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

Rami Sariola[a1] and Miia Martinsuo[a]
[a]Tampere University of Technology, Department of Industrial Management
P.O. Box 541, 33101 Tampere, Finland
[1] Corresponding author: rami.sariola@tut.fi

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Abstract

Project delivery involves networks of customers, contractors, sub-contractors, suppliers, and designers. Strong interorganizational relationships are considered relevant to project performance. Previous research has focused on contractual relationships in direct supply chains, with little attention to suppliers and their non-contractual relationships. 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. The intent is to identify the key factors relevant to enhancing the supplier's non-contractual relationships with designers. The results reveal the supplier's activeness and technical capability as antecedents to trust, and supplier's technical capability and supplier-designer cooperation beyond project boundaries as antecedents to commitment. The different antecedents of trust and commitment imply alternative pathways for strengthening non-contractual relationships in construction projects, thereby deviating from activities in contractual relationships. Further research is proposed on other types of third parties and other antecedents of commitment.

Keywords: project networks; relationship strength; interorganizational relationship; non-contractual relationship; trust; commitment

1 Introduction

Construction projects are delivered in networks of main contractors, their suppliers, and various third parties. Examples of the third parties are designers, consultants and advisors, all of whom are widely used in construction projects (Bresnen and Marshall, 2000). In construction project networks, the project customer is usually the investor and user of the project product. The main contractor delivers the project to the project customer and receives components and partial deliveries from component suppliers.

Manufacturers of construction components and materials as component suppliers are among the most neglected categories in research in the construction sector (Larsson et al., 2006), although as much as 75%–80% of the gross work done in the construction industry involves the purchasing of material and subcontracting of services (Dubois and Gadde, 2000; Miller et al., 2002). Component suppliers operate in more stable markets than the other project actors, and therefore they are able to maintain R&D programs and develop new solutions (Blayse & Manley, 2004). This is why suppliers are regarded as key sources of innovations in the construction industry (Bygballe & Ingemansson, 2014; Gambatese & Hallowell, 2011). Component suppliers' position in project networks is not ideal, since their only contractual relationship is with the main contractor, and contractors are not motivated to enhance their relationships with suppliers (Bygballe & Ingemansson, 2014). Instead, many main contractors select suppliers through competitive tendering based on price (Miller et al., 2002). This is a problem for component suppliers because they are not able to contribute to the construction project before tendering and their innovation potential is wasted (Eriksson et al., 2007).

The decision-making environment in construction projects often includes not only a clear customer and supplier but also third parties that influence the decision making. Designers are chosen as the relevant third parties because they are responsible for designing the construction and specifying materials and components used in the projects, consequently determining the quality of the building (Emmitt, 2006). The quality of designs and specifications is a major concern in construction projects. Designers' inadequate information about materials and components available are causing quality problems and hindering innovations (Emmitt, 2006; Peat, 2009). Designers need technical knowledge during specifications (Emmitt and Yeomans, 2008) and component suppliers have knowledge that can help designers in multiple ways (Gil et al., 2001). Component suppliers are trying to provide this knowledge for designers (Emmitt, 2006; Manley, 2008), but they are facing design firms' "gatekeeping mechanism" that hinders the information flow (Emmitt, 2001). However, Emmitt (2006) has noticed that a good relationship with designers allows the component supplier to go through these gatekeeping mechanisms and enables the component supplier to contribute to the construction project already in the design phase. The relationship between component suppliers and designers is essential for construction innovations, but more research is needed in order to understand this important link in the construction supply chain (Emmitt, 2001; Manley, 2008).

This research focuses on component suppliers as the project network's non-central actors whose interest is to enhance their relationships with designers. Component suppliers' relationships with designers are different compared to customer-contractor and contractor-subcontractor relationships that have been studied earlier (Bygballe et al., 2010). The main difference is that component suppliers and designers are not in a contractual relationship with each other. Suppliers' connections to construction project actors are weak (Håkansson and Ingemansson, 2013) and therefore the relationship between suppliers and designers are likely to be weak. We concentrate on ways to strengthen these relationships. Although earlier research has offered evidence on relationship strength in contractual relationships in project networks, the strength of non-contractual relationships typical to complex project networks has not been studied sufficiently. In this research, we use the concept of relationship strength that characterizes an interorganizational relationship in terms of trust and commitment (in line with Bove and Johnson, 2001; Hausman, 2001; Morgan and Hunt, 1994).

The purpose of this study is to develop and test a framework of non-contractual relationship strength between component suppliers and designers as third parties and its antecedents. The goal is to identify the relevant factors that may promote relationship strength in the non-contractual relationships of component suppliers. In this study, we focus on the relationship between designers and component suppliers, particularly from the viewpoint of the designers. For the purpose of the research, other potential viewpoints are excluded (e.g., component suppliers, contractors, customers, and any other third parties). These viewpoints are suggested as topics for future research.

The next chapter justifies the need for enhanced interorganizational relationships in supplier-designer relationships. Then, we develop the concept of relationship strength and a framework on its antecedents. After introducing the hypothetic-deductive research design and questionnaire method, the results section presents the testing of the stated hypotheses with a sample of 89 designers. In the discussion, the key findings in light of the empirical evidence and earlier research are summarized. As contributions, we identify key factors that explain relationship strength between designers and suppliers from the designers' perspective, and suggest avenues for further research.

2 Enhancement of interorganizational relationships in project networks

2.1 Importance of enhancing supplier-designer relationships

Manufacturers as component suppliers have innovation potential but there are barriers that hinder their contribution to construction projects. A major barrier from the suppliers' perspective is that they do not have sufficient knowledge about customer needs, product development needs and potential areas for innovating (Larsson et al., 2006; Wandahl et al., 2011). Suppliers often do not often have direct linkages to project customers in construction project networks. Designers are key actors in this respect because they are engaged in the early phases of the construction projects and they are providing professional design service for the project customer or the main contractor. This is why they have good knowledge about customer needs and development needs that would be helpful for component suppliers.

Component suppliers are motivated to provide information for designers in order to generate demand for their components (Emmitt, 2006; Manley, 2008). By providing information for designers, component suppliers try to raise the designers' awareness about their offering and to get their new components adopted by the designers. This is important for component suppliers because designers tend to use familiar materials and components in their design specifications in order to minimize their risk (Emmitt, 2006). The main contractors and project customers are using designer's specifications as a guideline in their purchasing decisions (Errasti et al., 2009; Peat, 2009). If the specifications are fulfilled, then the designer remains responsible. In these situations the designer may transfer the liability to the supplier through warranties or guarantees. If the contractor does not follow the specifications, then the liability is transferred to the contractor (Emmitt and Yeomans, 2008). Contractors are usually transferring the liability further to suppliers through contractual clauses (Eriksson et al., 2007). In private sector projects, designers may select a specific product to the specifications because they perceive that the quality of the building would suffer if the contractor chooses the product (Emmitt, 2006). In the public sector, legislation and regulations prohibit the designers' appointment of suppliers and limits the interaction between designers and possible component suppliers before tendering. However, legislation and regulations do not remove the fact that the designers are using familiar materials and components in specifications that are narrowing down the potential component suppliers who are able to tender.

Designers cannot have a working knowledge of all relevant standards and codes. Component suppliers have the best expertise and technical knowledge in their field (Khalfan et al., 2008; Manley, 2008). This is why designers need technical assistance and product information from component suppliers during specifications in order to ensure the quality of designs (Emmitt and Yeomans, 2008; van Leeuwen and van der Zee, 2005). Gil et al. (2001) have studied how component suppliers' 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 (Gil et al., 2001). It is reported that designers often take an informal contact with familiar component suppliers when facing specification problems (Emmitt, 2006). Based on this, component suppliers need to enhance their relationship with designers in order to contribute to the construction project before tendering.

Successful innovation in construction projects often requires cooperation and working relationships between the network actors (Ozorhon, 2013; Rutten et al., 2009). In particular, the role of suppliers and designers is highlighted in construction innovations, because product and process innovations often originate from them and from their collaboration (Bygballe et al., 2010). However, there is a lack of research into the relationship between the adopters of new products (e.g. designers, contractors) and the suppliers (Larsson et al., 2006). Research on the relationships in project networks has been directed at the dyadic relationship between the project customer and main contractor (Bygballe et al., 2010). Recently, some studies have focused on dyadic relationships between the main contractor and subcontractors (e.g. Manu et al., 2015). The relationships outside these dyads have received very little attention; few studies examine the designers' roles in purchasing decisions and their relationships with suppliers in construction projects (Bygballe et al., 2010). More attention is needed, as the relationship between the designer and suppliers needs better explanation (Emmitt, 2001; Manley, 2008).

2.2 Evaluation of interorganizational relationships

Interorganizational relationships have received a great deal of attention in various business research settings, with different theoretical backgrounds and different terminologies (Autry and Golicic, 2010). Interorganizational 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 interorganizational 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 Golicic, 2010).

In construction project networks, interorganizational relationships are mainly transactional and adversarial, that is, in the beginning of the continuum (Bankvall et al., 2010; Kadefors, 2004; Laan et al., 2011). Enhancement of relationships has been a major concern in construction projects. Thus far, construction-specific research has concentrated on the contractors' and customers' contractual relationships (Bemelmans et al., 2012), ignoring other parties and non-contractual relationships in the project network.

Earlier literature has used constructs such as relationship strength, relationship quality, and relationship closeness to evaluate interorganizational relationship. The measurement of these closely related constructs has varied, even when the same term is used (Bove and

Johnsson, 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, 2003). Relationship strength is usually measured by trust and commitment (Bove and Johnsson, 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). 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 interorganizational relationships, and 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 interorganizational relationships.

Based on the discussion above, we use the construct of relationship strength to characterize the depth of non-contractual interorganizational relationships between component suppliers and designers. Earlier studies have focused on the evaluation of contractual relationships. We assume that trust and commitment can be considered key constructs in this non-contractual relationship as well. If the designer does not trust and is not committed to the component supplier, it is likely that the designer will not approve their components to be used in the projects.

3 Conceptual framework and hypotheses on factors explaining relationship strength

As previous research has already examined relationship strength in various interorganizational relationships, we sought prior evidence on its evaluation and antecedents, particularly those concerning the relationship between component suppliers and designers in delivery projects. We identify a few select factors that may drive relationship strength in non-contractual relationships typical to suppliers and designers.

3.1 Relationship strength

In this study, relationship strength characterizes an interorganizational 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).

Trust has been studied in different disciplines such as sociology, psychology, anthropology, economics, and management (Lau and Rowlinson, 2011). There is no widely recognized definition of trust (Meng, 2012). In this study, we focus on trust in project business, particularly in construction projects, which has recently been attracting growing research interest (e.g., Buvik and Rolfsen, 2015; Manu et al., 2015). Interorganizational trust in construction projects is linked with 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.

Component supplier's relationships in construction project networks are mostly of transactional nature, strained by conflict and mistrust (Eriksson et al., 2007; Miller et al., 2002). Lack of trust is a major barrier in cooperative relationships and innovations in construction projects (Akintoye and Main, 2007; Manu et al., 2015). Smyth and Edkins (2007) even argue that the strength of trust determines the strength of every relationship. In order to enhance relationships with designers, component suppliers should develop trust with them. Designers are very meticulous regarding supplier selection, because they have their own responsibilities and reputation to be mindful of. This is why they tend to select reliable and tested components from suppliers they trust (Martinsuo and Sariola, 2015). If trust is present in the designer-supplier relationship, parties do not have to think about underlying hidden motives, who is formally responsible for problems, or the risks of disclosing information (Kadefors, 2004). Trust-based relationships also enhance the innovation potential of project teams (Shazi et al., 2015).

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 (Håkansson and Snehota, 1995) and the desire to continue a relationship (Morgan and Hunt 1994). Commitment helps to stabilize the relationship and it is a key in achieving valuable outcomes for both parties (Ulaga and Eggert, 2006). Valuable outcomes for suppliers and designers 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 (Håkansson and Snehota, 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).

Previous research, particularly in the direct supply relationships of project networks, has already identified various factors that may explain trust and commitment (e.g., Kwon and Suh, 2004; Manu et al., 2015; Walter et al., 2003). Establishment of trust and commitment in construction relationships is crucial, but is also a challenging task. We have identified antecedents to be tested in this study that may be particularly relevant for non-contractual relationships between component suppliers and designers as third parties. We have chosen to focus on four potential antecedents: supplier’s activeness, technical capability of the supplier, supplier’s reputation, and supplier-designer-cooperation beyond project boundaries (Figure 1).

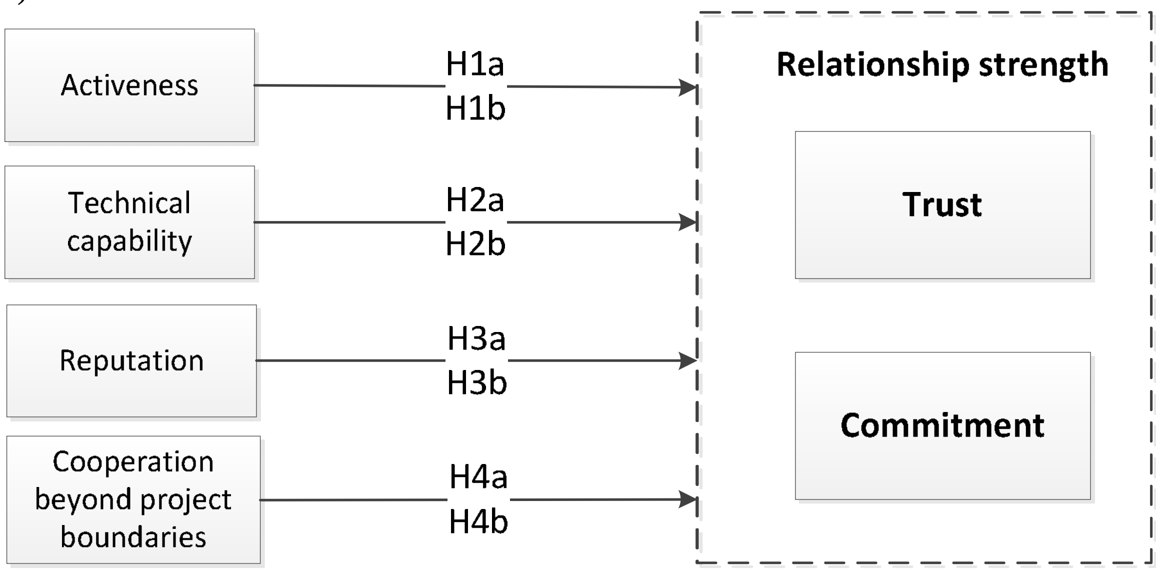


Figure 1. Framework and hypotheses on relationship strength in supplier-designer relationships.

The conceptual framework is presented in figure 1. This illustrates the construct of relationship strength and factors that enhance relationship strength. Below, we review earlier research on the topics and propose eight hypotheses to be tested in this framework, emphasizing the viewpoint of designers.

3.2 Supplier's activeness toward designers

Many authors (e.g., Ahola et al., 2013; Khalfan et al., 2007; Martinsuo and Ahola, 2010) have noticed in their case studies in direct supply chains that repeated interactions between actors strengthen their relationship. Repeated interactions provide opportunities for mutual trust to emerge and develop (Jiang et al., 2012). An interview study with architects and structural engineers as third parties has suggested that the suppliers' proactive activities are important to the relationship (Martinsuo and Sariola, 2015). The designers in their study related that they have the strongest relationship with those component suppliers with whom they interact the most. However, the nature of project business implies that repeated interactions are not self-evident. This is why component suppliers should be actively involved with designers. Earlier research has found that the supplier's presence at events and seminars (Ahola et al., 2013) and prompt visits by representatives (Emmitt and Yeomans, 2008) are good ways to foster interactions between the supplier and designers.

When studying the relationship strength between companies, it is important to acknowledge the differences between interpersonal and interorganizational relationships. It has been seen that interpersonal relationships increase trust and commitment between organizations (e.g., Haimala and Salminen, 2006; Kujala et al., 2013). As a matter of fact, in interorganizational relations, trust in the other organization and trust in its individual representatives are closely related (Laan et al., 2011). Due to the earlier evidence on the positive relationship consequences of the supplier's activeness, we anticipate that it is associated with trust and commitment.

Hypothesis 1a. Component supplier's activeness toward designers is positively associated with the trust that the designers direct toward the component supplier.
Hypothesis 1b. Component supplier's activeness toward designers is positively associated with the commitment that the designers direct toward the component supplier.

3.3 Supplier's technical capability

Project-based design, engineering, and construction firms operate within a dynamic environment in which rapid changes in the economy and society are creating demands for new types of buildings and structures (Gann and Salter, 2000). Construction industry is also increasingly concerned with sustainability issues, which draws attention to the lifecycles of construction materials and components (Ortiz et al., 2009). Moreover, the technical scope of projects is growing and, thus, technical requirements have driven the trend toward outsourcing to a wide range of suppliers (Smyth et al., 2010). These trends highlight the importance of component suppliers' technical capability that has been argued to motivate one to trust others in a project environment (Lau and Rowlinson, 2011).

Problems are unavoidable during a construction project and component 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. Architects describe their work as problem-solving. They constantly face different kinds of design problems and they need suppliers' technical help in solving problems (Emmitt and Yeomans, 2008). In an interview study, architects and structural engineers said that the relationship with the component supplier usually continues after successful problem-solving (Martinsuo and Sariola, 2015). Khalfan et al. (2007) have also found that successful problem-solving increases trust between actors in construction projects. Therefore, we anticipate a positive link between the suppliers' technical capability and relationship strength.

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.

3.4 Supplier's reputation

The supplier's reputation in an industry is based on its partner's perception that the supplier delivers quality products or services (Kwon and Suh, 2004; Lau and Rowlinson, 2011). Building a good reputation is important for suppliers, because the assessment of suppliers is largely made on the basis of their references and reputation (Watt et al., 2009). However, Kwon and Suh (2004) remind that building a reputation is not an easy task and takes time, but it is not impossible.

Ganesan and Hess (1997) encourage further studies on how the reputation of a firm in the industry affects perceptions of trust in an interorganizational relationship. Akintoye and Main (2007) and Khalfan et al. (2007) have noticed that construction project network actors (main contractors, sub-contractors, customers, consultants and end-users) consider a company's reputation as an important indicator of who could be trusted. Khalfan et al. (2007) also observed that a company's reputation had an impact on whether people felt comfortable about working with them in construction projects. In the supply chain context, Kwon and Suh (2004) have proved in their large survey study that a company's reputation in business transactions has a significant and positive impact on the level of trust. The role of the supplier's reputation in enhancing supplier-designer relationships has not been studied earlier. However, it has been stated that designers tend to select reliable and tested solutions (Roos et al., 2010), and we anticipate a positive relationship between the supplier's reputation and relationship strength.

Hypothesis 3a. Component supplier's reputation in a market is positively associated with the trust that the designers direct toward the supplier.
Hypothesis 3b. Component supplier's reputation in a market is positively associated with the commitment that the designers direct toward the supplier.

3.5 Supplier-designer cooperation beyond project boundaries

Suppliers are regarded as key sources for construction innovation, and they have R&D programs to develop their products (Blayse and Manley, 2004). However, component suppliers may have difficulties in determining what products should be developed and how existing products could be improved (Larsson et al., 2006), because they do not necessarily have a link to the end-users of their products. Designers are engaged with both customers and contractors in construction projects so they have knowledge regarding the customers' and contractors' needs. Successful innovation often requires cooperation among the different parties in a project network (Ozorhon, 2013; Rutten et al., 2009). According to Eriksson et al. (2007), cooperation between the supplier and designers is particularly important for construction innovations. That is why suppliers should cooperate with designers in their R&D programs. Some designers have been found to have an interest in this kind of cooperation and the possibility of bringing in the perspective of design rather early in the new product development process (Martinsuo and Sariola, 2015). Cooperation beyond project boundaries would increase innovation potential. Cooperation is also an antecedent of commitment (Čater and Čater, 2010: Mavondo and Rodrigo, 2001). In their case study on an urban regeneration project, Ozorhon et al. (2014) found that successful implementation of innovations also opens opportunities for further cooperation with parties involved, thereby enhancing commitment.

In the designer-centric study of Martinsuo and Sariola (2015), certain design and engineering offices cooperated with selected component suppliers outside projects. Usually, cooperation beyond projects implies product development or information sharing (Martinsuo and Sariola, 2015). This kind of interaction among suppliers and designers provides opportunities for mutual trust to emerge and develop (Jiang et al., 2012). We anticipate that the supplier's and designer's cooperation beyond project boundaries has a positive relationship with relationship strength.

Hypothesis 4a. Cooperation beyond project boundaries is positively associated with the trust that the designers direct toward the supplier.
Hypothesis 4b. Cooperation beyond project boundaries is positively associated with the commitment that the designers direct toward the supplier.

4 Methodology

Due to the increased interest in explaining the relationship strength between component suppliers and designers, and due to extant qualitative evidence on its antecedents, this study employs a quantitative, hypothetic-deductive research design, with a questionnaire as the primary source of data. In this study, we examine the relationship strength between construction component suppliers and designers. We purposefully chose to examine relationship strength from the designers' perspective due to three main reasons. First, as the literature review showed, designers have a key influencing role between contractors and suppliers, and their experiences define their behavioral patterns toward suppliers. Second, our earlier interview-based study with selected few component suppliers highlighted their interest to understand the designers' perspective better, and the survey was used also for this practical purpose. Third, we developed the questionnaire based on earlier literature on designers' and other third parties' experiences as well as an interview-based prestudy with designers [authors]. As we wanted to keep the questionnaire process manageable and build robust statistical models, it was not feasible to design a survey that would have covered both perspectives simultaneously. As a consequence, we focused on architects and structural engineers who are recognized as most relevant designers in construction projects. In [the target country], architects and structural engineers are employed by private design and engineering offices whose services are procured on a project-basis by customers or main contractors.

4.1 Data collection

Empirical data were collected through questionnaires. Initially, we developed a questionnaire based on previous literature and a qualitative study with designers. We tested the questionnaire with local academics and practitioners. Thereafter, we revised confusing items and added a few questions.

With the help of local labor organizations, we collected a list of randomly selected architects and structural engineers. The list included valid e-mail addresses of 386 architects and 193 structural engineers. The total number of architects in [the target country] is approximately 4000, which implies that the sample represents approximately 10% of the total population. Information on the total number of structural engineers is not available. A web-based tool (Webropol) was used to distribute and collect the surveys. We received 90 responses to the questionnaire, 51 from architects and 39 from structural engineers. We rejected one response from an architect, because the response was incomplete; therefore, the resulting response rate was 15% from the sample, which corresponds well with typical 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 percent), which is not surprising, since the construction industry is male-dominated in [the target country]. More information about the respondents is provided in table 1.

Table 1. Responedent’s backgroung information.

	Architects	Structural engineers
Number of respondents	50	39
Interviewee's experience		
Less than 10 years	3	11
11-20 years	18	4
21-30 years	13	10
over 30 years	16	14
Number of personnel		
1-10	31	8
11-20	10	7
21-30	3	6
31-100	2	2
101-300	2	4
over 300	2	12

In [the target country], the construction industry contributes approximately 10% of the gross national product (GNP). Further, the construction industry is regulated by Eurocodes and the national building code. Construction projects typically feature multi-partner subcontracting networks that are led by a main contractor. Contractual arrangements have much in common with those in the UK and US. In [the target country], architect offices are typically small firms. Engineering offices are usually bigger than architect offices, but still relatively small. This is also evident among the respondents, because most of the architects (82 percent) and a large share of structural engineers (39 percent) work in small offices with fewer than 20 people. Due to their consultant role, neither architects nor structural engineers have official power in construction projects.

In the beginning of the questionnaire, respondents selected one recently finished ordinary construction project and one component supplier from that project. A majority of the selected construction projects were new buildings (81%) and the customer of the entire project was more often from the private sector (57%) than the public sector (43%). Residential buildings were the most common project type (36%), followed by commercial buildings (30%), public buildings (21%), and industrial buildings (11%). The selected component suppliers were relatively big companies in the industry, because 94% were considered large or medium-sized companies in their line of business. The component suppliers under consideration produce a wide variety of components. The most common components were concrete (22%) and steel components (12%). In the following parts of the questionnaire, respondents assessed the selected component supplier’s activities and their relationship with this component supplier.

4.2 Measures

We used multi-item scales in this study and all items are 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. All item wordings, including reliability coefficients (Cronbach's alpha), are listed in appendix 1.

Dependent variable: Relationship strength

In this study, relationship strength characterizes an interorganizational relationship in terms of trust and commitment (in line with Bove and Johnson, 2001; Hausman, 2001; Morgan and Hunt, 1994). When relationship strength between two organizations is high, the interacting personnel rely on each other and are committed to the relationship. The trust dimension of relationship strength was measured by three items, adapted from Walter et al. (2003) and Ulaga and Eggert (2006). Similarly, the commitment dimension of relationship strength was measured by three items, adapted from Walter et al. (2003) and Ulaga and Eggert (2006).

These constructs were validated by using generalized least squares factor analysis with promax rotation, assuming that the two factors should be distinguishable but positively correlated. The factor analysis produced the two factors, trust and commitment, with Eigenvalues greater than 1, with each of the six items clearly yielding its highest loading on the expected factor. These two factors together explained 68.53% of the total variance in the model (Table 2).

Table 2. Factor analysis of the dependent variables

	Factor 1	**Factor 2**
	Trust	**Commitment**
Trust 1	**0,81**	0,19
Trust 2	**0,80**	0,32
Trust 3	**0,65**	0,21
Commitment 1	0,00	**0,99**
Commitment 2	0,17	**0,59**
Commitment 3	0,03	**0,45**

The measure of sampling adequacy (KMO) yielded 0.67, which is mediocre, since Kaiser (1974) recommended KMO values of greater than the threshold of 0.5 as being acceptable. We also tested a one-factor model, but it explained only 45.19% of the total variance in the model, so we used the two-factor model.

Independent variables

The antecedents of relationship strength have been studied earlier in various contexts. However, the relationship between the supplier and designer is different compared to earlier studies typically conducted in contractual relationships. The main difference is that suppliers and designers are not in a contractual relationship with each other, so the relationship is likely to be weak. Another reason is that there is no physical transaction between them, only information exchange. These are the reasons why we developed measures for independent variables specifically for this study. The measures were developed on the basis of our earlier interviews and we also applied earlier studies regarding relationship strength in other contexts. The measures were validated using generalized least squares factor analysis. Promax rotation method was used, because we assumed that the factors should be distinguishable, but they might be correlated.

The factor analysis produced four factors: supplier’s activeness toward designers, supplier’s technical capability, supplier’s reputation, and cooperation outside the project boundaries, with Eigenvalues greater than 1. This supports the unidimensionality of the scales. Each of the eleven items clearly yields its highest loading on the expected factor, and the values for Cronbach's alpha were acceptable. These four factors together explained 76.07% of the variance in the model (Table 3). The measure of sampling adequacy (KMO) yielded 0.69, which is acceptable (Kaiser, 1974).

Table 3. Factor analysis of the independent variables.

	Factor 1	**Factor 2**	**Factor 3**	**Factor 4**
	Activeness	**Technical**	**Reputation**	**Cooperation**
Activeness 1	**0,95**	0,02	-0,02	0,03
Activeness 2	**0,57**	0,02	0,08	-0,06
Technical 1	0,09	**0,81**	-0,07	-0,01
Technical 2	-0,11	**0,68**	0,02	0,18
Technical 3	0,07	**0,66**	0,09	-0,12
Reputation 1	0,03	-0,06	**0,97**	0,06
Reputation 2	0,11	-0,05	**0,93**	0,07
Reputation 3	-0,13	0,16	**0,68**	-0,16
Cooperation 1	-0,12	-0,04	0,06	**0,84**
Cooperation 2	-0,08	0,12	-0,02	**0,82**
Cooperation 3	0,26	-0,03	-0,04	**0,62**

Supplier's activeness toward designers is measured by two items**.** Earlier in this paper, we stated that the component supplier can be active toward designers by being present at events and seminars (Ahola et al., 2013) and by presenting their products actively to designers (Emmitt and Yeomans, 2008). We asked the respondent's experience with how active the component supplier is toward respondents in these two areas.

Supplier's technical capability is measured by three items based on the designer's experience. We asked how well the supplier's technical capability appears in typical interactions between the supplier and designer. Based on interviews and prior studies, typical interactions among these parties are product demonstrations, designers asking for the supplier's technical support, or designers asking for the supplier's help in problem-solving (Emmitt and Yeomans, 2008).

Supplier's reputation is measured by three items. We stated that supplier's reputation in the construction industry is based on the designer's perception of the supplier delivering quality products or services (in line with Kwon and Suh, 2004; Lau and Rowlinson, 2011). Individuals consider the supplier's reputation on the basis of brand image and references (Lau and Rowlinson, 2011). On this basis, we asked respondents to evaluate the supplier's references, the supplier's reputation, and the reputation of the supplier's product.

Cooperation beyond project boundaries is measured by three items. For example, Martinsuo and Sariola (2015) noticed that some of the design and engineering offices cooperate and interact with selected component suppliers beyond project boundaries. We proposed that this kind of activity enhances trust and commitment between component suppliers and third-parties. We measured the degree to which the designers have interacted or cooperated with the component supplier beyond project boundaries.

The dependent variables and the three first independent variables were calculated as averages of the items included in the variables. The distribution of the independent variable measuring the cooperation beyond project boundaries was somewhat skewed. The reason for this is that many of the respondents have not cooperated with the component supplier beyond project boundaries at all. That is why we transformed this variable into a dummy variable (1 = the designer has cooperated with the component supplier outside project boundaries, 0 = no cooperation).

The validity of the measures was verified through four different means. Firstly, the content validity was established through developing the measures based on earlier literature and qualitative research. Secondly, the convergence validity was established through checking the unidimensionality of the scales. The items loaded well on the intended factors, and the factor scores were sufficiently high (and exceptions will be covered 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 component 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 it showed that a single factor did not explain enough of variance and, therefore, common method bias is not a problem in this study.

Control variables

Although the main emphasis is on the effects of independent variables to relationship strength, we control for a number of other, possibly relevant, variables that might intervene with the results. Supplier's size may have an effect on the results, so we measured the size of the supplier firm in their field of industry with an ordinal scale (1 = Small, 2 = Medium, 3 = Large). The respondent's background may also have an effect on the results. We control for the respondent's profession using a dummy variable (0 = architect, 1 = structural engineer), work experience in the field, and size of engineering or architect office. Work experience in the field was measured using an ordinal scale (1 = under 10 years, 2 = 11–20 years, 3 = 21–30 years, 4 = over 30 years). The size of the engineering or architect office was measured by revenue (M€), and the size of the engineering and architect office varied between 0.05 M€ and 152M€. Another control variable is the size of the project in terms of budget, because Emmit and Yeomans (2008) argue that relationships are likely to be stronger in large projects. The size of the project is measured by budget (M€), and the size of the project varied between 0.3M€ and 550M€, where 91% of the projects were under 100M€. We also control for the project customer's background (0 = private sector, 1 = public sector), because the private sector and public sector customers have different regulations in [the target country].

4.3 Data analysis

In the first step of 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: we first added the control variables 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 is 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.

5 Results

5.1 Descriptive statistics

Table 4 displays the descriptive statistics and correlation coefficients of all variables. The results show that the designers perceive component suppliers as relatively trustworthy, acknowledging that they usually do not have a contractual relationship. The designers' commitment to the component supplier is, on average, slightly lower than trust. There is a positive and significant correlation between trust and commitment, thereby confirming the initial expectation. The designers' perceptions of the supplier's activeness, technical capability, and reputation are fairly high, whereas cooperation beyond project boundaries is experienced only by fewer than 40% of the respondents.

Table 4. Descriptive statistics and correlation coefficients.

	Mean	SD	1	2	3	4	5	6	7	8	9	10	11	
1 Profession	0.44	0.50	1.00											
2 Work experience	2.75	1.08	-0.05	1.00										
3 Revenue	13.30	31.47	0.39**	0.05	1.00									
4 Customer's back-ground	0.61	0.56	0.05	-0.13	-0.04	1.00								
5 Project size	30.52	75.10	0.22	0.16	0.64**	-0.06	1.00							
6 Supplier size	2.49	0.59	-0.11	-0.07	0.15	0.03	0.14	1.00						
7 Activeness	3.75	0.76	0.03	0.23*	0.07	-0.01	0.05	0.28**	1.00					
8 Technical	3.92	0.74	0.01	-0.07	-0.12	-0.17	0.01	0.10	0.18	1.00				
9 Reputation	3.73	0.85	-0.08	-0.05	0.12	-0.12	0.19	0.24*	0.31**	0.33**	1.00			
10 Coopera-tion	0.38	0.49	0.19	0.09	0.12	0.02	0.09	0.09	0.20	0.14	-0.11	1.00		
11 Trust	3.71	0.90	0.03	-0.02	0.04	-0.14	0.08	0.16	0.40**	0.63**	0.40**	0.17	1.00	
12 Commit-ment	3.17	0.88	0.22*	-0.16	-0.08	0.11	-0.11	0.16	0.00	0.29**	0.08	0.27*	0.27*	1.00

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

The results reveal that there are some significant correlations among the variables. Trust is positively and significantly correlated with all the other independent variables, except cooperation beyond project boundaries. Commitment, in turn, is positively and significantly correlated with the supplier's technical capability and cooperation across project boundaries. There are also some significant correlations between independent variables like we assumed earlier. Reputation is positively correlated with the supplier's activeness and technical capability.

5.2 Regression analysis results: antecedents of relationship strength

Linear multiple regressions are applied to test the hypotheses. As illustrated in table 5, 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 (although the beta coefficients are positive). 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 trusting the designer is toward the supplier.

Table 5. Regression results.

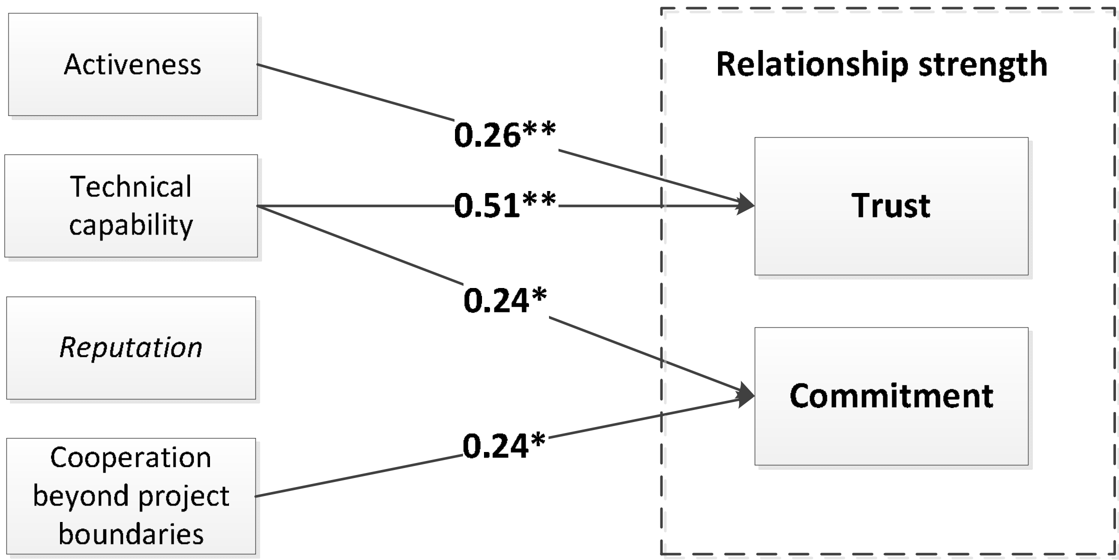
Dependent variable	Trust		Commitment	
	Model 1a	**Model 1b**	**Model 2a**	**Model 2b**
Controls				
Profession	0.05	-0.01	**0.32****	**0.27***
Work experience	-0.03	-0.05	-0.10	-0.06
Revenue	-0.05	0.07	-0.18	-0.13
Customer background	-0.11	-0.01	0.10	0.17
Project size	0.07	-0.01	-0.06	-0.11
Supplier 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
* $p < 0.05$
** $p < 0.01$

Models 2a and 2b test the antecedents of commitment. As shown in table 5, 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 have commitment to component 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 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 with 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 in the supplier relationship. The other independent variables have no significant effect, so hypotheses 1b and 3b are not supported.

In addition, we tested for the potential role of trust as a mediator between the independent variables and commitment. We used simple mediation models (Preacher and Hayes, 2008) for testing the significance of mediating effects. However, these models show no significant mediation effect, so trust did not appear as a mediator between the independent variables and commitment in this sample. The main results are illustrated in figure 2.



*   p<0.05
** p<0.01

Figure 2. Illustration of the results.

Figure 2 depicts only 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.

6 Discussion

In this study, the survey results have revealed antecedents of trust and commitment in non-contractual relationships. The identified antecedents may be particularly relevant for suppliers as the less central actors in project networks whose interest is to enhance their relationships with designers as third parties. Table 6 summarizes the results of hypothesis testing.

Table 6. Summary of the results of hypothesis testing.

Hypothesis 1a.	Component supplier's activeness toward designers is positively associated with the trust that designers direct toward the component supplier.	**Supported**
Hypothesis 1b.	Component supplier's activeness toward designers is positively associated with the commitment that designers direct toward the component supplier.	**Not supported**
Hypothesis 2a.	Component supplier's technical capability is positively associated with the trust that designers direct toward the supplier.	**Supported**
Hypothesis 2b.	Component supplier's technical capability is positively associated with the commitment that designers direct toward the supplier.	**Supported**
Hypothesis 3a.	Component supplier's reputation in a market is positively associated with the trust that designers direct toward the supplier.	**Not supported**
Hypothesis 3b.	Component supplier's reputation in a market is positively associated with the commitment that designers direct toward the supplier.	**Not supported**
Hypothesis 4a.	Cooperation beyond project boundaries is positively associated with the trust that designers direct toward the supplier.	**Not supported**
Hypothesis 4b.	Cooperation beyond project boundaries is positively associated with the commitment that designers direct toward the supplier.	**Supported**

Prior research suggests that trust and commitment are positively related (Bove and Johnson, 2001; Kwon and Suh, 2004; Morgan and Hunt, 1994). This research verifies this suggestion in a non-contractual relationship between designers and suppliers, because trust and commitment variables are significantly positively correlated ($p < 0.05$) in the survey sample. Some earlier studies also suggest that trust may be a necessary condition for commitment (Håkansson and Snehota, 1995). Our research does not support this, because trust was not identified as a mediator between the independent variables and commitment in the sample. Next, we discuss the antecedents of relationship strength through the hypotheses.

6.1 Antecedents of trust

The results of this study indicate that the supplier's activeness toward designers is an antecedent of relationship strength, in terms of trust. This supports the stated hypothesis 1a and lends support to prior research that emphasizes the importance of repeated interactions in relationship development (e.g., Ahola et al., 2013; Khalfan et al., 2007; Martinsuo and Ahola, 2010). Prior studies have focused on contractual relationships, where some level of interaction is self-evident. We focused on non-contractual relationships between component suppliers and designers. In this relationship, repeated interactions are highly dependent on the component supplier's actions because designers do not often take the initiative towards component suppliers. In project business, it is an easy task to focus on ongoing projects with the contractor and neglect the importance of activeness towards designers.

Another antecedent of relationship strength, in terms of trust, is the supplier's technical capability. Many authors have identified that problem-solving ability and technical competence are important elements of building trust in contractual relationships (e.g., Khalfan et al., 2007; Lau and Rowlinson, 2011; Meng, 2012). Our result complements earlier research by providing evidence that technical capability is also an important antecedent of trust in non-contractual relationship. Rapid changes in the economy, sustainability concerns and contractors' trend to outsource work to a wide range of suppliers are highlighting the component suppliers' technical capability. Further, some earlier studies suggest that designers need the suppliers' technical help in problem-solving situations and this may increase the trust between them (Emmitt, 2006). These earlier studies have been qualitative interview studies in a contractual setting, thus our quantitative results confirm their suggestions in non-contractual setting and support hypothesis 2a.

The results indicate that cooperation beyond project boundaries and supplier's reputation are not antecedents of relationship strength in terms of trust; thus, hypotheses 3a and 4a are not supported. These are somewhat contradictory results compared to prior research that have focused on contractual relationships. In their large survey study, Kwon and Suh (2004) have proved that a company's reputation has a significant and positive association with the level of trust. However, they conducted their research in a supply chain context. A company's reputation has been suggested as an antecedent of trust in the construction industry (Khalfan et al. 2007). Both Kwon and Suh (2004) and Khalfan et al. (2007) emphasize the importance of a company's reputation in the early phases of the relationship. This might explain the contradictory results: the respondents in our study have worked with the selected supplier already earlier at least in one project. Cooperation between component suppliers and designers is important in terms of innovations and new product development (Ozorhon, 2013; Rutten et al., 2009). This kind of interaction provides opportunities for mutual trust to emerge and develop (Jiang et al., 2012). However, only 38 percent of designers in our sample have cooperated with the component suppliers outside the project boundaries. This result implies that designers and component suppliers do not cooperate actively in the construction industry, which may partly explain a low degree of innovations in the industry. It is possible that the low degree of cooperation beyond project boundaries in our sample and the use of a dummy variable were not sufficient to reveal its implications for trust.

6.2 Antecedents of commitment

The results indicate that the supplier's technical capability and cooperation beyond project boundaries are antecedents of relationship strength, in terms of commitment, so hypotheses 2b and 4b are supported. The technical scope of projects is growing and, therefore, the technical requirements are increasing (Smyth et al., 2010). Component suppliers have the best expertise and technical knowledge in their field (Khalfan et al., 2008; Manley, 2008) and designers often take an informal contact with familiar component suppliers when facing technical problems (Emmitt, 2006). Our results confirm that the supplier's technical capability is an important antecedent of commitment between component suppliers and designers. This result lends support to an earlier notion that the designer's relationship with component suppliers usually continues after successful problem-solving (Martinsuo and Sariola, 2015). Prior research has suggested that cooperation is an antecedent of commitment in contractual relationships (Čater and Čater, 2010; Mavondo and Rodrigo, 2001). Our results show support to these suggestions and confirms that cooperation is also a relevant antecedent of commitment in non-contractual relationship between the component supplier and designer. Some authors have argued that cooperation is a consequence of commitment (Morgan and Hunt, 1994). In our research setting, the questions on cooperation were in past tense and commitment in present tense, thereby indicating the hypothesized link. The component supplier's technical capability and cooperation outside project boundaries bring direct consequences for designers (i.e. technical assistance and possibility to influence the supplier's new product development), which may explain the commitment that designers direct toward the component supplier.

Hypotheses 1b and 3b are not supported, since the survey results reveal that the supplier's activeness and supplier's reputation do not explain relationships strength, in terms of commitment. According to Sharma et al. (2006) commitment is built through interpersonal interaction over time. Supplier's activeness towards designers increases interaction between the supplier and designers, but there is no significant relationship between supplier's activeness and commitment in our results. One potential explanation is that the supplier's activeness towards designers does not imply that the same persons interact with each other over time. If this is true, component suppliers should seek activities that increase interpersonal interaction with designers. In their interview study, Khalfan et al. (2007) observed that people in the construction industry felt comfortable about working with a supplier with a good reputation. Designers also rely on reliable and tested solutions in their design specifications (Roos et al., 2010). The results in this study do not support the hypothesized link between the supplier's reputation and commitment. It may be that designers like to use products of the suppliers with a good reputation, but a good reputation itself is not enough for the designers to be committed to the relationships, because there are no direct consequences for designers.

In the results, the respondents' profession and size of the supplier firm appeared as control variables linked with the designers' experiences of commitment. Structural engineers were more likely than architects to have commitment to component suppliers, and respondents experienced commitment more often with larger suppliers than small ones. Structural engineers have a similar educational background and engineering culture as employees of component suppliers [in the target country], whereas architects have a different educational background and culture (Ankrah and Langford, 2005). This might be one potential reason why structural engineers are more committed to the component suppliers than architects. Small component suppliers do not have as much resources to invest in R&D and employ an adequate level of technical staff as larger component suppliers have (Emmitt and Yeomans, 2008). This may hinder the commitment between the small component suppliers and designers. Characteristics of relationship parties have been suggested as antecedents of trust and commitment (Athanasopoulou, 2009). Our results show partial support for this because the characteristics of the designer and the supplier were antecedents to commitment.

7 Conclusions

This study has centered on the designers' perspective to designer-supplier relationships in project networks. The focus was on relationship strength as a feature characterizing the nature and depth of the relationship. Previous research on relationship strength has mainly been conceptual and concentrated on customer-supplier relationships (Bove and Johnson, 2001). This study brings empirical evidence regarding supplier-designer relationships to research regarding relationship strength. Previous studies in project networks have largely concentrated on direct, contractual project relationships, for example, between contractors and subcontractors, or contractors and their customers. The non-contractual relationships of suppliers have largely been neglected in previous research. The findings of our questionnaire study have revealed that the designer's experience of the supplier's activeness, the supplier's technical capability, and designer-supplier cooperation beyond projects' boundaries have a positive link with their perception of the relationship strength between the supplier and designer. The results have shown slight differences in how the antecedent factors explain trust and commitment. It is notable that only the supplier's technical capability was an antecedent of both constructs.

This research contributes to literature regarding construction innovations and the actor's position in a project network. Component suppliers are regarded as key sources for construction innovations (Bygballe and Ingemansson, 2014; Gambatese and Hallowell, 2011) but their non-central position in construction project networks hinders their innovation potential. The actor's position in a project network depends on the capability of creating new relationships and strengthening existing relationships (Pauget and Wald, 2013). This research offers important knowledge and practices for enhancing the less central actor's relationships with designers in construction project networks. Thereby, the results offer ideas for enhancing the less central actor's position in project networks. Earlier literature acknowledge that the relationship between component suppliers and designers is essential for construction innovations, but more research is called for (Emmitt, 2001; Manley, 2008). This research answers the call and helps to explain this important link in construction supply chains. Still more empirical research is needed to understand the proposed link between enhanced supplier-designer relationship and construction innovations.

As managerial implications, the research suggests practical ways in which construction component suppliers may take action toward enhanced relationships with designers. In particular, the research suggests that component suppliers should be active towards designers and develop their technical capability in order to become trustworthy from the designers' perspective. The component supplier's technical capability is the main antecedent of relationship strength because it is also positively related to the commitment that designers direct toward the supplier. As such, the supplier's technical capability has the most implication for component suppliers whose interest is to enhance their relationships with designers. The research encourages component suppliers to engage in cooperation with designers beyond project boundaries, for example, through joint R&D, because designers experiencing such cooperation are more committed in the supplier relationship. These practical ways could be used to construct a more central position in project networks through an enhanced relationship with designers.

This study had certain limitations in research design and data collection, of which we are aware. The questionnaire survey design was limited by the unavailability of earlier empirical evidence on designer-supplier cooperation and other types of non-contractual relationships, which is why 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 sampling procedure limited attention to a random sample of architects and structural engineers representing a minority of the population, and the response rate was comparable to other web-based surveys. We are aware that the group of 89 respondents may not be completely representative of the population, and due to the lack of complete information on the population, it is difficult to evaluate the representativeness of the respondents. Further, the questionnaire was targeted at single individuals, and both the independent and dependent variables were built on question items responded to by single informants. The single respondent and single method issue may cause potential biases in responses. Moreover, we attempted to provide background information on the respondents and the data collection procedure to improve the replicability of the study. It is evident that further research is needed to validate the findings.

The study was limited through its single country context and its choice of architects and structural engineers as relevant third parties in construction project networks. Construction project networks include other third parties that were not covered here, for example, consultants, logistics providers, retailers, installers, and transport firms that could be covered in future research. Similarly, the strength of relationships could be examined from some other perspectives, such as suppliers, contractors and customers. Each of them has a different experience of designer cooperation and relationship, and all viewpoints may offer an important aspect of relationship strength. The study revealed that the antecedent factors explained more of trust than commitment, which indicates that there are other practices and mechanisms that drive the commitment between designers and suppliers. Further research could explore other aspects of the designer-supplier cooperation, such as incentives, interaction routines, and services to map the antecedents of commitment further.

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Appendix 1. Variable structures and reliability coefficient Cronbach Alphas.

Trust (Dependent variable)	**Cronbach alpha**
You can count on the supplier's support if you need it. You can count on the supplier in keeping the promises it makes. The supplier is not always honest to you. (reverse scored)	**0,84**
Commitment (Dependent variable)	
Your design office has an interest to maintain the relationship with the supplier. Your design office is committed to the relationship with the supplier. You are willing to invest time in developing the relationship with this supplier.	**0,72**
Supplier's activeness (Independent variable)	
The supplier is actively present at construction industry events (fairs and seminars etc.) The supplier promotes and introduces its products actively.	**0,73**
Supplier's technical capability (Independent variable)	
The supplier can help you in problem solving situations. The supplier offers high-quality technical support. The supplier's representatives are technically qualified.	**0,75**
Supplier's reputation (Independent variable)	
Compare the supplier with its competitors using the following criteria The reputation of the supplier's products. The reputation of the supplier. The supplier's references.	**0,89**
Cooperation beyond project boundaries (Independent variable)	
You work with the supplier beyond the project boundaries. The supplier has cooperated with your design office in issues not linked with projects. You have participated in some ways in the supplier's product or business development activities.	**0,78**