationships with other actors in a construction project. Their only contractual relationship is with the contractor, and contractors tend to select suppliers through competitive tendering based on price (Miller et al., 2002). This is a problem for suppliers, because their

product and component sales are dependent on the purchasing decisions made during the construction projects. In competitive tendering, suppliers can only compete based on price and are not integrated in the design and planning of the work that they are responsible for executing (Miller et al., 2002). This is known as the trap of the competitive bidding process (Cova and Salle, 2007). Therefore, suppliers are interested in finding other ways to influence design and purchasing decisions before tendering.

Since suppliers operate in more stable markets than the other project actors, they can maintain R&D programs and develop new solutions (Blayse and Manley, 2004). Therefore, suppliers have the best technical knowledge in their field and are regarded as key sources of innovation in the construction industry (Bygballe and Ingemansson, 2014; Gambatese and Hallowell, 2011; Hemström et al., 2017). However, suppliers' non-central position in project networks hinders their contribution to construction innovation. Purchasing decisions and construction innovation are discussed next in more detail, because these are major motives for suppliers to improve their position in project networks.

2.1.5. Purchasing decisions in construction project networks

In a construction project network, actors collaborate and make purchasing decisions before and during project execution (Hobday, 2000). Kolltveit and Grønhaug (2004) address the importance of the early phases of a construction project because they influence project performance dramatically. In the early project phases, the project's client and experts, such as designers and contractors, define the project proposal according to the client's needs and local building codes. Some authors argue that designers are now less active in the early project phases than they once were. The reason for this is that the early project phases are increasingly being led by the contractor and the client in cooperation (Jalkala et al., 2010; Winch and Schneider, 1993). In the construction sector, this phenomenon is called partnering. According to Crespín-Mazet and Portier (2010), since construction clients are reluctant to engage in project partnering, partnering has not diffused extensively in the construction industry.

The design phase starts once the project proposal has been completed (Kolltveit and Grønhaug, 2004), and then the conceptual ideas are converted into design specifications by architects and structural engineers. Designers tend to use familiar materials and components in their design specifications in order to minimize risk (Emmitt, 2006). In private sector projects, designers may select a specific product for the specifications because they perceive that the quality of the building would suffer if the contractor were allowed to choose the product (Emmitt, 2006). In the public sector, legislation and regulations prohibit the designers from appointing suppliers and limits the interaction between designers and possible suppliers before tendering. However, legislation and regulations do not negate the fact that the designers use familiar materials and components in specifications in order to narrow down the potential suppliers who are able to tender. These design specifications

broadly affect other project participants because the specifications are used as a guideline for constructing the building. Still, there is only limited research on the selection and specification of construction components as part of the project network (Emmitt, 2006).

Contractors and clients use the designer's specifications as a guideline in their purchasing decisions (Errasti et al., 2009; Peat, 2009). As mentioned earlier, contractors tend to select suppliers separately for each project by using competitive bidding (Hartmann and Caerteling, 2010; Rundquist et al., 2013). Competitive bidding has traditionally been considered the most effective way to achieve the lowest prices (Cox and Thompson, 1997), and project-level agreements are flexible. It is reported that some clients insist that contractors should use competitive bidding in their supplier procurement (Beach et al., 2005); however, contractors also select suppliers for series of projects. These business-level agreements are labeled as framework agreements and they last for a certain duration (e.g., one year or two years) (Pala et al., 2014). Long-term agreements are recommended because they enable long-term relationships, mutual development, and more efficient purchasing process. It seems that contractors' supplier selection is context dependent and there is not a common approach taken toward using project-level and business-level agreements (Frödell, 2014). Clearly more research is needed on contractors' supplier selection and how these business-level agreements influence clients' purchasing decisions in construction projects.

2.1.6. Innovation in construction project networks

The construction industry is accused of being non-innovative and conservative (Hemström et al., 2017). An industry's innovativeness is usually measured through R&D investment and the number of patents filed, and previous research in Europe shows that the construction industry is lagging behind other industries in terms of its R&D investment (Bygballe and Ingemansson, 2011). However, it is argued that these measures do not accurately reflect the innovativeness of the construction industry because of its unique features. The construction industry is largely project based and fragmented, which means that innovations are developed at the project level and construction companies tend to invest less in R&D and rarely create new patents (Aouad et al., 2010). Regardless of the measurement, scholars and practitioners seem to agree that there is a need to understand how to enhance innovation in the construction industry (Blayse and Manley, 2004; Eriksson and Szentes, 2017; Gambatese and Hallowell, 2011).

The contractor's role in construction innovation could be described as a "systems integrator." According to Winch (1998): "The systems integrator is at the interface between the innovation superstructure and the innovation substructure - new ideas are proposed within the latter and accepted within the former, mediated by the systems integrator" (p. 274). The innovation substructure involves suppliers, subcontractors, and specialist consultants. The innovation superstructure consists of clients, regulators, and professional institutions (Figure 4). The systems integrators have an important role in construction innovations, since they act as intermediaries between innovation substructures and innovation superstructures. Innovation substructures develop new ideas, but implementation of

these ideas depends on how convinced the systems integrator is of the merits of the new ideas (Winch, 1998). The survey by Aouad et al. (2010) indicates that contractors largely innovate to improve their processes and services. According to Hemström et al. (2017), designers perceive that contractors have a huge influence on the innovativeness of the construction industry. Contractors are the single systems integrator in construction projects in which they are contractually responsible for the design and construction (i.e., design-build and turnkey projects) (Rutten et al., 2009). Otherwise, the systems integrator role is shared between the principal designer and the main contractor (Winch, 1998).

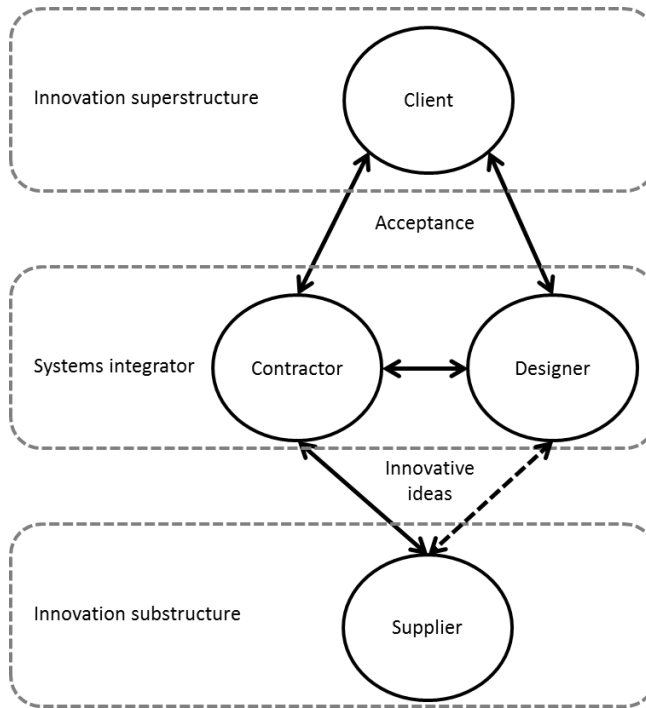


FIGURE 4. Actors' roles in construction innovation.

Designers fulfill the systems integrator role in the design phase, unless the contractor is responsible for the design. Designers are engaged in the early phases of the projects and they have a fairly central position in a construction project network (Yang et al., 2011). They are responsible for designing the construction and specifying materials and products used in the projects (Errasti et al., 2009). The questionnaire study by Håkansson and Ingemansson (2013) with over 400 Swedish construction contractors revealed that 28% of the studied contractors perceived the ideas and opinions of technical consultants and architects as very important drivers of renewal. Also, Bygballe et al. (2010) highlight the role of suppliers, architects, and consultants in construction innovation, because product and process innovations often come from them and from the collaboration between them. Therefore, designers play an important role in the diffusion of construction innovations.

Clients belong to the innovation superstructure that accepts construction innovations. Recent research suggests that clients carry out a critical role in construction innovation (Hemström et al., 2017; Loosemore and Richard, 2015; Ozorhon, 2013). Clients have the power in a construction project network to demand innovation and to create an environment in which innovation can flourish. However, the construction sector serves a variety of clients with different needs and capabilities. Clients are not equally mature or willing to enhance innovation in their construction projects. Large repeat clients are most likely to drive innovation in the construction industry, whereas one-off clients are less likely drivers of innovation (Manley, 2008). Therefore, the client's role in construction innovation ranges from passive to dominant.

Manufacturing companies as suppliers belong to the innovation substructure that develops new construction innovations. Suppliers differ from other actors in the construction industry because they are product- and not project-oriented (Larsson et al., 2006). The suppliers have the best knowledge in their field, so they are capable of developing designs and suggesting alternative solutions that could yield significant cost savings. Therefore, suppliers are regarded as key sources of innovation in the construction industry (Bygballe and Ingemansson, 2014; Gambatese and Hallowell, 2011; Hemström et al., 2017)). For example, Pries and Dorée (2005) found that suppliers produce over 60% of all innovations in the Dutch construction industry. Still, the rate of innovation in the construction material industry is lower than in most other sectors (Wandahl et al., 2011).

Previous literature has identified several factors that hinder suppliers' innovation potential in the construction industry. The construction industry is accused of having a tendency to resist change. Once built, structures are expected to last a long time. Designers and contractors have liabilities that limit their work, so it is less risky for them to use tried and tested, rather than new, solutions (Blayse and Manley, 2004; Eriksson and Szentes, 2017). Therefore, it is more difficult for suppliers to convince designers and contractors of the benefits of new innovative products and solutions. Gambatese and Hallowell (2011) noticed in their survey that suppliers with a greater diffusion of innovations also marketed their products more extensively. This implies that suppliers need marketing capabilities to convince contractors and designers to try something new.

A major barrier from the suppliers' perspective is that they do not have sufficient knowledge of client needs, product development needs, and potential areas for innovation (Wandahl et al., 2011; Larsson et al., 2006). Suppliers do not often have direct links to clients in construction project networks. Suppliers' relationships with designers and contractors are key in this respect. Designers are engaged in the early phases of the construction project (Hemström et al., 2017), so they have good knowledge about client needs and development needs that would be helpful for suppliers. On the other hand, contractors have knowledge about client needs as well as the development needs of actual building processes. Prior literature has emphasized that inter-organizational relationships and collaboration are critical factors for construction innovation (Eriksson and Szentes, 2017; Ozorhon, 2013; Rutten et al., 2009). However, there is a lack of research into the relationship between the adopters of new products (e.g., designers and contractors) and the suppliers (Larsson et al., 2006).

2.2. Improvement of suppliers' position in construction project networks

Suppliers are an example of a non-central actor with an interest in improving their position in project networks. Suppliers' degree centrality is low, since they most often have a direct relationship only with the contractors, and these relationships are mostly weak, because contractors tend to select suppliers based on competitive tendering. Based on earlier research, an actor's position in a project network depends on their capability to create new, and to strengthen existing, relationships (Pauget and Wald, 2013). Therefore, suppliers can improve their degree centrality by creating new relationships and enhancing their existing ones with contractors and designers.

Suppliers' closeness centrality is also low, since suppliers are highly dependent on intermediary actors (contractors or designers) to access other parts of the network (Rowley, 1997). Contractors and designers have high betweenness centrality in a construction project network because they integrate suppliers and clients that are otherwise non-connected actors (Freeman, 1978). For example, to influence clients' purchasing decisions or innovation acceptance, the supplier needs to convince designers or contractors of the benefits of their product or new solution. Therefore, suppliers need marketing capabilities to influence clients' purchasing decision and innovation acceptance through contractors and designers. Marketing activities are also important because suppliers can develop their position in a network by influencing the knowledge and understanding of other actors (Håkansson and Ford, 2002). These two ways of improving the position of suppliers in construction projects are discussed in this chapter.

2.2.1. Suppliers' marketing activities in project networks

Researchers in the field of project marketing have identified a need to depict the unique features of project marketing in relation to other types of industrial marketing. These features are discontinuity, uniqueness, and the complexity of projects. Project marketing research has increased understanding about what happens before and after the call for bids in order to help project-selling firms escape the trap of the competitive bidding process (Cova and Salle, 2007). Project marketing takes place in various steps, some of which are company-level general marketing activities and others are pre-tender project-based activities and tender preparation activities (Cova et al., 2002).

Companies may adopt two alternative marketing postures in their project-seeking activities: constructivist or deterministic (Skaates and Tikkanen, 2003). In the constructivist posture, the supplier aims at an active co-construction of project demand with the client and other relevant network partners (Cova and Holstius, 1993). The marketing activities in a constructivist posture happen before the invitation to tender. In the deterministic posture, the supplier anticipates and learns to comprehend the competitive bidding (Jalkala et al., 2010). In this posture, the marketing activities happen after the invitation to tender. Current marketing strategies in project business mostly aim to construct

the demand instead of reacting to calls for tender (Cova and Salle, 2005), and Jalkala et al. (2010) note that the deterministic posture is not an option for many companies that operate in projects.

Project marketing research (Cova and Salle, 2008; Jalkala et al., 2010; Skaates and Tikkanen, 2003) highlights the importance of identifying actors, their relationships, their roles, and their influences in the project network. A supplier should also identify its own position in this network. The position in a network is an outcome of a supplier's relationship with other network actors and the offerings that have been developed, marketed, and purchased through them. To be successful in project marketing, the supplier needs to achieve credibility to be considered as a potential supplier by important actors (Haimala, 2008). It is not enough for the supplier to concentrate on marketing activities toward the client, because clients codefine projects with contractors and designers (Cova and Salle, 2008). As noted in an earlier chapter (2.1.5), contractors and designers have significant influence over client decision making. Therefore, the suppliers' marketing activities toward contractors and designers seem to be essential.

The design of buildings is rarely a standard procedure, and it is likely that designers will face an unfamiliar problem that cannot be resolved by applying tried and tested solutions alone (Emmitt and Yeomans, 2008). Designers cannot have a working knowledge of all relevant standards and codes. Suppliers have the best expertise and technical knowledge in their field (Khalfan et al., 2008; Manley, 2008). Therefore, designers need technical assistance and product information from suppliers regarding specifications in order to ensure the quality of their designs (Emmitt and Yeomans, 2008; van Leeuwen and van der Zee, 2005). Gil et al. (2001) have studied how suppliers' and subcontractors' knowledge and expertise can help designers in construction projects. They provide examples where the supplier's knowledge helps the designer to take all the relevant information (space considerations, lead times, fabrication capabilities, and constructability) into account in the design phase and develop creative solutions. They indicate that suppliers can get involved in the early design phase if the designer suggests suppliers, who can help them in the design phase, to the client (Gil et al., 2001). Facing unfamiliar problems can act as triggers for cooperation from the designer's side. Peat (2009) has discovered that designers often make informal contacts with familiar suppliers when faced with specification problems. Based on this, suppliers need to market their products and enhance their relationship with designers in order to contribute to the designs before tendering.

The design specifications influence purchasing decisions in construction projects because the specifications are used as a guideline for constructing the building. Skaates and Tikkanen (2003) suggest that some actors in the network should be influenced indirectly, whereas others should be influenced directly. From the suppliers' point of view, the designer relationship can be considered a potential source of bargaining power in their contractor relationships because it offers them a possible way to indirectly influence the contractors' and clients' final purchasing decisions.

Project marketing research has concentrated on clients' contractor selection and contractors' marketing activities. Earlier research has suggested several marketing activities that contractors could

use to enhance project sales. These activities are services (Cova and Salle, 2008), interpersonal relationships (Cova and Salle, 2008; Crespín-Mazet and Ghauri, 2007), references (Skaates and Tikkanen, 2003), and visits to facilities (Salminen, 2001). These marketing activities are aimed at clients and the main goal is to influence clients' purchasing decisions. Jalkala et al. (2010) have noticed that project suppliers' orientation has shifted away from influencing clients and moved toward cooperating with them.

Suppliers of construction components have marketed their products to designers and contractors for decades (Emmitt and Yeomans, 2008). Still, only a limited amount of research has been published in academic journals about their marketing activities. Marketing activities identified in earlier research fall into three categories: promotional literature, trade representatives, and services. Promotional literature includes articles and advertisements in trade journals used to raise awareness about a supplier's products within the industry (Peat, 2009). Suppliers' products and materials are widely marketed through the trade representatives. Although trade representatives' importance as part of project marketing has been acknowledged, it has received little attention in the literature (Prior, 2013). Services have become an important part of suppliers' offerings in many industries (Kujala et al., 2013), including the construction industry. Suppliers can offer different kinds of services (e.g., technical advice, provision of free drawings, details, specifications and schedules, and provision of CAD files) to designers to promote their products' use as part of a construction design. Designers also appreciate the services provided by the supplier. Some of them even regard these services as equally important as the characteristics of the product being offered (Emmitt and Yeomans, 2008). It is known that some suppliers also provide services (e.g., installation of components) to contractors to influence their purchasing decision.

Emmitt and Yeomans (2008) have noticed that suppliers' marketing activities towards designers in construction projects are not as successful as they could be. The main reason is that suppliers do not understand designers' needs and behaviors in the design phase. The same could be argued in terms of suppliers' marketing activities towards contractors, because there is a lack of research about contractors' needs and their purchasing behavior. Therefore, more research is needed about the expectations of contractors and designers for suppliers.

2.2.2. Enhancing suppliers' relationships in construction project networks

Suppliers' relationships in construction project networks are mostly of a transactional nature, and often strained by conflict and feelings of mistrust (Eriksson et al., 2007; Miller et al., 2002). Enhancing relationships is a way for suppliers to improve their position in project networks and to achieve credibility among designers and contractors. Enhanced relationships also provide an opportunity for suppliers to influence purchasing decisions before tendering. The importance of these relationships is justified by their capacity to facilitate the knowledge exchange between individuals and firms (Blayse and Manley, 2004). To enhance relationships with contractors and designers, suppliers should develop trust and commitment with them. Lack of trust is a major barrier in cooperative relationships

and innovations in construction projects (Akintoye and Main, 2007; Manu et al., 2015). Designers and contractors are very meticulous regarding supplier selection, because they have their own responsibilities and reputations to consider. Consequently, they tend to select reliable and tested components from suppliers they trust (Emmitt and Yeomans, 2008). If trust is present in the inter-organizational relationship, parties do not have to worry about underlying hidden motives, who is formally responsible for problems, or the risks of disclosing information (Kadefors, 2004). Commitment expresses the desire of actors to invest their resources in developing relationships (Crespin-Mazet and Ghauri, 2007). Transactional relationships do not require investment, but more enhanced relationships require investment from both parties (Pala et al., 2014). Therefore, suppliers need to develop commitment with contractors and designers.

2.2.2.1 Enhancement of inter-organizational relationships in project networks

Prior research on practices toward strengthening the inter-organizational relationships in project networks is somewhat scattered. Therefore, different practices for strengthening relationships from different research streams are identified and collected in Tables 1 and 2. Table 1 includes cooperative practices from project management literature.

TABLE 1. Summary of previous research about cooperative practices needed for relationship strength in project networks

Reference	Data and method	Cooperative practices	Deliverable	Contribution to this study
Ahola et al., 2013	Qualitative single case study. Oil and gas industry	Personal involvement and closeness, presence at events, collaboration agreements	Strong relationship	Supplier's activities toward the third party (university)
Fulford and Standing, 2014	Qualitative case study in three organizations. Construction industry	ICT integration and information sharing	Collaboration → Relationship strength	ICT integration and information sharing strengthen relationships
Gustafsson et al., 2010	Case study approach with CROL method. Multiple industries	Managing critical events, focusing on the client and considering the situation from the client's perspective	Trust, confidence, and client satisfaction → relationship strength	Operational events can strengthen or weaken the relationship
Kadefors, 2004	Literature review. Construction industry	Economic incentives, formalized team building, joint goal formulation, and system for problem solving	Trust → Relationship strength	Processes of trust development are dynamic, complex, and sometimes even contradictory
Kujala et al., 2013	Qualitative multiple-case study. Three cases representing different industries	Adding services to offerings	Familiarity, trust, and mutuality → Relationship strength	Through services, a supplier can enhance the relationship strength

Reference	Data and method	Cooperative practices	Deliverable	Contribution to this study
Leufkens and Noorderhaven, 2011	Qualitative interview study with 39 interviews. Shipbuilding industry	Overcome social interest, concentrate on mutual interest	Collaborative relationship	Organizational interests are socially constructed by the individuals
Martinsuo and Ahola, 2010	Qualitative case study. Two cases from construction, engineering, and shipbuilding industries	Integrative control and co-operation practices (e.g., monitoring, team processes, and integrative persons)	Commitment, duration of the relationship	The nature of the relationship is reflected in various integration activities
Meng, 2010	Expert interviews and two case studies. Construction industry	List of key relationship indicators (e.g., communication, problem solving, risk allocation, joint objectives)	Collaborative relationship	Assessment criteria for collaborative relationships
Smyth and Edkins, 2007	Questionnaire survey with 300 respondents. Multiple industries	A shift from relational contracting to relationship management	Trust and confidence → relationship strength	Development of trust and confidence strengthen relationships

Earlier research on project management has mainly concentrated on the strength of relationships between the project supplier and the client. Only recently has the study by Ahola et al. (2013) taken the strength of the relationship between the project supplier and a third party into account. They recognized that frequent interaction during project marketing and repeated project deliveries enabled the development of strong inter-organizational relationships. They also discovered that the supplier's presence at various events and seminars, personal involvement and closeness, and formal collaboration agreements strengthened their relationships with third parties (Ahola et al., 2013). Also, other authors have suggested that repeated satisfactory interactions help to build commitment and trust between buyers and suppliers, thereby strengthening the relationship (e.g., Khalfan et al., 2007; Martinsuo and Ahola, 2010).

Relationships between the different parties of a multi-organizational project are dependent on the interests of the parties. Leufkens and Noorderhaven (2011) argue that these interests are socially constructed by the individuals and it is essential to overcome conflicting interests between parties. Most studies look at inter-organizational relationships only at the organizational level. When contractors and suppliers are involved in a construction project, the social interactions take place at the individual actor level, and the inter-organizational relationships are characterized by individuals working together. This is why Bemelmans et al. (2012a), Ellegaard et al. (2010), and Kamann et al. (2006) argue that further studies should take interpersonal relationships and the individual actor level into account. Previously, Donaldson and Toole (2000) discovered that strong relationships develop

when there are mutual benefits to be gained. They also argued that signaling a faith in the relationship is a good way to strengthen the relationship.

Existing literature has mainly concentrated on what can increase the strength of relationships, but some studies have called for a greater understanding of the less pleasant aspects of relationships, too. Holmlund-Rytkönen and Strandvik (2005) introduce the concept of relationship stress that is the “perceived cumulative effects of negative experiences in the business relationship” (p. 12). They note that negative incidents and problems are sources of relationship stress that could weaken the relationship. Such negative aspects have been also studied through critical events that are regarded as changes in actor bonds, resource ties, and activity links (Schurr et al., 2008). Some authors argue that critical events either strengthen or weaken the relationship (Gustafsson et al., 2010; Schurr, 2007). That is why Gustafsson et al. (2010) highlight the importance of managing critical events. They argue that suppliers should focus more on the client and consider the critical events from the client’s perspective.

2.2.2.2 Enhancement of inter-organizational relationships in construction supply chains

Research streams covering cooperative practices in the construction industry are relationship-based procurement systems and supply chain management. These cooperative practices are summarized in Table 2. In their literature review, Bygballe et al. (2010) divide cooperative practices in partnering literature into formal tools (e.g., team building, workshops, facilitators, incentives, and contracts) and informal aspects (e.g., social dynamics and cultural-structural aspects). Bresnen and Marshall (2002) observed in their case study that there was some skepticism among workers regarding the value of formal tools, such as team building and workshops. The workers placed a greater emphasis on the value of informal aspects. Shared offices, informal social events, and continuity of personnel were regarded as particularly effective ways to strengthen relationships (Bresnen and Marshall, 2002). Few researchers have studied the informal nature of relationship development in detail.

TABLE 2. Summary of cooperative practices needed for relationship strength in construction supply chains

Reference	Data and method	Cooperative practices	Deliverable	Contribution to this study
Bresnen and Marshall, 2002	Qualitative case study. Two cases with 36 interviews	Informal social events, continuity of personnel, co-location (shared offices)	Reinforced relationship	Relationship reinforced when it matures over time and mutual benefits are realized
Bygballe et al., 2010	Literature review	Formal tools and informal (relational) aspects	Partnering relationship	Earlier literature has focused on formal tools

Reference	Data and method	Cooperative practices	Deliverable	Contribution to this study
Eriksson et al., 2007	Single case study with action research approach	List of collaborative procedures (e.g., early procurement, joint objectives, shared offices)	Subcontractor involvement	Increased communication and feedback between subcontractors and consultants improves relationships between them
Khalfan et al., 2007	Qualitative multiple-case study. Five cases and 40 interviews in total	Working together, problem solving, shared goals, reciprocity, and reasonable behavior	Trust → relationship strength	Focuses on construction projects and considers the whole project network. Also identifies barriers to trust
Laan et al., 2011	Longitudinal case study with 30 interviews	Co-location and transparency	Trust → relationship strength	Highlights the importance of interpersonal trust
Lau and Rowlinson, 2009	A case study approach. Questionnaires with 40 responses	Keeping commitments and demonstrating co-operation	Trust → relationship strength	Trust exists at organizational and individual levels. Trust has to be built at both levels
Pala et al., 2014	Questionnaire survey with 47 responses	Shared ICT technologies with upstream and downstream supply chains	Collaboration → relationship strength	ICT technologies can facilitate cooperative and collaborative relationships
Smyth and Fitch, 2009	Action research with a large contractor firm	Key account management and relationship management systems	Relationship strength	Relationship building is left to individuals but there is no guidance on how to build and manage relationships

Many authors have researched trust building. These studies are relevant because trust is a measure of relationship strength (e.g., Bove and Johnson, 2001; Smyth and Edkins, 2007). Khalfan et al. (2007) and Laan et al. (2011) have studied trust building in construction projects specifically. According to Khalfan et al. (2007), the main ways to build trust in construction projects are working together, problem solving, shared goals, reciprocity, and reasonable behavior. Laan et al. (2011) highlight the importance of interpersonal trust. They observed that their respondents referred to the interpersonal level, instead of the inter-organizational level, when there was a question about trust. Co-location and transparency between persons were raised as the main ways to develop interpersonal trust (Laan et al., 2011). Lau and Rowlinson (2009) support this by stating that trust exists at organizational and individual levels. Trust should be built at both levels. Smyth and Fitch (2009) suggest more managerial activities for strengthening the relationships because they noted that the development of trust and commitment was primarily left to individuals. They call for organizational management support, systems, procedures, and leadership that aid in the development of relationships.

The enhancement of relationships has been a major concern in construction-related research, and the interest in enhancing inter-organizational relationships has increased over the past decade (Eriksson, 2010). Different kinds of relationship-based procurement systems, such as partnering and project alliancing, have been suggested as ways to enhance relationships in construction project networks (Eriksson, 2010). Project alliances are legally binding contractual arrangements and the monetary rewards for parties depend upon the success of all parties, whereas partnering is a voluntary, long-term-oriented cooperation that is not legally binding (Love et al., 2010). Strong relationships are requirements for successful partnering and alliance projects and they are based on mutual trust and commitment (Eriksson et al., 2007; Lloyd-Walker and Walker, 2011; Love et al., 2010). Joint objectives, conflict resolution techniques, contracts, and authentic leadership have been suggested as ways to strengthening the relationships in partnering and alliance projects (Eriksson et al., 2007; Lloyd-Walker and Walker, 2011).

Implementing relationship-based procurement systems in the construction industry features certain challenges. The most common challenges are related to a culture of using traditional procurement that has led to adversarial relationships and mistrust between project participants (Crespin-Mazet and Portier, 2010; Eriksson et al., 2007). A problem related to suppliers and designers is that relationship-based procurement systems and their incentive schemes are most often focused solely on the relationships between clients and main contractors. Designers are sometimes involved, but suppliers and subcontractors are very rarely involved (Eriksson et al., 2007). Based on the discussion above, relationship-based procurement systems represent means to strengthen relationships between central project actors bound by contracts and long-term interests.

To conclude, construction-specific research has concentrated on the contractors' and clients' contractual relationships (Bemelmans, 2012), ignoring other parties and non-contractual relationships in the project network. Very few empirical studies focus on other relationship types adopted by different actors in project networks, the characteristics of different types of relationships, and in what circumstances these relationships are created and developed (Bemelmans, 2012; Meng, 2010; Meng et al., 2011). In particular, the enhancement of suppliers' relationships with contractors and designers has not attracted much attention in previous research.

2.2.2.3 Nature of contractor-supplier relationships

Contractor-supplier relationships have not gained much attention in the literature, although contractors are increasingly dependent on their suppliers to deliver their projects (Bemelmans et al., 2012a). Nowadays, as much as 60–80% of the project turnover is spent on materials and subcontracting services (Bygballe and Ingemansson, 2014). The high percentage of purchasing in construction projects emphasizes the importance and potential of supplier relationships (Bemelmans et al., 2012b). Contractors usually select suppliers through competitive tendering rather than by pursuing long-term relationships with them (Eriksson et al., 2007). Dainty et al. (2001) reported problems in the adoption of long-term cooperative relationships with suppliers. Contractors' employees were skeptical of this

practice and cost issues, rather than the added value that suppliers could offer them, remained the main focus in their supplier relationships. There are also successful examples of cooperative relationships. Bygballe and Ingemansson (2014) describe an example in which a contractor decided to use a single supplier and together they developed a new solution to use in future projects. A case study by Manley (2008) shows another example in which a strong relationship between the contractor and supplier enabled the implementation of the supplier's innovation in a construction project.

Frödell (2011) has identified multiple criteria that both the supplier and contractor should fulfill in order to achieve an efficient contractor-supplier relationship. Most of the criteria require that contractors adopt long-term relationships with suppliers. The problem is that contractors seemed hesitant to do this, so he calls for further research about the constraints related to establishing and maintaining contractor-supplier relationships (Frödell, 2011). A recent study by Bygballe and Ingemansson (2014) supports this notion by indicating that contractor companies are not motivated to enhance their relationships with suppliers. Ross and Goulding (2007) provide a contrasting view, as their survey results indicate that contractors are willing to develop closer relationships with their supply chain. However, research into the practices for enhancing contractor-supplier relationships in the construction industry is scarce.

2.2.2.4 Nature of designer-supplier relationships

The relationship between the supplier and the designer is different when compared to client-contractor and contractor-subcontractor relationships, which have been studied earlier (Bygballe et al., 2010). The main difference is that suppliers and designers are not in a contractual relationship with each other and these companies do not engage in material or financial transactions, only in information exchange. Consequently, earlier studies on strengthening relationships in project networks are not directly applicable to this specific relationship.

Suppliers' trade representatives are often an interpersonal link between suppliers and design offices. The purpose of the trade representative is to raise designers' awareness about a supplier's products and the aim is to get the supplier's product into the specifications (Emmitt, 2001). Trade representatives try to provide this knowledge to designers (Emmitt, 2006; Manley, 2008), but they come up against design offices' "gatekeeping mechanism" that hinders the interaction (Emmitt, 2001). According to Emmitt (2001), some large design offices complained that they felt pestered by trade representatives and that sales-oriented trade representatives were regarded as a waste of time. Therefore, trade representatives were not allowed to visit unless they had been invited.

Emmitt (2006) has noticed that a good relationship with designers allows the supplier to pass through these gatekeeping mechanisms and enables the supplier to contribute to the construction project from as early as the design phase. However, there is lack of research about practices for enhancing suppliers' relationships with designers.

2.2.2.5 Enhancing cooperation in a triadic setting

Construction-related research acknowledges multi-actor networks and relationships, but few studies concern suppliers in multi-actor settings (Bygballe et al., 2010). According to Mahmoud-Jouini (2000), architectural and technical definitions as design variables in construction projects may serve as a link within which the different organizations can collaborate. Her case studies revealed examples where the reassessment of architectural and technical definitions played a central role as skills for new technological offerings. The quality of designs and specifications is a major concern in construction projects. Designers' inadequate information about the materials and components available cause quality problems and hinder innovation (Emmitt, 2006; Peat, 2009). Such skills do not need to be possessed by one actor, but they may be accessed indirectly through partnerships and networking.

Earlier literature has acknowledged that contractors' and suppliers' involvement in design might provide better solutions through their contributions of expertise and knowledge (Arditi et al., 2002; Eriksson et al., 2007). Suppliers have the best expertise and technical knowledge in their fields (Khalfan et al., 2008; Manley, 2008). Therefore, designers need to seek technical assistance and product information from suppliers during specifications in order to ensure the quality of their designs (Emmitt and Yeomans, 2008; van Leeuwen and van der Zee, 2005). One common problem in design specification is that a designer fails to consider how a contractor will implement the design (Arditi et al., 2002). Misunderstandings have resulted in errors, rework, and unnecessary costs in construction projects (Love et al., 2004). Comprehensive knowledge and better designs could be achieved through the engagement of all three actors in the design and construction phase. However, there is a lack of research on inter-organizational relationships and collaboration between suppliers, contractors, and designers in triadic settings.

2.3. Synthesis

The literature review demonstrates that prior literature on project networks, project marketing, inter-organizational relationships, and construction innovation have focused on the central actors in construction project networks. Suppliers, as non-central actors, represent one of the most neglected research categories in the construction industry (Larsson et al., 2006), although they play a significant role in construction projects. Therefore, this research concentrates on suppliers in construction projects. The research gaps that justify the research objective and research questions are collected in Table 3 below.

TABLE 3. Identified research gaps

Literature stream	Research focus	Research setting	Gap in research
Project network	Centrality	Central actors	Improving non-central actors' positions
	Direct ties	Strong relationships	Enhancement of weak relationships
Project marketing	Marketing postures	Project-oriented firms	Suppliers' marketing activities toward other network actors
	Project milieu		Contractors' and designers' influences on clients' purchasing decisions
	Contractors' marketing activities		
Inter-organizational relationships in project networks	Partnering	Contractor-client relationship	Suppliers' and designers' relationships
	Alliance	Contractor-subcontractor relationship	Non-contractual relationships
	Contractual relationships		Interconnectedness of relationships
			Business-level cooperation
			Triadic cooperation
Construction innovation	Actors' roles in construction innovation	Client	Utilization of suppliers' potential
	Hindering factors	Contractor	Practices for fostering innovation
			Relationship between adopters of innovations and sources of innovation

Project networks are increasingly researched in terms of their structures. Previous attention has frequently been placed on actors at the center of the project network and its strong direct ties. There is insufficient knowledge on improving non-central actors' positions in a single project network and in a project business network. This gap justifies this research since its objective is to increase our understanding about the improvement of non-central actors' positions in project networks.

Suppliers are an example of a non-central actor with a vested interest in improving their position in project networks for several reasons. First of all, suppliers' product sales are dependent on the pur-

chasing decisions made in construction projects. Project marketing research has increased understanding about what happens before and after the call for bids goes out in order to help project-selling firms escape the trap of the competitive bidding process (Cova and Salle, 2007). However, the focus has been on clients' contractor selection and contractors' marketing activities. Clearly less is known about supplier selection in construction projects and suppliers' marketing activities toward other project actors. This gap in the research justifies the first research question.

Second reason is innovation. Construction innovation research acknowledges that suppliers have the potential to develop new innovations (Bygballe and Ingemansson, 2014; Gambatese and Hal-lowell, 2011). Research has identified multiple factors that hinder suppliers' innovation potential, but there is no research on practices that foster suppliers' innovation potential. Earlier research highlights that inter-organizational relationships and cooperation have a significant influence on construction innovation; however, there is a lack of research into the relationship and cooperation between the adopters of new products (e.g., designers and contractors) and the suppliers (Larsson et al., 2006). Inter-organizational relationship research in construction projects has concentrated on contractors' and clients' dyadic relationships (Bemelmans, 2012). As a result, suppliers' and designers' relationships, and interconnectedness of relationships have been ignored. To conclude, there is insufficient knowledge on how suppliers can strengthen their direct and indirect relationships in construction project networks. These gaps justify the second research question.

3. Methodology

3.1. Research context

The research is conducted in Finland with three supplier companies and their relevant third parties and contractors. All the suppliers are construction component manufacturers that produce and sell high-quality material-based intermediary components directly to construction contractors, or indirectly to consumers through wholesale dealers as distributors. Preliminary interviews were conducted at each of the component manufacturing firms before this research began. These interviews revealed the need of these three supplier firms to understand the role of third parties and contractors in purchasing decisions, and to improve their position in construction project networks (Martinsuo et al., 2012). This need served as a starting point for this research. The chosen third parties are architects and structural engineers. They were chosen because previous research and the three suppliers have acknowledged that architects and structural engineers have an influence on purchasing decisions and they play a relevant role in construction project networks (Voordijk et al., 2000). This research collects data from architects, structural engineers, and contractors so that suppliers can improve their operations in construction project networks.

In Finland, the construction industry accounts for about 10% of the gross national product (GNP). Finland's construction industry is similar to that of other Nordic countries and is regulated by Euro-codes and a national building code. A major difference between Finland's construction industry and those of other European countries is climate considerations. The long and cold winter must be considered when planning and executing projects. Contractual arrangements have much in common with those in the UK and the US. For example, construction projects typically feature multi-partner subcontracting networks that are led by a contractor. The contractors are increasingly dependent on suppliers and subcontractors for project delivery, as they do not have all the required expertise and resources to deliver the entire construction project on their own. In Finland, architects and structural engineers are employed by private design and engineering firms whose services are procured on a project-to-project basis by the contractors or clients. Architectural firms are typically small. Engineering firms are usually bigger than architectural firms, but still a lot smaller than most contractor firms. Due to their consultant role, neither architects nor structural engineers have official power in the projects.

3.2. Research setting

Figure 5 presents a simplified view of the research setting. The research focuses on suppliers' relationships with contractors and designers in a construction project network. Clients are not the focus of the research, but their role in decision making is considered. Therefore, 'client' is written in *italics*

and encircled by a dotted line. Suppliers are connected to the contractor and designers by dotted lines in the figure, which represents the weak relationships that suppliers usually have. Suppliers, contractors, and designers are connected to each other, so they form a relationship triad. Therefore, supplier-contractor and supplier-designer relationships are studied in a triadic setting.

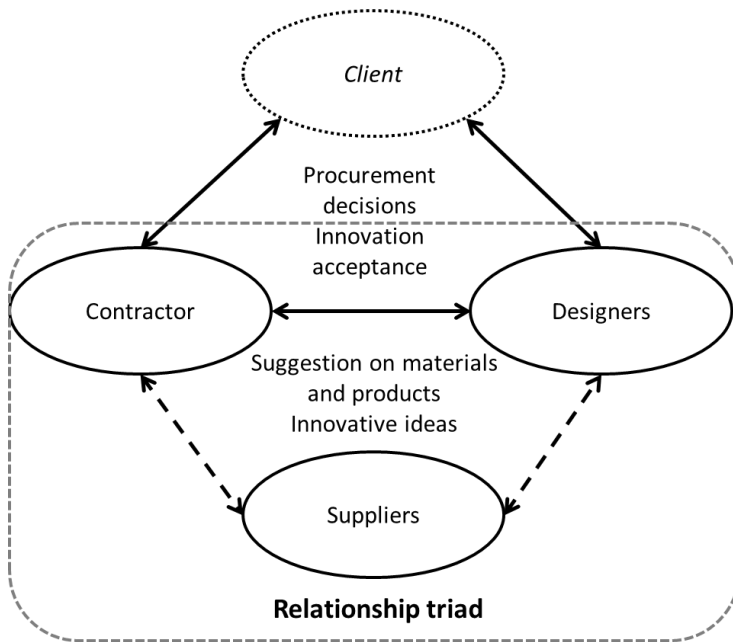


FIGURE 5. Illustration of the research setting of the dissertation.

A mixed methods research strategy was employed in the research setting. Mixed methods research is defined as “research in which the investigator collects and analyzes data, integrates the findings, and draws inferences using both qualitative and quantitative approaches or methods in a single study or program of inquiry” (Tashakkori and Creswell, 2007, p. 4). A mixed methods research strategy was employed in this dissertation because it can provide stronger inferences by combining qualitative data and quantitative data (Teddlie and Tashakkori, 2009).

Supplier-designer relationships have been studied insufficiently. There is a lack of qualitative and quantitative research on the subject. Therefore, a sequential mixed design was employed to answer exploratory and confirmatory questions in a predetermined order (Teddlie and Tashakkori, 2009). A qualitative, exploratory research with interview data was conducted first to increase understanding about supplier-designer relationships (Article I). The results of the exploratory research led to the formulation of conceptual research in which the framework and propositions on enhanced relationships between suppliers and designers were developed (Article II). Based on this exploratory and conceptual research, a series of quantitative hypotheses were developed and tested in a hypothet-

ico-deductive research design, with a questionnaire as the data source (Article III). The final inferences should be stronger because they were based on the results of both qualitative and quantitative research (Teddle and Tashakkori, 2009).

Supplier-contractor relationships have been studied somewhat more than supplier-designer relationships. A qualitative exploratory research with interview data was conducted to identify practices for enhancing the contractor-supplier relationship and utilizing the suppliers' innovation potential in construction projects (Article IV and Chapter 4.5). The inferences were based on individuals' perceptions that limit the external validity of the research. Due to limited time and resources for this dissertation research, further studies are encouraged to test and verify the success of the identified practices by quantitative research design.

3.3. Research methods

Table 4 summarizes the research methods, data collection, and data analysis technique employed in each individual article. Each individual article discusses the research methods, data collection, and data analysis more thoroughly.

TABLE 4. Research methods used in individual articles

Article	Research method	Data collection	Data analysis
Article I	<ul style="list-style-type: none"> • Qualitative research approach • Explorative research design 	<ul style="list-style-type: none"> • Semi-structured interview protocol • 11 interviews with architects • 11 interviews with structural engineers 	<ul style="list-style-type: none"> • Content analysis • Inductive approach
Article II	<ul style="list-style-type: none"> • Literature-based methodology • Conceptual approach 	<ul style="list-style-type: none"> • Literature search 	<ul style="list-style-type: none"> • Thematic analysis
Article III	<ul style="list-style-type: none"> • Quantitative research approach • Hypothetico-deductive research design 	<ul style="list-style-type: none"> • Structured questionnaires • 50 approved responses from architects • 39 approved responses from structural engineers 	<ul style="list-style-type: none"> • Factor analysis (construct validation) • Stepwise linear regression
Article IV and Chapter 4.5	<ul style="list-style-type: none"> • Qualitative research approach • Explorative research design 	<ul style="list-style-type: none"> • Semi-structured interview protocol • 18 interviews with purchasing personnel from 8 contractor firms 	<ul style="list-style-type: none"> • Content analysis • Inductive approach

A qualitative, exploratory research was employed in Articles I and IV and the additional results in Chapter 4.5. Exploratory research aims to generate information about unknown aspects of a phenomenon (Teddle and Tashakkori, 2009). Therefore, it is suitable for studying supplier-designer and supplier-contractor relationships that have not been studied sufficiently. A qualitative research design was chosen because it is suitable for studying the “how” type of research questions (Corbin and Strauss, 2008; Yin, 2003), and it is often exploratory in nature.

In Article II, the approach was conceptual. Previous empirical research on business relationships, project networks, and relationship strength was reviewed systematically to identify the factors required for strengthening relationships in project networks. Based on the literature review, a conceptual framework on factors explaining relationship strength between suppliers and designers in project networks was developed. Seven propositions are stated to be tested within this framework.

Due to the increased interest in explaining the relationship strength between suppliers and designers, and due to extant qualitative evidence on its antecedents, Article III employed a quantitative, hypothetico-deductive research design. Hypotheses were developed based on a theory and a conceptual framework, then tested by collecting quantitative data through a questionnaire.

3.4. Data collection and analysis

3.4.1. Interviews with designers

A purposive heterogeneous sampling strategy was used to select interviewees because it provides the opportunity to get information from interviewees who are relevant to the research in question (Bryman, 2015). In Article I, interviews were conducted with 22 structural engineers and architects as relevant third parties to discover the specifics of third-party relationship development in construction projects. One criterion for interviewee selection was their specialization in different kinds of construction projects. The specialties of the selected architects and structural engineers were evenly distributed between the design of residential, commercial, industrial, and public buildings. Renovation and infrastructure projects were excluded. A variety of interviewees was sought, so other selection criteria dealt with the interviewee's job title and firm's size. An equal share of architects and structural engineers among the interviewees was targeted to enable comparison between the two groups. Twenty-two interviews were considered a manageable and sufficient amount to offer a broad overview of the third parties' role in construction projects; different types of project types were included, and data saturation was observed during the early stages of the analysis. Interviews were conducted as individual meetings, with the exception of one paired interview with architects and one paired interview with structural engineers.

The interviews were conducted using a semi-structured interview protocol. The interview outline included questions related to the following themes: general information about the respondent and

company, material and component selection in construction projects, expectations of third parties towards suppliers, and collaboration between third parties and suppliers. In addition, some direct questions regarding the three component manufacturers were included. The interviews were recorded and fully transcribed. The interview data were content analyzed using an inductive approach on three themes: the influence and role of third parties in the construction projects, their expectations towards suppliers, and practices and starting points for (i.e., ways to initiate and develop) suppliers' third-party cooperation. Categories of third-party expectations were developed to estimate agreement among the 22 interviewees. Cross-tabulation is also used to highlight some findings.

3.4.2. Interviews with contractors

In Article IV and the additional findings presented in Chapter 4.5, purchasing personnel from contractor firms were selected as interviewees because they interact with suppliers and designers during construction projects. A purposive heterogeneous sampling strategy was also used to select these interviewees. Including employee- and managerial-level interviewees from small and large contractor firms was the objective, and therefore the selection criteria dealt with the interviewee's job title and the firm's size. Eight contractor firms of different sizes were selected as target companies in order to achieve variety. Selected firms varied from small local contractors to large international contractors. Eighteen interviewees were considered a manageable and sufficient amount to offer a broad overview of practice to exploit suppliers' potential in construction innovations, and data saturation was observed during the early stages of the analysis. Sixteen interviews were conducted as individual meetings, and there was one paired interview with two purchasing engineers.

The interviews were conducted using a semi-structured interview protocol to discover the specifics of the contractor-supplier relationships and innovations in construction projects. The interview outline included questions related to the following themes: general information about the respondent and company, purchasing decisions in construction projects, relationship and cooperation between contractors, suppliers and designers, and suppliers' role in construction innovations. The interviews were recorded and fully transcribed.

In the first phase of the analysis, the interview data was content analyzed for familiarization purposes. In the second phase, business-level and project-level practices were identified. This categorization was done because earlier literature noted that project- and business-level activities fulfill different roles in enhancing relationships and facilitating construction innovation (e.g., Gann and Salter, 2000; Jansson et al., 2015). Business-level practices are intra-organizational activities that are implemented outside a single project context, and these practices can influence multiple projects. Project-level practices are implemented within a single project context and usually have an impact on a single project only. Identification of project- and business-level practices showed that practices for enhancing relationships and those for utilizing the suppliers' innovation potential differ. Therefore, business-level and project-level practices were further divided into relationship-oriented and innovation-oriented practices to achieve a more detailed practice analysis.

Contractor interviews were further analyzed to explore the potential for triadic cooperation between contractors, designers, and suppliers (Chapter 4.5). An inductive approach on two themes was employed. The themes were the motives for the contractor to engage in triadic cooperation, and practices and challenges regarding the adoption of triadic cooperation between suppliers, contractors, and designers in construction project networks. Motives for contractors to engage in relationships were identified from interview data by using the Atlas.ti-program. Based on this identification, categories of contractor motives were developed to estimate the level of agreement between the 18 interviewees. Practices and challenges related to the adoption of triadic cooperation were also identified from interview data by using the Atlas.ti-program.

3.4.3. Literature review and framework development

The literature search in Article II focused on project management and construction management journals. Within these journals, primarily empirical studies on third-party relationships and strengthening the weak relationships in project networks were sought. This literature was somewhat scant, so the literature search was expanded to include literature concerning stronger relationships, namely inter-organizational relationships in project networks, supply chain management in construction, and relationship-based procurement. This way, the key empirical studies that have explored or explained relationship strength in some way or another were tracked.

A thematic analysis was used to analyze key empirical studies. Thematic analysis includes the formulation of themes within an educational criticism (Teddlie and Tashakkori, 2009). Themes were identified by gathering context, research methods, cooperative practices, and deliverables from each article into a table. From this table, similarities and differences in cooperative practices were analyzed to form themes. The identified themes were not directly applicable to supplier-designer relationships; therefore, earlier interview data gathered from designers was used to develop identified themes into propositions and a conceptual framework.

3.4.4. Questionnaire

Empirical data in Article III were collected through questionnaires. Initially, a questionnaire was developed based on previous literature and interviews with designers. The questionnaire was tested with local academics and practitioners. Thereafter, confusing items were corrected, and a few questions were added. With the help of local labor organizations, a list of randomly selected architects and structural engineers was formed. The list included valid e-mail addresses of 386 architects and 193 structural engineers. The total number of architects in Finland is approximately 4000, which implies that the sample represents approximately 10% of the total population. Information on the total number of structural engineers was not available. A web-based tool (Webropol) was used to distribute and collect the surveys. Ninety responses to the questionnaire were received, 51 from architects and 39 from structural engineers. One response from an architect was rejected because the response was incomplete; therefore, the resulting response rate was 15% from the sample,

which corresponds well to the typical response rate for electronic surveys. The age of the respondents varied between 25 and 65 years. Approximately 60% of the respondents were over 45 years old. Most of the respondents were men (75%), which is not surprising since the Finnish construction industry is predominantly male.

Variables used in the questionnaire study were developed based on the theoretical framework, and these are listed in Table 5. A detailed discussion of the formation of the variables is presented in Article III.

TABLE 5. Variables used in the questionnaire study

Dependent variable	Relationship strength
Independent variables	Supplier's activeness toward designers Supplier's technical capability Supplier's reputation Cooperation beyond project boundaries
Control variables	Supplier's size Respondent's background Respondent's work experience Revenue of design office Size of the project Client's background

Multi-item scales were used in this study and all items were measured on a five-point Likert scale from 1 "strongly disagree" to 5 "strongly agree." The scales employed in the present study were either developed specifically for this study or adapted from existing scales to suit the context of the present study. Scale items were developed on the basis of the review of literature and earlier interviews with architects and structural engineers.

In the first step of the quantitative analysis, descriptive statistics and correlation coefficients were calculated to assess the properties of the data. Then, stepwise linear regression analyses were conducted to test the associations between independent and dependent variables. The base model for both dependent variables included two steps: first the control variables were added and then the independent variables. The base models functioned well. To eliminate the issue of multicollinearity in the regression analysis, a variance inflation factor (VIF) test was performed. All the VIF values were below 1.80 and the tolerance levels were above 0.56, thereby confirming that multicollinearity was not a problem in this data set for regression modeling (Field, 2009). The tested models with the independent variables included were significant and had good explanatory power.

4. Findings

4.1. Developing a supplier's third-party relationships and cooperation in project networks

Article I explored the expectations of third parties in their relationships with suppliers, and the creation and management of such relationships in construction projects. The third parties chosen were architects and structural engineers, referred to jointly as 'designers' below. In addition, the article investigated purchasing decisions from the designers' perspective. This chapter presents the main findings of Article I. More detailed findings are presented in the published article.

4.1.1. Influence of designers on purchasing decisions in construction projects

Purchasing decisions in construction projects are context dependent. Still, there are some commonalities between different kinds of construction projects. Two primary steps can be identified in purchasing decisions, alongside significant influence exerted by architects and structural engineers. The first step is material selection, which is done during the design phase of the construction project. Designers make the preliminary material and product selections based on the requirements set for the project. Architects and structural engineers set the requirements for any materials and products to be used in the construction phase. They propose a specific brand name product that possesses certain technical qualities, or they list all the technical requirements that the product should fulfill. Architects create the overall aesthetic and design of buildings and other structures. Users' needs, official regulations, and town planning rules set various requirements for the design. Based on the requirements and their own vision, the architects select suitable materials and products. After selecting the materials and products, the architect drafts a design proposal and the client or construction manager approves it. The approved design proposal functions as a starting point for the structural design. Structural engineers design the structures to withstand stresses and pressures, such as weather and human use. They ensure that buildings and other structures remain strong and secure throughout their lifespan. Structural engineers choose appropriate materials and products to meet the design specifications. Sometimes they also interfere in the architectural design from a technical point of view.

The second step is supplier selection, which is prepared during the design phase, but the final decision is usually made only during the execution phase of the construction project. The contractor can invite suppliers to tender for different materials and products. Despite the architect's and structural engineer's proposals, the main contractor does not have to select the specific brands of products included in the design as such, but the selected products must meet all the same requirements. The main contractors' own interests can affect the supplier selection, or they might have previous experience with some other material and could request a change in materials. Furthermore, some main contractors have framework agreements with various suppliers that allow them to purchase high

volumes of construction materials at a lower price. Based on the tendering, the main contractor proposes the best supplier's product to the client, who then makes the final purchasing decisions. If the proposed product fulfills all the requirements and is cheaper than the product names in the design, then it can be selected instead of the architect's or structural engineer's preference. If the proposed product is not in line with all the requirements, then the client usually asks the architect's or structural engineer's opinion. Because architects and structural engineers have their own responsibilities and reputations to protect, they are very meticulous about material and product changes. Eventually, the client's final purchasing decision is a trade-off between requirements and price.

Based on the interviews, the power of designers' influence depends on the project type, client profile, and procurement method. Architects and structural engineers said that they have less power in recurring projects than in unique and complex projects. Designers expressed having more power when the client plans to own the building for a long time. Then it is easier to justify the material and supplier selections because the client's interest is that the building lasts and looks good for a long time. Interviewees also mentioned that they have more power when traditional procurement methods are used. This means that the main contractor is selected only after the design phase and most of the material selections have already been done.

4.1.2. Expectations of designers toward suppliers

According to the above overview, designers have the opportunity to significantly influence construction purchasing. Suppliers can affect these selections by meeting the expectations that the designers might have for them. The interviews revealed a number of the designers' key expectations for the suppliers (Figure 6).

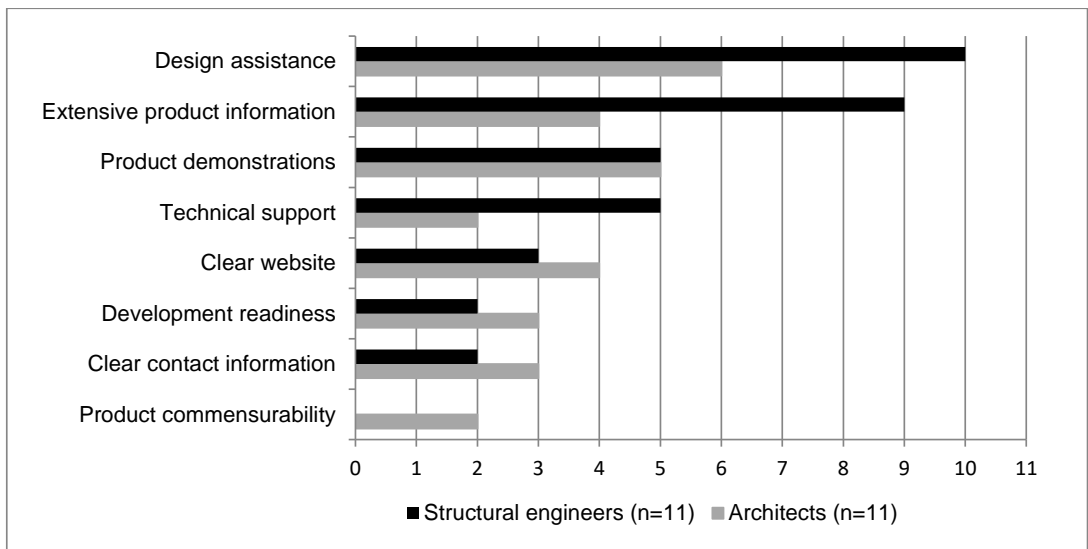


FIGURE 6. Summary of expectations of designers toward suppliers.

Design assistance, extensive and easily accessible product information, and product demonstrations are the most important expectations. Structural engineers almost unanimously expect suppliers to offer some design assistance to them and have product information easily accessible. In all, architects' expectations toward suppliers vary somewhat more than structural engineers' expectations, and are more oriented towards the visual aspects of knowledge availability, besides design assistance.

4.1.3. Practices of suppliers' cooperation with designers

Suppliers can have an influence on construction purchasing decisions through enhancing their cooperation with architects and structural engineers. Designers are positively oriented toward closer relationships and cooperation with suppliers. Cooperation usually begins within a single project and if the cooperation works well then it continues in future projects. According to the interviewees, it is very important to get the first opportunity for cooperation. Cooperation can come from the supplier's own initiative, the designer's initiative, or even another party's initiative. Initiatives and forms of cooperation that were identified in the interviews are summarized in Table 6.

TABLE 6. Initiatives and forms of cooperation with suppliers, experienced by designers.

	Designer's initiative	Supplier's initiative	Another party's initiative	The form of consequent cooperation
Knowledge-related	Ask for technical support	Product demonstrations		Technical consultation
Project-related	Design problem		Request for change	Problem solving
			Special requirements	Change management
				Product modification or development
Development-oriented	Development proposal	Request for product development		Cooperation on product development
		New solution		Pilot project
Relationship-oriented	Request a meeting	Request a meeting		Interpersonal relationship
				Partnership

In all, the initiatives may deal with product-oriented knowledge, the construction project, the development of construction materials and products, and the relationship between the parties more generally and over the long term. The results show that interpersonal relations are very often the trigger for developing closer relationships between these parties. Based on the interviews, key success factors for developing cooperative relationships are continuous and open information exchanges between the parties, solidarity between parties, and commitment to and reasonable resources for cooperation.

4.1.4. Contribution of Article I

Earlier research has not studied the influences of contractors and designers on the purchasing decisions made in construction projects (Emmitt, 2006; Frödell, 2014). This article contributes to the existing research by describing the influence from the designers' perspective, and findings reveal the crucial role of architects' and structural engineers' original proposals, as well as their acceptance of change requests with regard to the contractor's or client's choice of materials and suppliers. The article also offers important knowledge about the relationship between construction suppliers and designers, particularly in terms of designers' expectations and practical initiatives to enhance the relationship.

4.2. Framework for enhanced third-party relationships in project networks

The second article investigated third-party relationships between suppliers and designers in construction project networks and sought to increase understanding of how such relationships could be strengthened. This chapter presents the main findings of Article II. More detailed findings are presented in the published article.

4.2.1. Conceptual framework on relationship strength between designers and suppliers

Prior research on practices strengthening relationships in networks is somewhat scattered. This article contributes by collecting cooperative practices from different research streams, namely inter-organizational relationships in project networks, supply chain management in construction, and relationship-based procurement in construction projects. The existing literature has emphasized supply chain integration as a way to improve the performance of construction projects, and many authors have argued that design and construction should become better integrated (Jørgensen and Emmitt, 2009). However, earlier research has concentrated on firms at the center of the project network and their strong dyadic relationships. Suppliers and their relationships to designers are largely neglected in previous studies (Emmitt, 1997; Larsson et al., 2006).

Based on the literature review, a conceptual framework for enhanced third-party relationships between suppliers and designers in construction project networks was developed (Figure 7). Relationship strength is the dependent variable in this framework and it characterizes an inter-organizational relationship between the supplier and a design firm in terms of trust and commitment.

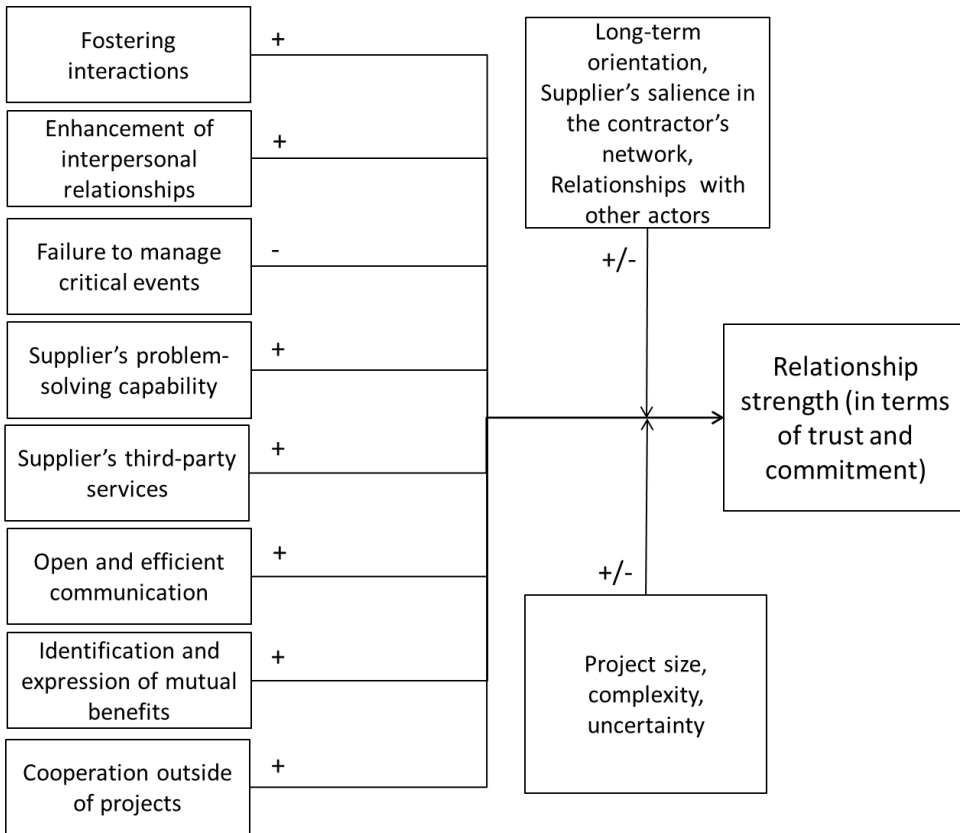


FIGURE 7. Conceptual framework on factors explaining relationship strength between suppliers and designers in project networks.

Previous literature implicates that the size, complexity, and uncertainty of the project, and the supplier's long-term orientation, position in the project network, and relationships with other network actors influence the relationship strength between suppliers and designers. It is assumed in this framework that these issues moderate the effectiveness of cooperative practices. Eight possible cooperative practices are presented in Figure 7. Based on these cooperative practices, seven propositions are stated to be tested within this framework (Table 7).

TABLE 7. Stated propositions

Proposition 1a.	Fostering interactions between suppliers and designers enhance the relationship strength between them at the organizational level.
Proposition 1b.	Enhancement of interpersonal relationships between a supplier and designer is positively associated with the relationship strength between the companies.
Proposition 2.	Failing to manage critical events in a joint project is negatively associated with supplier's and designer's relationship strength.
Proposition 3.	Supplier's problem-solving capability is positively associated with supplier's and designer's relationship strength.
Proposition 4.	Suppliers' third-party services are positively associated with the relationship strength between the companies.
Proposition 5.	Open and efficient communication enhances the relationship strength between the supplier and designers.
Proposition 6.	Identification and expression of mutual benefits enhances the relationship strength between the supplier and designers.
Proposition 7.	Cooperation outside of construction projects (e.g., in joint R&D) enhances the supplier's and designer's relationship strength.

The novelty of these propositions lies in the fact that the proposed cooperative practices have not been studied sufficiently in quantitative research designs and not at all for this specific third-party relationship. These propositions are justified in Article II.

4.2.2. Contribution of Article II

The conceptual framework contributes by offering knowledge on how the less salient, non-contractual relationships between suppliers and designers in project networks can be strengthened. This is important because many authors argue that inter-organizational relationship research should take into account all the parties involved in the construction supply and demand chains (e.g., Akintoye and Main, 2007). The conceptual framework also contributes to literature concerning actors' positions in a project network. Stronger ties with network members may increase the supplier's centrality in a contractor's project network (Pauget and Wald, 2013). This research formed the background for Article III, where the conceptual framework was further developed and tested in hypothetico-deductive research.

4.3. Enhancing the supplier's non-contractual project relationships with designers

As previous research has already examined relationship strength in various inter-organizational relationships, Article III sought prior evidence of its evaluation and antecedents, particularly those concerning the relationship between suppliers and designers in delivery projects. This study develops and tests a framework of relationship strength and its antecedents in the non-contractual relationship between suppliers and designers as third parties in construction projects. This chapter presents the main findings of Article III. More detailed findings are presented in the published article.

4.3.1. Antecedents of relationship strength

Establishment of trust and commitment in construction relationships is crucial, but is also a challenging task to accomplish. Antecedents that may be particularly relevant for non-contractual relationships between suppliers and designers were identified to be tested in this study. This study focuses on four potential antecedents: supplier's activeness, technical capability of the supplier, supplier's reputation, and supplier-designer cooperation beyond project boundaries. Table 8 lists the hypotheses formed.

TABLE 8. Hypotheses on relationship strength in supplier-designer relationships

Hypothesis 1a.	Component supplier's activeness toward designers is positively associated with the trust that designers direct toward the component supplier.
Hypothesis 1b.	Component supplier's activeness toward designers is positively associated with the commitment that designers direct toward the component supplier.
Hypothesis 2a.	Component supplier's technical capability is positively associated with the trust that designers direct toward the supplier.
Hypothesis 2b.	Component supplier's technical capability is positively associated with the commitment that designers direct toward the supplier.
Hypothesis 3a.	Component supplier's reputation in a market is positively associated with the trust that designers direct toward the supplier.
Hypothesis 3b.	Component supplier's reputation in a market is positively associated with the commitment that designers direct toward the supplier.
Hypothesis 4a.	Cooperation beyond project boundaries is positively associated with the trust that designers direct toward the supplier.
Hypothesis 4b.	Cooperation beyond project boundaries is positively associated with the commitment that designers direct toward the supplier.

Detailed justification and development of these hypothesis and related measures are presented in Article III.

4.3.2. Regression analysis results: Antecedents of relationship strength

Multiple linear regressions are applied to test the hypotheses. As illustrated in Table 9, trust is the dependent variable in Models 1a and 1b. Model 1a includes only the control variables; the model has no explanatory power, it is not significant, and none of the control variables has a significant association with trust. Model 1b adds the independent variables of supplier's activeness, supplier's technical capability, supplier's reputation, and supplier-designer cooperation beyond project boundaries to the model. The model has a high explanatory power (42%) and is significant, and the change compared to the base model is significant. The results reveal that the supplier's reputation and cooperation beyond project boundaries are not associated with trust at a significant level. Supplier activeness has a significant positive association (standardized beta = 0.26, $p < 0.01$) with trust, which supports Hypothesis 1a. In other words, when the designer perceives the supplier to be active in their relationship, the designer is also more trusting towards the supplier. The supplier's technical capability also has a strong and significant positive association (standardized beta = 0.51, $p < 0.01$) with trust, which supports Hypothesis 2a. Thus, the higher the designer's perception of the supplier's technical capability, the more the designer trusts the supplier.

TABLE 9. Regression results

Dependent variable	Trust		Commitment	
	Model 1a	Model 1b	Model 2a	Model 2b
Controls				
Profession	0.05	-0.01	0.32**	0.27*
Work experience	-0.03	-0.05	-0.10	-0.06
Revenue	-0.05	0.07	-0.18	-0.13
Customer background	-0.11	-0.01	0.10	0.17
Project size	0.07	-0.01	-0.06	-0.11
Supplier size	0.16	-0.01	0.23*	0.20
Independent variables				
Activeness		0.26**		-0.15
Technical		0.51**		0.24*
Reputation		0.15		0.09
Cooperation		0.07		0.24*
R ²	0.04	0.48	0.15	0.28
Adjusted R ²	0.00	0.42	0.09	0.19
R ² change	0.04	0.44	0.16	0.13
F	0.63	7.29	2.51	3.11
Sig. F change	n.s.	0.00	0.03	0.01

n = 89

* $p < 0.05$

Models 2a and 2b test the antecedents of commitment. As shown in Table 9, the first model has some explanatory power and is significant, thereby suggesting that the control variables alone explain commitment at a significant level. Of the control variables, the designer's profession is positive

and at a significant level associated with commitment in Models 2a and 2b. This implies that structural engineers are more likely than architects to be committed to suppliers. Further, the supplier's size is positively associated with commitment in Model 2a, thereby suggesting that respondents experience commitment more often with larger suppliers than they do with small ones.

Model 2b adds the independent variables to the model. The model is significant and has a moderate explanatory power (19%), and the change compared to the base model is significant. The results show that the supplier's technical capability is positively and significantly associated (standardized beta = 0.24, $p < 0.05$) with commitment, thereby supporting Hypothesis 2b. Thus, the higher the designer perceives the supplier's technical capabilities, the more committed the designer is to the supplier. Supplier-designer cooperation beyond project boundaries also has a significant positive association (standardized beta = 0.24, $p < 0.05$) with commitment, which supports Hypothesis 4b. Thus, designers who are involved in cooperation with the supplier beyond project boundaries are more committed to the supplier relationship. The other independent variables have no significant effect, so Hypotheses 1b and 3b are not supported.

In addition, the potential role of trust as a mediator between the independent variables and commitment were tested. Simple mediation models (Preacher and Hayes, 2008) were used to test the significance of mediating effects. However, these models show no significant mediation effect, so trust did not appear to mediate the independent variables and commitment in this sample. The main results are illustrated in Figure 8.

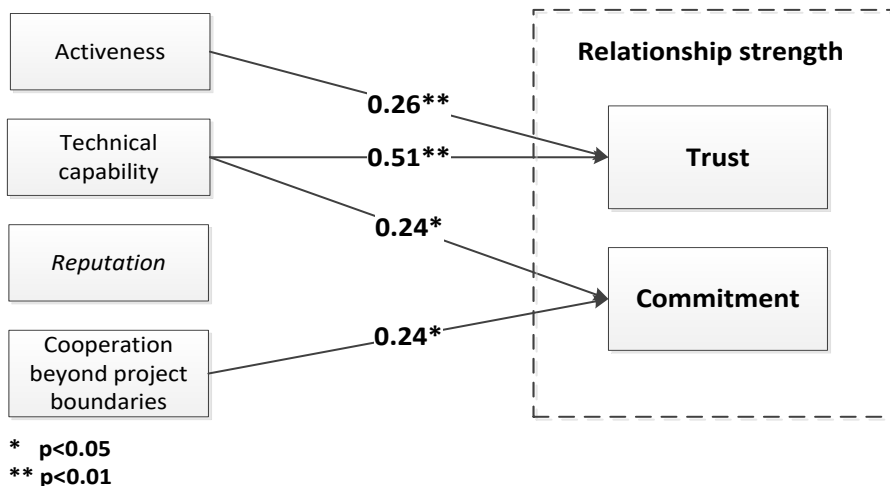


FIGURE 8. Illustration of the results.

Figure 8 only depicts the statistically significant relationships between the independent and dependent variables. Supplier's activeness has a strong and significant positive association with trust, but

no significant association with commitment. The results indicate that the supplier's technical capability is the most influential independent variable in this research. It has a strong and significant positive association with both the dimensions of relationship strength. The results did not reveal a significant relationship between reputation and relationship strength dimensions. Cooperation beyond project boundaries has a positive and significant association with relationship strength in terms of commitment, but not in terms of trust.

4.3.3. Contribution of Article III

Previous research on relationship strength has mainly been conceptual and has concentrated on contractual relationships (Bove and Johnson, 2001). This study brings empirical evidence regarding non-contractual relationships between suppliers and designers to the existing research on relationship strength. The findings revealed that the designer's experience of the supplier's activeness, the supplier's technical capability, and designer-supplier cooperation beyond project boundaries have a positive link to their perception of the relationship strength between the supplier and designer.

This research offers important knowledge on and practices for enhancing non-central actors' relationships with designers in construction project networks. Thereby, the results offer ideas for improving non-central actors' positions in project networks.

4.4. Utilizing the innovation potential of suppliers in construction projects

The fourth article focused on practices for enhancing contractor-supplier relationships and practices for utilizing suppliers' innovation potential in construction projects. This chapter presents the main findings of Article IV. More detailed findings are presented in the published article.

4.4.1. Relationship-oriented practices

Based on information provided in the interviews, the contractors experience improvement opportunities in their relationships with suppliers. Interviewees describe various business-level and project-level practices for enhancing the contractor-supplier relationship (Table 10).

TABLE 10. Relationship-oriented practices at business and project levels

	Contractor's practices	Supplier's practices
Business level	Framework agreements	Specific contact person
	Partnering	Reliable operation
	Category management	High-quality products
Project level	Reasonable tendering	Quick reactions to questions and problems
	Giving positive and negative feedback	Ensuring deliveries

Most of the interviewees select suppliers for a single construction project based on tendering. Still, they want to maintain a good relationship with these suppliers. Framework agreements with suppliers were mentioned frequently in the interviews. A framework agreement is a formal contract between the contractor and the supplier that guarantees a common future for at least one year. Although framework agreements are based on tenders, and the main motive is procurement efficiency, interviewees indicated that these agreements enhance their contractor-supplier relationships. This type of agreement increases interpersonal interaction and people get to know each other, which engenders trust between the contractor and supplier, thereby enhancing their relationship. A few interviewees indicated that they had partners on the supply side, or that they were looking for such partners. Their partner supplier checks the designs before tendering. This practice is highly useful for contractors, so sometimes they reward the partner by giving the delivery to them without tendering. Another type of reward that came up in the interviews was the piloting of the supplier's new product. These reward methods are not agreed upon in advance, but they keep the supplier satisfied. Only one interviewee stated that they were looking for a partner arrangement that focused on innovation.

Many interviewees underlined that contractor-supplier relationships are formed and enhanced on a personal level. The appropriate frequency of personal contact with supplier representatives depends on how well the supplier's products suit ongoing and forthcoming projects. The interviews suggest that some contractor firms ensure sufficient personal contact by appointing a category manager to oversee a certain product category. The category manager is responsible for keeping in touch with the suppliers and following the development of the product category. This category management practice enhances the contractors' relationships with the suppliers, which facilitates further cooperation and development activities.

In turn, the contractors expect the suppliers to also have a specific contact person in their company. This person should visit regularly, and the supplier should inform the contractor if their contact person changes. The question “how can a supplier enhance their relationship with a contractor” received one overwhelming response: through the supplier’s consistent good work. Interviewees expect high-quality products and reliable operation from their suppliers. Experiences from earlier projects indicate the quality of a supplier’s operations. Positive experiences and reliable deliveries enhance trust and cooperation between the contractor and supplier.

The suppliers’ quick reactions to questions and problems appear to be an important practice that enhances the contractor-supplier relationship. Construction project work is time-sensitive by nature, so a supplier’s quick reaction is highly valuable to contractors. Interviewees also greatly appreciate when a supplier confirms the correct delivery date a few weeks before the actual delivery. Delivery dates are agreed on with the suppliers in advance, but changes happen often in projects, and contractors do not always remember to inform the suppliers of such changes.

4.4.2. Innovation-oriented practices

The contractor interviewees unanimously agreed that the construction industry needs innovation as it has not developed much in the last 20 years. They also agree that the suppliers have a very important role to play in the development of innovations. This implies that the contractors acknowledge the suppliers’ innovation potential. Interviews revealed business- and project-level practices for utilizing this potential (Table 11). The main motive for the contractors to utilize the suppliers’ innovation potential is improved efficiency related to project objectives, cost, time, quality, and safety.

TABLE 11. Innovation-oriented practices at business and project levels

	Contractor's practices	Supplier's practices
Business level	Resources for development	Presenting new products and solutions
	Piloting new products and solutions	Proposing new product pilots
	Guiding supplier in new product implementation	Asking feedback and development ideas
Project level	Requesting alternative solutions	Checking designs in detail
	Tendering with incomplete designs	Proposing alternative solutions
	Cooperation in project network	

Most interviewees expected suppliers to actively provide information about new products and solutions to contractors, because contractors do not possess knowledge about every new solution. Suppliers should use multiple channels to share information. E-mail, trade journals, and websites are basic channels for information exchange, but many interviewees also highlighted the importance of personal product demonstrations.

The contractors acknowledged that new products should be piloted, but interviewees emphasized that the initiative for piloting should come from the supplier. They encourage the suppliers to actively propose new product pilots to contractors. If the contractor and supplier have a common interest, then a new product can be piloted. It came up in the interviews that development work requires resources and risk taking on the part of the contractor. Therefore, the suppliers should offer a price discount, or otherwise demonstrate a product's benefits, to get the first pilot. Contractors can also guide suppliers to bring new products to market. It is imperative to present new products or solutions to the correct audience. Depending on the situation, this could be the client, architect, structural designer, contractor, or subcontractor. Interviewees indicated that they can guide the supplier to present their ideas to the right people.

Regarding new product development, interviewees mentioned that problems occur at the construction site. Contractors use products at the construction site, so they are the only source of feedback and development ideas for suppliers. The problem is that the contractors do not automatically give their feedback to suppliers. Therefore, the suppliers need to ask for feedback and development ideas from contractors.

Contractors acknowledged that suppliers have the best knowledge in their field, so they are the most capable in terms of design development and the provision of alternative solutions. Interviewees added that designs can be over-dimensional or outdated. Therefore, some contractors request alternative solutions from suppliers in tendering. The interviewees emphasized the suppliers' development initiatives during and after tendering. In the tendering phase, some suppliers check the designs at the detail level, and differentiate themselves positively by raising questions and proposing alternative solutions. This is appreciated by the contractors, because it could solve problems and yield cost savings.

Interviewees described practices to enhance cooperation in the construction project network. Organizing meetings between the contractor, supplier, designer, and client was the most common practice that the interviewees mentioned. One contractor firm actively organizes workshops during the design phase of a project. They invite clients, designers, and relevant suppliers to their main workplace once a week. During the workshops, these parties develop the construction project further in small groups. Participants give positive feedback on this practice because it is an effective way to share information and develop new solutions. As a result, this contractor has developed a completely new manufacturing method for precast balconies in this manner. These new precast balconies fulfill the stakeholders' needs and are cheaper to produce.

4.4.3. Contribution of Article IV

The findings show that business-level practices for enhancing the relationships between contractors and suppliers are mainly formal at the organizational level. It is noteworthy that these practices are also the antecedents of informal socialization, and they have not been studied sufficiently in the construction industry (Lawson et al., 2009). At the project level, social interaction happens at an interpersonal level, and it most often starts with tendering. Many authors (e.g., Bemelmans et al., 2012a; Ellegaard et al., 2010) argue that further studies should take interpersonal relationships and the individual actor level into account. This research contributes by considering the informal and personal-level aspects of these practices that are relevant for improving the contractor-supplier relationship.

4.5. Potential for triadic cooperation in construction project networks

The potential for triadic cooperation between suppliers, contractors, and designers in construction project networks was also explored during the research process. This section presents the key findings of the analysis that utilized the same interview data as Article IV. Contractor interviewees highlighted that contractors, designers, and suppliers should work together more often, but currently these parties work rather independently. Contractors seemed to be motivated to engage in triadic cooperation with suppliers and designers. Four primary motives, each mentioned at least two times, are presented in Figure 9.

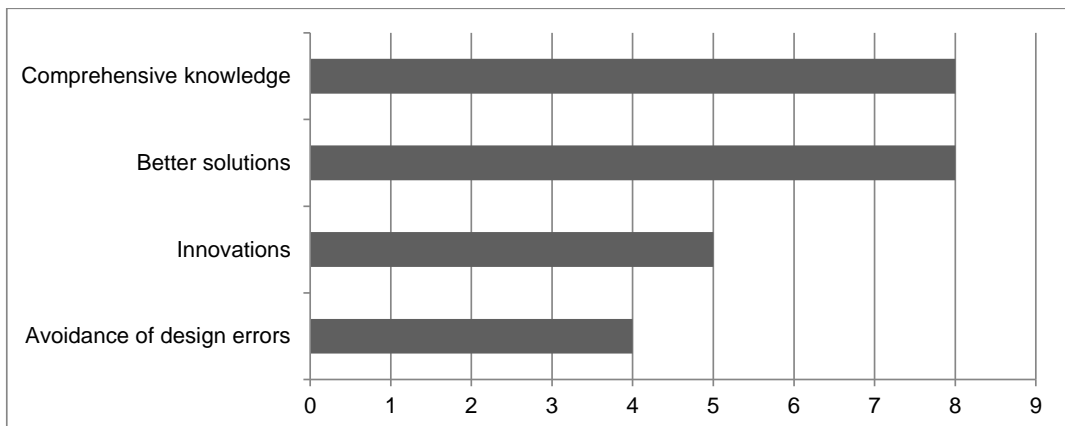


FIGURE 9. Motives for contractors to engage in triadic cooperation.

The two main motives for contractors to engage in triadic cooperation were comprehensive knowledge and better solutions. These motives are linked to each other. Cooperation among contractors, suppliers, and designers enable comprehensive knowledge to be gathered. This means

that each party's viewpoint is taken into account and the best available expertise is utilized, which most often leads to better solutions. Interviewees highlighted that triadic cooperation facilitates innovations, and that was the third biggest motive for contractors. Innovations are more likely to occur when the viewpoints and expertise of the contractor, supplier, and designer are combined. Four interviewees also mentioned avoidance of design errors as a motivator. According to interviewees, design changes and errors occur in every project. Triadic cooperation makes it possible to get the design right the first time, or at least notice design errors sooner.

Based on the interviews, only a few contractors have engaged in triadic cooperation in their construction projects. However, contractors were able to identify practices to foster triadic cooperation with suppliers and designers. Organizing meetings between contractors, suppliers, and designers was the practice that most commonly suggested by interviewees. Meetings should be arranged as early in the project as possible. In the meeting, these three parties go through the designs in detail and develop designs in collaboration. Moreover, follow-up meetings during the period of construction, where contractors, suppliers, and designers further refine designs and solve possible problems, were regarded as a highly useful practice. Interviewees mentioned that encouraging suppliers to offer alternative solutions and tendering with incomplete designs initiate the dialogue between contractors, suppliers, and designers. Tendering with incomplete designs is a possible practice in projects where the contractor has design responsibility.

Although multiple motives were identified, there are also some challenges related to triadic cooperation. Based on the interviews, project delivery method, public procurement regulations, resources, and commitment are the biggest challenges. The interviewees mentioned that the project delivery method should allow the contractor, supplier, and designer to work together from as early as in the design phase. Otherwise, contractors have no motive to engage in triadic cooperation. For this reason, the design-bid-build method is problematic. Public procurement regulations also pose a challenge because these restrict the involvement of suppliers before tendering. Cooperation also requires resources. Interviewees noted that money and schedules can be problematic in a project environment. The interviewees also emphasized that clients, contractors, designers, and suppliers should be fully committed to and supportive of triadic cooperation.

5. Discussion and conclusions

5.1. Influencing purchasing decisions in construction project networks

The first research question considers how suppliers can influence purchasing decisions through contractors and designers. To answer this question, this thesis provides empirical evidence on how designers and contractors influence purchasing decisions in construction project networks. Articles I and IV showed that the power of designers and contractors to influence purchasing decisions depends on the project type and contracting method. Based on Article I, designers have more power in complex projects because clients look for an expert (e.g., architect or structural engineer) who can handle the complexity best and develop the project jointly. Article IV in turn indicated that contractors have more power in recurring projects. The reason is that contractors have framework agreements with suppliers for high-volume products and components. These agreements allow contractors to purchase construction materials and components at a lower price. The client's final purchasing decision is a trade-off between requirements and price, and a lower price often wins.

The contracting method largely determines contractors' and designers' power to influence. Article I indicated that designers have more power when traditional contracting methods are used because the main contractor is selected after the design phase is complete and most of the material selections have already been done. Article IV pointed out that the contractor is the sole systems integrator between the supplier and the client in construction projects, where the contractor is contractually responsible for the design and construction (i.e., design-build and turnkey projects) (Rutten et al., 2009). The contractor has the power to guide designers, which guarantees their major influence on purchasing decisions.

To conclude, both contractors and designers could have a significant influence on purchasing decisions. Suppliers should identify the actor with the most influential role in purchasing decisions and try to exert their influence through this actor. Therefore, it seems to be essential that the suppliers direct their marketing activities toward contractors and designers. Suppliers have marketed their products to contractors and designers for decades, but their marketing activities have not been as successful as they could be (Emmitt and Yeomans, 2008). Articles I and IV provided information about contractors' and designers' expectations of suppliers. For suppliers, these expectations are guidelines for developing their marketing activities toward contractors and designers; these will be discussed in the following chapters.

5.1.1. Suppliers' marketing activities directed at designers

The influence of designers is channeled through specifications and expertise that clients use as a guideline in their decision making. The results of Article I and Article III indicate that designers have slightly different expectations of suppliers at the business level and at the project level. Therefore,

this thesis argues that suppliers need to shift their business- and project-level marketing activities toward designers in order to influence purchasing decisions in construction projects.

Research on designers' selection and specification of construction components is limited. Many suppliers fail in their marketing attempts because they do not understand the behavior and motivation of designers during specification work (Emmitt and Yeomans, 2008). Based on Article I, designers expect suppliers to make their work easier and faster. Suppliers can fulfill these expectations by providing easily accessible information on their websites (extensive product information and clear contact information), and design assistance (technical support, ready-to-use CAD pictures and 3D objects, and design software) at the business level. Designers have these high expectations because of their workloads and their schedules. Designers are often required to meet unrealistic deadlines to complete the design documentation for construction projects (Lopez et al., 2010). This research suggests that providing services that make designers' work easier and faster is a marketing practice that will encourage designers to select one supplier's product over that of their rival supplier.

Article I showed that designers expect that suppliers' trade representatives will demonstrate their products to them. Product demonstrations are highly important for the supplier because designers must be aware of the supplier's products. Otherwise, their products are not included in the specifications. Earlier research has acknowledged the importance of product demonstrations and trade representatives, but empirical research is scarce (Prior, 2013). It seems as though the behavior and timing of the trade representative determines the effectiveness of this marketing activity. Article I pointed out that designers do not like "being sold to" and they expected design guidance, samples, references, and technical knowledge from trade representatives. Article III also highlighted the importance of suppliers' technical capability. Furthermore, designers felt that product demonstrations were not useful if they were not currently engaged in projects in which the supplier's product could be used. Therefore, suppliers' trade representatives should be technically proficient and figure out who is potentially working on a particular project in order to schedule the product demonstrations in its early design phase.

5.1.2. Suppliers' marketing activities directed at contractors

In construction projects, the contractor is usually responsible for the purchasing. A contractor's purchasing behavior depends on their contracting method, and suppliers need to adjust their marketing activities based on that. Article I indicated that designers' specifications guide the contractors' purchasing preparations when the contractors are not contractually responsible for the design. Despite the designers' proposals, the main contractor does not have to select the specific product brands included in the design as such, but the selected products should meet the same requirements. Article IV, on the other hand, showed that contractors can guide designers in projects where they are contractually responsible for the design.

Article IV showed that contractors have framework agreements and partnering arrangements with selected suppliers at the business level. These agreements influence purchasing decisions in construction projects since contractors require or suggest using their preferred suppliers' products in all of their projects for specified period. The extent of the contractor's influence depends on the contracting method, as mentioned earlier. Achieving a framework agreement and making a partnering arrangement will be discussed in the next section that considers the enhancement of contractor-supplier relationships.

Contractors most often select suppliers for a single construction project based on competitive tendering (Article IV). This is in line with earlier research (e.g., Miller et al., 2002; Rundquist et al., 2013). Therefore, suppliers need to engage in deterministic marketing activities at the project level. Based on Article IV, this research expected that suppliers would check designs in detail and suggest alternative solutions in the tendering phase. Suggesting alternative products or solutions is one possible way for suppliers to differentiate themselves from their competitors at the project level. Contractors suggest alternative solutions to the client and designers if they offer value in terms of cost, schedule, quality, or safety. However, Article I showed that designers are meticulous about materials, product choices, and changes because they have their own responsibilities and reputations to protect. Therefore, suppliers should be able to justify the solution to designers as well.

5.1.3. Influencing purchasing decisions through innovation

Article IV showed that contractors expect suppliers to actively provide them with information about new products and propose new product pilots to them at the business level. Contractors highlighted the importance of personal product demonstrations, but noted that e-mails, trade journals, and websites are basic channels for general marketing at the business level. Contractors also stated that implementing new products requires resources and risk taking on their part. Therefore, the suppliers should offer a price discount, or otherwise demonstrate the benefits of their product, to get the first pilot. Promoting new products to contractors is an important way to influence purchasing decisions. Article IV implied that contractors can pilot new products in projects for which they are contractually responsible for the designs, or guide suppliers to present new solutions to the designer or client if they are convinced of the new product's benefits.

Similarly, suppliers can influence purchasing decisions by convincing designers of the advantages of new products. Article I implied that designers can justify the use of a new product to the client if they are convinced of its potential. This can lead to a very important first reference for the new product. Article I also showed that structural engineers were interested in the technical aspects and architects were interested in the visual aspects of new products. Designers were also concerned about the risks associated with the use of new products; instead, they tend to favor familiar products in design specifications (Article I). Therefore, suppliers should adjust their new product demonstrations according to the designers' interests and offer test results or guarantees that mitigate the risk to them.

5.1.4. Analyzing purchasing decisions from a triadic perspective

As indicated above, suppliers can influence purchasing decisions through contractors and designers. Articles I and IV indicated that the supplier's interaction with designers might have an influence on their relationship with the contractor and vice versa. This implies that the supplier-designer and supplier-contractor relationships are interconnected (Ritter, 2000; Vedel et al., 2012). Therefore, purchasing decisions should be analyzed from a triadic perspective. Ritter (2000) identified 10 different cases describing the possible impacts among inter-organizational relationships. These cases are used to describe possible impacts between the supplier-contractor relationship and the supplier-designer relationship.

The supplier's interaction with designers offers a possible way of influencing the contractors' purchasing decisions indirectly. The purpose of the trade representative is to raise designers' awareness about a supplier's products and the aim is to get the supplier's product into the specifications (Emmitt, 2001). If the trade representative is successful in this, the contractor might have to purchase the product from the supplier (Article I). In such cases the supplier bypasses the contractor, resulting in a "bypass effect" (Ritter, 2000). This usually weakens the relationship between the supplier and the contractor. On the other hand, the supplier's product in the specification might initiate a new relationship between the contractor and the supplier, whose product is included in the designs. In these cases, the supplier's interaction with the designer has a positive "initiation effect" (Ritter, 2000).

The supplier's interaction with the contractor might also influence the supplier-designer relationship. In Articles I and IV it is shown that the contractor can require the use of their partner supplier's product in the project. In this case, the contractor forbids the designer's interaction with other suppliers. Ritter (2000) labels this as the "hierarchy effect." This restricts the designer's creativity and options in the design phase and might cause negativity toward the partner supplier's products. The supplier can also suggest alternative products or development ideas in the tendering phase through the contractor (Article IV). Ritter (2000) calls this the "assistance effect," and it usually has a positive influence on the supplier-designer relationship. On the other hand, article I showed that designers are not always very gratified for the product changes, because they are then required to check or correct the designs. Therefore, the designer may be prejudiced against the supplier's suggestions.

Articles I and IV showed that suppliers should market their innovations for contractors and designers. If the supplier can convince the contractor about the advantages of the new product, the contractor can guide the supplier in presenting their innovation to the designer (Article IV). Ritter (2000) calls this the "initiation effect," because the contractor is introducing the supplier and the designer to each other. In this case, the supplier-contractor relationship positively influences the supplier-designer relationship. However, contractors and designers are risk averse (Blayse and Manley, 2004; Eriksson and Szentes, 2017). Therefore, they might take a negative attitude toward the supplier of the new product if the idea of using the new product is not their own.

5.2. Enhancement of suppliers' relationships with contractors and designers

The second research question concerned the enhancement of suppliers' relationships with contractors and designers in project networks. Enhancing relationships has been a major concern in construction-related research, but suppliers' relationships have not gained the attention they deserve. Each actor in a project network has different expectations regarding their relationships (Gadde et al., 2003), and fulfilling these expectations leads to enhanced relationships. This thesis contributes to earlier research by identifying contractors' and designers' expectations for suppliers and listing the practices that can be used to meet these expectations (Table 12). The practices are further divided into business- and project-level practices, because these play different roles in enhancing relationships.

TABLE 12. Practices for enhancing suppliers' relationships in construction project networks

	Business level	Project level
Activeness	Product demonstrations Presence at construction industry events Proposing new product pilots Nominated contact person	Ensuring deliveries Asking for feedback and development ideas
Technical capability	Technically qualified trade representatives Technical support Design assistance	Problem solving Suggesting alternative solutions Checking designs in detail Quick responses to questions Triadic cooperation
Cooperation	New product development Requesting a meeting Factory visits High-quality products Reliable operations	

5.2.1. Suppliers' activeness towards contractors and designers

Many authors (Ahola et al., 2013; Khalfan et al., 2007; Martinsuo and Ahola, 2010) have noticed in their case studies of direct supply chains that repeated interactions between actors strengthen their relationships. Repeated interactions provide opportunities for mutual trust to emerge and develop (Jiang et al., 2011). The contractors and designers in this study conveyed that they have the strongest relationships with those suppliers with whom they interact the most. This result complements the previous literature by showing that repeated interactions also foster weak relationships outside the

direct supply chain. However, the nature of project business implies that repeated interactions are not self-evident. Therefore, suppliers should be active in engaging with contractors and designers.

The results of Article III indicated that suppliers' activeness toward designers is positively associated with the trust that designers direct toward suppliers. The suppliers' activeness was measured by how actively they promoted and introduced their products and how actively they attended industry events and seminars. Also, contractors expected suppliers to actively give them information about new products and propose product pilots to them. Therefore, suppliers' product demonstrations and supplier's presence at events and seminars are important ways for suppliers to foster interactions with contractors and designers at the business level.

Regarding interactions, contractors and designers expected that suppliers would appoint contact persons for them. This business-level practice makes interaction more fluent and enhances interpersonal relationships. When studying the relationship strength between companies it is important to acknowledge the differences between interpersonal and inter-organizational relationships (Kamann et al., 2006). It has been observed that interpersonal relationships increase trust and commitment between organizations (e.g., Haimala, 2008; Kujala et al., 2013). Therefore, for suppliers, it is highly important that their representatives are able to create and enhance interpersonal relationships with contractors and designers. However, the development of relationships should not be left to individuals. Smyth and Fitch (2009) call for organizational management support, systems, procedures, and leadership to aid in the development of relationships.

Article IV showed that some contractors ensure sufficient interaction with suppliers by appointing a category manager to oversee a certain product category. The category manager is responsible for keeping in touch with the suppliers and following the development of the product category. Therefore, contractors' category managers and suppliers' representatives are counterparts that form the interpersonal link between organizations. A similar interpersonal link was not identified between suppliers and designers.

At the project level, contractors expect suppliers to confirm delivery dates in advance and ask for feedback and development ideas from contractors upon concluding each project (Article IV). Designers also indicated that they could offer development ideas to suppliers after projects (Article I). Asking for feedback and development ideas is a project-level practice that enables interaction and signals development readiness for contractors and designers. Feedback and development ideas are also important for suppliers' new product development because they do not often have sufficient information about product development needs (Larsson et al., 2006).

5.2.2. Suppliers' technical capability

The technical scope of projects is growing; thus, technical requirements have driven the trend toward outsourcing to a wide range of suppliers and subcontractors (Smyth et al., 2010). These trends highlight the importance of suppliers' technical capability that has been argued to motivate one to trust

others in a project environment (Lau and Rowlinson, 2009). Problems are unavoidable during a construction project and suppliers' technical capability is usually tested in problem-solving situations. Meng (2012) argues that the effectiveness of problem-solving processes is an important indicator for describing the relationship between the parties in construction projects. Therefore, this thesis argues that suppliers need to develop and demonstrate their technical capabilities to enhance their relationships with contractors and designers.

The results of Article I highlighted the importance of suppliers' technical capability as their design assistance and technical support were among the most important expectations of designers. Article III validated this finding as the results of the survey showed that suppliers' technical capability is positively associated with the trust and the commitment that designers direct toward them. Suppliers' technical capability was measured by three items based on the designers' experience. Designers evaluated how well suppliers' technical capabilities appeared to be in product demonstrations, technical support, and problem-solving situations. Based on this result, suppliers can enhance their relationships with designers by employing technically qualified trade representatives, by providing high-quality technical support, and by being able to help designers resolve problems.

The contractors in this study acknowledged that suppliers are the most knowledgeable in their field, so they are the most capable of engaging in design development and the provision of alternative solutions. Contractors said that designs can be over-dimensional or outdated. This is a problem well-known in the literature since designers' inadequate information about materials and components available often cause quality problems (Emmitt, 2006; Peat, 2009). Therefore, contractors expect that suppliers will check designs in detail and suggest alternative solutions (Article IV). Based on the results, suppliers can differentiate themselves positively at the project level by checking over designs in detail, asking questions, and proposing alternative solutions. Article IV also showed that a supplier's technical capability could lead to a long-term agreement with a contractor, since a few contractors were looking for partners who could provide design assistance in the design phase.

Construction project work is time-sensitive by nature, so a supplier's ability to quickly react is highly valuable to contractors and designers (Articles I and IV). Thus, suppliers that aim to enhance their relationships should promptly respond to technical questions and deliver fast solutions to problems encountered by contractors and designers. Research by Khalfan et al. (2007) showed that successful problem-solving increases trust at the construction site and successful problem-solving without referring to contracts could build relationships.

Article IV and Chapter 4.5 showed that contractors were motivated to initiate triadic cooperation at the project level between contractors, designers, and suppliers. Previous research has suggested that cooperation among these actors could lead to better designs and new innovations (e.g., Ozorhon, 2013; Hemström et al., 2017), but no practices to initiate cooperation have been proposed. This research showed that contractors can initiate cooperation between contractors, suppliers, and designers by inviting technically capable suppliers to attend design meetings and workshops. The

design phase of the project is the optimal phase in which to utilize the suppliers' technical capabilities, because decisions made during the design phase determine the materials and components that will be used in a construction project. The ability to influence designs is significantly lower in the construction phase. The importance of early supplier involvement is acknowledged in recent product development literature (Petersen et al., 2005), but the suppliers are not usually involved in the design phase of a construction project (Briscoe and Dainty, 2005).

5.2.3. Cooperation at the business level

Project networks are temporary sets of intra- and inter-organizational relationships between individuals and organizations that interact within the scope of one or several projects (Manning, 2005; Pauget and Wald, 2013). Relationships and project teams are often set up in project-based firms on a project-to-project basis (Rundquist et al., 2013). This became evident in Article IV, as contractors tend to select suppliers for individual projects based on competitive tendering. Therefore, development of long-term contractor-supplier cooperation at the business level is challenging. However, the results revealed that contractors were motivated to develop long-term collaborative relationships with suppliers (Article IV). Article I showed that designers were also interested in cooperating with suppliers at the business level. The results of Article III indicated that cooperation at the business level is positively associated with the commitment that designers direct toward the supplier. Thus, this thesis argues that suppliers could enhance their relationships with contractors and designers by fostering cooperation at the business level.

Suppliers can actively promote business-level cooperation by arranging a meeting, asking for help in new product development, or by inviting contractors and designers to visit their factories (Article I). Arranging a meeting or a factory visit is one possible way to get to know each other's business and generate new ideas for cooperation. Understanding each other's business helps to facilitate a closer and more innovative working relationship (Rundquist et al., 2013). This is highly important for suppliers' business-level cooperation with contractors and designers, since the business of project-focused firms and product-focused firms differs significantly. Rundquist et al. (2013) call this the project-product gap in the construction industry. This gap is causing onsite problems (Thunberg et al., 2017) and hindering construction innovations (Rundquist et al., 2013). It is acknowledged that construction innovations require cooperation among the different parties in a project network (Ozorhon, 2013; Rutten et al., 2009). Suppliers have the possibility to actively cooperate at the business level by involving contractors and designers in their new product development projects. Involvement in new product development, regular interaction, and sharing of sensitive information positively influence the development of trust (Jiang et al., 2011). Designers and contractors are interested in participating suppliers' new product developments, but limited time and resources for development work in project-oriented firms were considered hindering factors, so suppliers should offer reasonable compensation in exchange for cooperation (Article I and Article IV).

Articles I and IV showed that the initiative to engage in business-level cooperation can come from contractors and designers. Suppliers should identify these initiatives and take action to foster business-level cooperation. Possible initiatives from designers are product development proposals and meeting requests (Article I). Suppliers can develop their products based on such proposals and involve designers in the development process. Article IV showed that contractors' initiatives for business-level cooperation are invitations to tender for framework agreements, either annually or biennially. Achieving a framework agreement with a contractor means that they become the preferred supplier (Bemelmans et al., 2012b). This is the first step for a supplier towards creating more a collaborative relationship with contractors, since it enables cooperation at the business level and actors get to know each other, which engenders trust between the contractor and supplier, thereby enhancing their relationship. Although suppliers are selected based on competitive tendering, price is not as dominant a criterion as it is at the project level. Contractors expect high-quality products, development readiness, and reliable operation from their preferred suppliers (Article IV). Framework agreements are cost-efficient for suppliers because they do not have to involve tendering for each project, which saves them costs related to administration (Sundquist et al., 2012).

The next step for suppliers is partnering arrangements. Partnering has attracted a great deal of attention in recent research. However, the partnering research has focused on strong relationships between clients, contractors, and consultants (Bygballe et al., 2010; Eriksson et al., 2007). Practical research about implementing partnering between contractors and their suppliers is almost nonexistent (Eom et al., 2015). Article IV showed that contractors had few partnering arrangements with suppliers who provide design assistance to contractors. Partnering arrangements usually included the informal rewarding of suppliers (i.e., awarding the contract to a partner supplier without tendering). While earlier research acknowledges formal rewarding (through objective rewarding criteria) to enhance relationships (e.g., Bresnen, 2007; Khalfan et al., 2007), this thesis emphasized informal rewarding as a practice for enhancing the contractor-supplier relationships at the business level.

Strategic partnering is the most collaborative relationship in the construction industry (Pala et al., 2014). Ross and Goulding (2007) noted that contractors are willing to develop closer relationships with their supply chain, but they are not advanced within it. Only one contractor in this study stated that it was looking for a strategic partnership arrangement with suppliers (Article IV). This result complements earlier research by indicating that contractors are in the early stages of developing their relationships with suppliers.

Supply chain management literature acknowledges that developing collaborative relationships requires resources from contractors and suppliers (Pala et al., 2014). Contractors should classify suppliers into various categories and focus their resources on the most important suppliers with whom the cooperation could offer significant value (Bemelmans et al., 2012b; Rundquist et al., 2013). Therefore, suppliers willing to develop collaborative relationships with contractors need to convince contractors of the value that cooperation can yield.

5.3. Contributions

5.3.1. Contributions to project network research

This thesis offers two main contributions to the project network literature. The first contribution relates to understanding the improvement of non-central actors' positions in the construction project network. The second contribution relates to the analysis of project-level and business-level practices for improving actors' positions in project networks.

Prior literature has focused on central actors and less attention has been paid to the non-central firms whose aim might be to improve their position in project networks. An actor's position in a project network is defined by the characteristics of their relationships and by other network actors' perceptions (Gadde et al., 2003). Therefore, this thesis argues that non-central actors can improve their positions in project networks by enhancing their relationships with central actors and by influencing the perceptions and knowledge of other actors.

This thesis focused on suppliers as non-central actors and their relationships with contractors and designers. A supplier's position in a project network is non-central because its connections to construction project actors are weak (Håkansson and Ingemansson, 2013). Non-central actors usually have low closeness centrality, which means that they are dependent on intermediary actors to access other regions of the network (Rowley, 1997). This is also the case with suppliers in a construction project network, since they do not usually have direct links to clients in construction project networks. Contractors and designers are the most central actors in project networks from a supplier's perspective, since they are intermediaries between suppliers and other project actors. Therefore, enhancement of suppliers' relationships with contractors and designers improves their centrality.

This thesis demonstrates that enhanced relationships with central actors provide access to information and improve a supplier's potential to influence others in the project network. However, enhancing non-central actors' relationships is context dependent because each actor in project networks has different expectations and interests in terms of their relationships (Gadde et al., 2003). Trust is a key measure of relationship strength, and in project business trust is a current conviction that another party is willing to consider individual and organizational interests within the context and under possible events (Smyth et al., 2010). Therefore, this thesis suggests that considering the expectations and interests of central actors in the project network is a key success factor in enhancing non-central actors' relationships in project networks.

As discussed earlier in this thesis, an actor's position in a project network is determined by the perceptions and actions of other actors (Gadde et al., 2003). This thesis showed that suppliers are dependent on the actions of contractors and designers who are intermediary actors between suppliers and clients. Contractors' and designers' perceptions are revealed in their purchasing decisions, which determine suppliers' positions in the project network. To be considered as a potential supplier

in a project network, suppliers need to influence contractors' and designers' perceptions, as discussed in Chapter 5.1. This thesis contributes to previous literature by indicating that non-central actors' marketing activities need to target intermediary actors in order to improve their position in project networks.

Project network research recognizes a project business network that combines the past, present, and future into a network of business actors that are, or potentially could be, involved in mutual business activities in current or future project networks (Arto et al., 2008). Single project networks are formed to achieve predefined targets and actors are selected from underlying project business networks (Figure 10). Prior research on actors' positions in networks has not differentiated between project networks and project business networks.

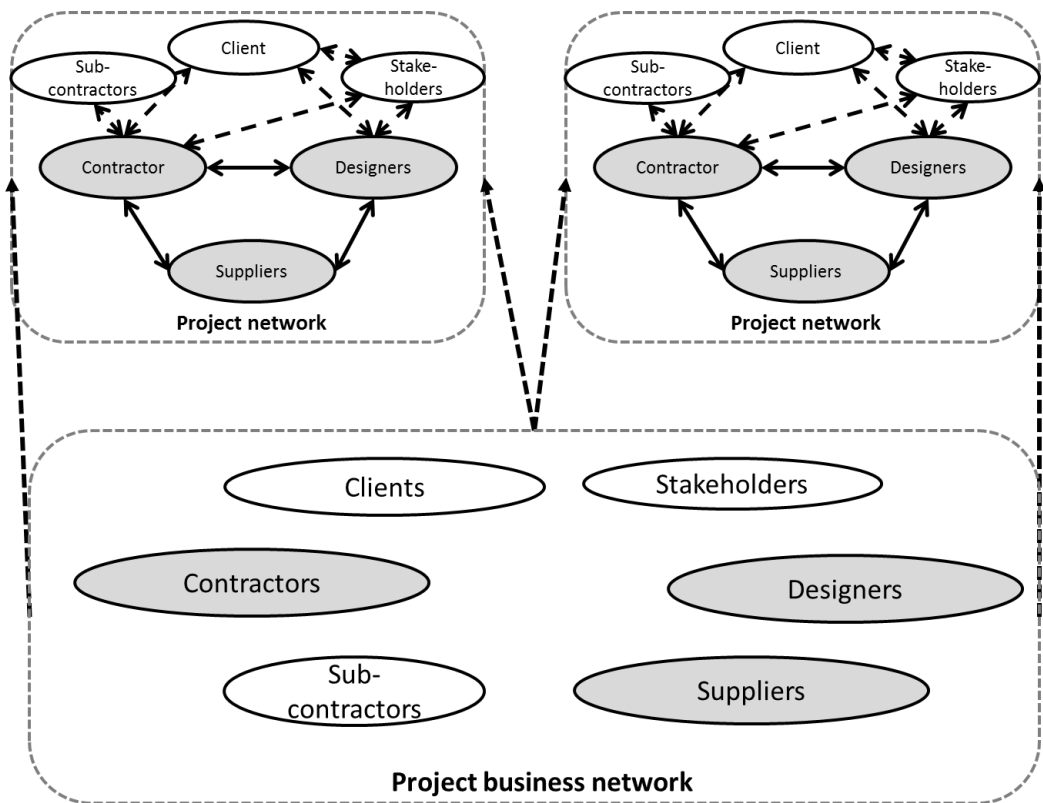


FIGURE 10. Project business network and project networks.

It has been noted that project-based firms may have advanced project processes, but they often have much weaker business processes (Gann, 2001). This thesis contributes to earlier literature by differentiating business-level and project-level practices for improving non-central actors' positions.

Business-level practices are defined as practices that are implemented outside a single project context, and these practices can influence multiple projects. Project-level practices are implemented within a single project context, and usually have an impact on a single project alone. Business-level practices aim to improve an actor's position in a project business network. Project-level practices aim to improve an actor's position in a project network. Based on these findings, suppliers can improve their position in a single project network by implementing project-level practices, but they need to develop business-level practices to improve their position in the underlying project business network. However, the difference is not so clear because business-level practices influence project networks and project-level practices can have consequences for the project business network.

5.3.2. Contributions to project marketing research

Project marketing research has concentrated on the marketing activities of project-selling firms, such as contractors (Cova and Salle, 2007). The findings of this thesis contribute to existing research by providing new insight into project marketing activities that product-oriented firms, such as suppliers, can apply in construction project networks. This thesis highlights the need for suppliers to have an early influence on purchasing decisions, since decisions made during the design phase determine the materials and components that will be used in a construction project.

The findings showed that designers and contractors have a significant influence on the purchasing decisions made in construction project networks. In line with project marketing research (Cova and Salle, 2008; Jalkala et al., 2010; Skaates and Tikkanen, 2003), this thesis suggests that suppliers should identify the actor that has the most influential role in purchasing decisions and focus marketing activities on that actor at the project level. Depending on project contracting, the most influential actor at the project level can be contractor, designer, or client. At the business level, suppliers should market their products and technical capabilities to both designers and contractors in order to be considered as potential suppliers in the project business network. This thesis did not investigate suppliers' marketing activities directed toward clients, but it is suggested as a topic for future research.

While earlier research has focused on clients' contractor selection and contractors' marketing activities, clearly less is known about supplier selection and suppliers' marketing activities directed at contractors and designers. This thesis contributes to earlier research by improving understanding of designers' and contractors' needs and their behavior during purchasing preparation, which has not attracted much attention in previous research (Emmitt and Yeomans, 2008; Manley, 2008). Based on this understanding, this research proposes that suppliers market directly to designers and contractors. These marketing activities are highly important for suppliers who want to escape the trap of the competitive bidding process.

The proposed marketing activities for suppliers aim to make designers' work easier during specification so that they will use the suppliers' products instead of their competitors' products. Therefore, suppliers' marketing activities toward designers are a form of constructivist project marketing (Cova

and Salle, 2005). This study indicates that suppliers should use both constructivist and deterministic postures in their marketing activities towards contractors, although current marketing strategies mostly suggest taking a constructivist posture (Jalkala et al., 2010). The reason for using a deterministic posture is the fact that most contractors still select suppliers based on competitive tendering. Therefore, suppliers need to employ deterministic marketing activities (e.g., checking designs in detail and suggesting alternative solutions) that differentiate them from their competitors in the tendering phase. Constructivist marketing activities towards contractors aim to provide information about new products, get product pilots, and achieve long-term agreements with contractors.

5.3.3. Contributions to inter-organizational relationships research

This thesis concentrated on suppliers as non-central actors in construction project networks and their inter-organizational relationships with contractors and designers. This is a new perspective, because earlier research has focused on contractors' and clients' strong inter-organizational relationships instead (Bemelmans et al., 2012a; Bygballe et al., 2010). Suppliers' relationships differ from contractors' and clients' relationships because they are usually weak. Furthermore, suppliers and designers do not have contractual relationships. Therefore, this thesis contributes by increasing understanding about strengthening non-central actors' weak relationships.

This thesis highlighted the importance of trust and commitment in inter-organizational relationships. Consequently, relationship strength is suggested as a measure to evaluate non-central actors' relationships in construction project networks. Prior research on practices aimed at strengthening relationships in networks is somewhat scattered. This thesis contributes by collecting practices from different research streams, namely inter-organizational relationships in project networks, supply chain management in construction, and relationship-based procurement in construction projects. Based on a literature review and empirical data, this thesis divides the identified practices into three different categories: activeness, technical capability, and cooperation. The practices in these categories help suppliers to strengthen their relationships with contractors and designers.

Earlier research highlighted the importance of cooperation between the different parties in construction project networks (e.g., Hemström et al., 2017; Ozorhon, 2013; Rutten et al., 2009). However, there is a lack of research into the cooperation between the adopters of new products (e.g., architects, structural engineers, and contractors) and the suppliers (Emmitt, 1997; Larsson et al., 2006). This thesis contributes by increasing understanding about the cooperation between suppliers, contractors, and designers at project and business levels. The results showed that the initiative to engage in cooperation can come from contractors, designers, or suppliers. At the project level, contractors' and designers' initiatives for cooperating with suppliers were usually related to the design of the building. Therefore, this thesis lends support to the idea that design and planning work can be considered as an important linking point between collaboration partners in construction projects (Mahmoud-Jouini, 2000). At the business level, suppliers' initiatives for engaging in cooperation with

contractors and designers related to new product development. Therefore, suppliers' new product development is suggested as another linking point between suppliers, contractors, and designers.

Inter-organizational relationships in construction project networks have been mainly studied from the dyadic perspective, particularly regarding the dyads formed between clients and main contractors (e.g., Bresnen and Marshall, 2000) or between contractors and their subcontractors (e.g., Beemelmans et al., 2012a). This thesis contributes to earlier research by analyzing the interconnectedness of supplier-contractor and supplier-designer relationships from a triadic perspective. The triadic perspective revealed that these relationships are interconnected and that the influences of these interconnections become evident during purchasing decisions. The analysis indicated that suppliers' marketing activities aimed at designers might have a negative or a positive influence on their relationships with contractors. In an analogous way, suppliers' marketing activities aimed at the contractor might have a negative or a positive influence on their relationships with designers. Therefore, suppliers should analyze and consider their interactions with contractors and designers from a triadic perspective. Construction project networks include also other relationships that are interconnected. For example, suppliers' relationships with subcontractors and contractors, and clients' relationships with contractors and designers form relevant triads in project networks. The dyadic perspective is not enough for understanding the interconnections between these relationships (Vedel et al., 2012). For that reason, this thesis suggests that interorganizational relationships in construction project networks should be analyzed from the triadic perspective.

Chapter 4.5 implied that triadic cooperation between contractors, designers, and suppliers could yield benefits such as comprehensive knowledge, better solutions, innovations, and prevent design errors. However, currently these parties work rather separately and focus on their own interests. Identifying the interests of project network actors and overcoming conflicting interests is a key factor for success in developing multi-actor cooperation (Leufkens and Noorderhaven, 2011). Project alliance research suggests that setting joint objectives and rewarding actors for achieving these objectives enables multi-actor cooperation (Lloyd-Walker and Walker, 2011). Based on this knowledge, this thesis suggests that clients or contractors develop supply alliances with joint objectives and rewards that motivate contractors, designers, and suppliers to cooperate already in the design phase of the project.

5.3.4. Contributions to construction innovation research

This thesis was motivated by the fact that suppliers possess huge innovation potential in the construction industry (Bygballe and Ingemansson, 2014; Gambatese and Hallowell, 2011; Hemström et al., 2017), but there are barriers in construction project networks that hinder this potential. This research contributes by suggesting ways to overcome these barriers.

The first barrier is that suppliers do not have sufficient knowledge of client needs, product development needs, and potential areas for innovation (Larsson et al., 2006; Rundquist et al., 2013; Wandahl et al., 2011). Contractors and designers in this study implied that they have knowledge that would

help suppliers to develop their products (Article I and Article IV). However, they do not automatically give this information to suppliers. Therefore, suppliers need to actively seek out this information from contractors and designers. Suppliers can do this by asking for feedback and development ideas from contractors and designers after each project. Another practice is to invite contractors and designers to participate in the development of suppliers' new products.

The second barrier is that contractors and designers tend to favor tried and tested solutions (Blayse and Manley, 2004; Eriksson and Szentes, 2017; Hemström et al., 2017). This thesis implies that overcoming this barrier requires the suppliers to have marketing capabilities. There is very little research that deals with the role of suppliers in promoting and diffusing innovation in the construction industry (Manley, 2008). This thesis contributes to earlier research by revealing issues that need to be considered, while promoting innovations for systems integrators, namely contractors and designers, in this study. Previous research has acknowledged that the implementation of innovations depends on how convinced the systems integrator is of the merits of the new ideas (Winch, 1998). To convince contractors and designers of the benefits of new products, this thesis suggests that suppliers adjust their new product demonstrations according to contractors' and designers' interests and offer test results or guarantees that mitigate the risk to contractors and designers. Recent research by Hemström et al. (2017) support this suggestion. In their research, architects in Sweden suggested that the improved communication of test results and innovation knowledge could facilitate innovativeness in the construction industry. Furthermore, this thesis implies that suppliers' enhanced relationships with systems integrators increase the chances of convincing them of the benefits of new products.

The third barrier that became evident in this study was that contractors and designers do not fully utilize suppliers' innovation potential. Contractors and designers in this study implied that they acknowledge suppliers' development and innovation potential (Article I, Article III, and Article IV); however, they do not actively utilize this potential in the design phase. The importance of early supplier involvement is acknowledged in new product development literature (Petersen et al., 2005), but the suppliers are not usually involved in the design phase of a construction project (Briscoe and Dainty, 2005). Therefore, this research encourages contractors and designers to actively involve suppliers, who are capable of developing designs and innovations, in the design phase. Article IV showed that contractors are passive in utilizing the suppliers' innovation potential at the business level. One reason might be their short-term project-level focus (Eriksson and Szentes, 2017). The contractors have practices to utilize the suppliers' innovation potential, but they expect the initiative to come solely from the suppliers. This research suggests that contractors should take a more active role at the business level. This can be done by proposing development needs to suppliers, helping suppliers in the adoption of new products, setting development targets in framework agreements, and developing partnering arrangements with suppliers that are focusing on the development of new innovations.

5.4. Managerial implications

As a managerial implication, this research offers potential project- and business-level practices for enhancing contractor-supplier and designer-supplier relationships (Table 12). Suppliers could use these practices to construct a more central position in project networks through an enhanced relationship with contractors and designers. The research suggests that suppliers should be active in engaging with designers and contractors. Otherwise, the suppliers do not get the opportunity to interact with contractors and designers that is essential to enhancing their relationships. Suppliers should demonstrate their technical capability in order to gain the designers' and contractors' trust. Furthermore, suppliers should promote cooperation and identify contractors' and designers' initiatives for cooperation. This study indicates that suppliers can influence purchasing decisions by developing their marketing activities to target contractors and designers. Chapter 5.1 suggested a number of marketing activities that suppliers can employ to market their new products and knowledge more effectively.

For contractors and designers, this thesis suggests a variety of practices to enhance their relationships with suppliers (Tables 6 and 10). The results of Article IV also revealed opportunities to exploit suppliers' knowledge and innovation potential in construction project networks (Table 11). In particular, involving suppliers in the design phase of construction projects enables the exploitation of suppliers' potential. Contractors and designers could also foster construction innovation by giving feedback and offering development ideas to suppliers. This is crucial for suppliers who often have insufficient information about product development needs.

Overall, the study highlights the importance of business-level actions. It is important to enhance relationships and solve problems at the project level, but enhancing relationships and developing new solutions at the business level is far more impactful. Earlier research has noticed that long-term relationships and cooperation at the business level enable continuous improvement and increase the opportunities for innovation to take place. Therefore, suppliers should promote business-level cooperation by involving contractors and designers in their new product development projects and by inviting contractors and designers to visit their factories. It is evident that contractors have a crucial role to play at the business level because they have the power to decide whether to engage in adversarial relationships or develop long-term collaborative relationships with suppliers. Therefore, this study encourages contractors to manage their supplier relationships at the business level and develop long-term collaborative relationships with suppliers who have the ability to develop designs and innovations.

5.5. Validity and reliability of the research

This research employed a mixed method research design in which quantitative and qualitative approaches are mixed during the research process. The validity and reliability of the research was pursued by using triangulation of data collection methods and research methods. Triangulation refers to the combinations and comparisons of multiple data collection methods and research methods (Teddlie and Tashakkori, 2009). This is widely used to increase validity and reliability of the research. In this research, the use of three data collection methods (interviews, literature search and questionnaires) and two research methods (quantitative and qualitative) increase validity and reliability of the research, because these methods counterbalance each other's validity and reliability problems (Abowitz and Toole, 2010). Furthermore, all the articles are published in high-quality journals. This confirmed the validity of the research since the articles were peer-reviewed and revised based on reviewers' comments before they were published.

Data quality in mixed methods research is determined by separate standards for quantitative and qualitative data. If the qualitative and quantitative data are valid and reliable, then the mixed method research will have good data quality (Teddlie and Tashakkori, 2009). The quality of the quantitative data can be evaluated through validity and reliability (Teddlie and Tashakkori, 2009). The validity of the quantitative data (Article III) was verified through four different means. Firstly, the content validity was established through developing the measures based on prior literature and qualitative research. Secondly, the convergence validity was established by checking the unidimensionality of the scales. The items loaded well on the intended factors, and the factor scores were sufficiently high (exceptions will be addressed in the limitations). Thirdly, in order to account for common method variance (Podsakoff and Organ, 1986), the respondents were purposefully instructed to focus on one recently finished ordinary construction project and one supplier from that project; to avoid social desirability bias towards successful projects, the questionnaire was organized to cover items for the independent variables before the dependent variables, and the scales were trimmed by removing overlapping items from the variables used. Fourthly, Harman's single factor test (Podsakoff and Organ, 1986) was used to examine the possible presence of common method variance, and since it showed that a single factor did not explain enough of the variance, common method bias was not a problem in this study.

The reliability of the quantitative data was estimated by calculating Cronbach's alpha for each factor. Cronbach's alpha measures the internal consistency of the variable and it is a widely used measure of reliability (Teddlie and Tashakkori, 2009). The values for Cronbach's alpha varied between 0.72 and 0.89. The values are acceptable if they are over 0.7. Thus, reliability of the quantitative data was acceptable.

The quality of the qualitative data can be evaluated through credibility, transferability, dependability, and confirmability (Lincoln and Guba, 1985). Credibility was pursued by achieving sufficient variety

in the respondent and company sampling (Articles I and IV). The interviews were also recorded and fully transcribed, which enabled reliable data analysis by ensuring that the relevant evidence could be traced. The findings were supported by using illustrative quotations from interviews. Furthermore, interpretations of the qualitative data were discussed with the co-author and other researchers. This is called a member check, which ensures the credibility of the researcher's interpretations (Teddle and Tashakkori, 2009).

The data collection and context of the research was described in detail in each article. Thick descriptions increase transparency of the data that is essential for transferability (Teddle and Tashakkori, 2009). Otherwise, the reader cannot make comparisons to the other studies. Dependability and confirmability was pursued by documenting the research (Lincoln and Guba, 1985). The interview protocols were developed in collaboration with the co-author and they were improved through pilot interviews. This ensures that questions are unambiguous and comprehensible. Furthermore, interview outlines were sent to each interviewee before the interview, so they knew objectives of the research. Each step of the research was documented so that other researchers can evaluate the results and repeat the study if necessary.

5.6. Limitations and suggestions for further research

This study was limited by its single country context, choices regarding the research methods, and the data collection. In Finland, the construction industry is similar to that of other Nordic countries. It is regulated by Eurocodes and the national building code. The national building code and Finnish authorities set strict requirements for suppliers' products that hinder suppliers' innovation potential. Therefore, the national characteristics of the construction industry should be considered when evaluating the applicability of the results to other countries. For that reason, further research is encouraged to test the results of this study in the context of different countries. The international context should also be included in future studies because this study focused on national projects.

A mixed methods research strategy, which included both qualitative and quantitative research methods, was employed in this study. The data quality set limitations on the validity and reliability of the study. These limitations were discussed earlier in Chapter 3.5. The data collection was limited by the decision to focus on contractors and designers as interviewees. The construction project networks include multiple actors that were not covered here, such as clients, subcontractors, and authorities—they should be included in future research. The project type considered in this research also served as a limitation: as the selected interviewees worked in building projects, the identified practices may not be applicable to infrastructure projects. Furthermore, the results of Articles I and IV are based on interviewees' perceptions, which limits the external validity of the research. Each interviewee gave their opinion on the project network in which they are involved. Therefore, the data

included only one perspective from each project network. Further research could focus on a single project network more thoroughly and incorporate multiple perspectives.

The quantitative method employed in Article III was limited by the unavailability of earlier empirical evidence on designer-supplier cooperation and other types of non-contractual relationships. Therefore, the theoretical model was partially based on evidence from contractual project relationships and qualitative evidence. Further research is needed to improve the validity of the framework on relationship strength and its antecedents in non-contractual relationships.

The focus on suppliers of materials and components delimited the study as the findings do not include the perspective of service suppliers. Therefore, the practices identified for enhancing the suppliers' position in project networks are not directly applicable to service suppliers. Further research could explore the relationships and innovation potential of service suppliers in construction project networks. This thesis identified potential benefits that the triadic cooperation among contractors, designers and suppliers could enable. However, this thesis explored the potential of triadic cooperation from the contractors' perspective alone, which limits the validity of the findings. For that reason, future research should consider exploring multiple viewpoints on triadic cooperation in case studies, country comparisons in triadic cooperation, and differences in triadic cooperation in different project types. Issues concerning responsibility sharing in multi-partner cooperation should also be considered more broadly.

This thesis differentiated between business-level and project-level practices for improving the positions of non-central actors. Further research is encouraged to explore how inter-organizational relationships differ in project networks and in project business networks. In addition, examining business-level practices for sustaining a central position in a project business network is suggested as a topic of future research. Suppliers' development of new products and the design phase of a construction project are suggested as linking points between suppliers, contractors, and designers. A case study exploring the benefits of triadic cooperation for new product development and in the design phase would be particularly interesting.

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IV

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