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Coordinating collaboration in contractually different complex construction projects

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Structured abstract:

Purpose – The study compares the coordination of supply chain networks in contractually different complex construction projects.
Design/methodology/approach – A comparative case study of the coordination of collaborative work in two successful hospital construction projects was conducted. One of the projects applied multiple dyadic contracts, whereas the other project applied one multi-party contract between the parties. The projects were located in the USA. Data was collected by observing the coordination on the construction sites for six weeks and by conducting 72 interviews.
Findings – The paper shows that depending on the contract type, the timing and extent of complementary procedural coordination differs during projects. Compared with one multi-party contract, the multiple dyadic contracts needed to be complemented during the design phase with three additional procedural coordination mechanisms: 1) organizational design, 2) processes for collaborative work, and 3) integrated concurrent engineering sessions. Additionally, common rules of conduct were taken into use during the construction phase. However, regardless of the contract type, procedural coordination mechanisms, such as co-located working, collaborative decision making in inter-organizational meetings, a liaison role, and shared project goals were needed throughout the projects.
Practical implications – If multiple dyadic contracts are applied, procedural coordination mechanisms have to be co-created by all supply chain parties at the beginning of the project.
Originality/value – The study provides understanding on successful contractual and complementary procedural coordination mechanisms of supply chain networks in complex construction projects.

Keywords: Coordination, collaboration, construction supply chain, comparative case study, multi-party contract, dyadic contract

Article classification: Research paper

Introduction

The aim of this paper is to study the coordination of supply chain networks in complex construction projects. The lack of coordination between construction supply chain parties is one of the key reasons for poor performance in the construction industry (Sebastian, 2011). Increasing the coordination of the parties' collaborative work at the project level can help to improve construction supply chain performance (Humphreys et al., 2003; Love et al., 2004; Hossain, 2009; Bygballe and Ingemansson, 2014). However, we still lack knowledge on the coordination of collaborative work between multiple companies in a supply chain (Boddy et al., 2000; Power, 2005; Stock et al., 2010; Roehrich and Lewis, 2014; Kembro et al., 2014).

Contractual coordination is known to be important in defining financial and other rights, whereas procedural coordination is needed during project execution (Sobrero and Schrader, 1998; Nielsen, 2010). Procedural coordination aims at ensuring that the agreed contractual mechanisms are implemented in the everyday communication between interrelated employees (Sobrero and Schrader, 1998). The construction supply chain is usually thought to exist for the duration of a single project which has led the industry to focus on financial transactions through contracts instead of collaborative work between the parties of the supply chain network during the project (Dubois and Gadde, 2000). Consequently, the parties traditionally rely on contractual coordination, i.e., formal contracts that specify each party's financial and other rights, responsibilities, and duties.

However, Bresnen and Marshall (2000) and Dossick and Neff (2011) discuss that cultural and organizational boundaries in construction projects can hinder collaborative work, communication, and joint problem solving regardless of contractual agreements. Following their and Sobrero and Roberts' (2002) arguments, this paper suggests that contractual coordination alone does not lead to enhanced project delivery, but that contractual coordination needs to be complemented with the procedural coordination of the construction supply chain network during the project.

This paper addresses the following research question: How to complement contractual coordination with procedural coordination of construction supply chain parties' collaborative work? To research the phenomenon empirically, a comparative case study of the coordination of collaborative work in two successful, contractually different hospital construction projects participated in by multiple companies was conducted.

The findings of the paper contribute to the understanding about coordinating collaborative work in complex construction supply chain networks by revealing how procedural coordination successfully complemented contractual coordination in two contractually different hospital construction projects. The findings suggest that depending on the contract type, the timing and extent of complementary procedural coordination mechanisms differ during projects.

1 COORDINATING CONSTRUCTION SUPPLY CHAIN PARTIES' COLLABORATIVE WORK

1.1 A hospital construction project: a complex context for coordinating collaborative work

The construction supply chain is highly fragmented and operates in an environment of uncertainty and complexity (Fearne and Fowler, 2006), which complicates collaborative work (Barlow, 2000). The fragmentation of the construction supply chain manifests in the separation of design and construction, lack of coordination, conflicts, low productivity, and insufficient communication (Xue et al., 2005; Bankvall et al., 2010; Pala et al., 2014).

A hospital construction project entails a construction supply chain, a network of companies connected by the flows of information, funds, materials, and services. The project parties represent a variety of expertise from different companies, such as the client, the architect, the main contractor, construction management consultants, other designers, and suppliers. The parties' collaborative work takes place in the construction supply chain process which is roughly composed of five sequential phases: conceptual design, detailed design, construction, maintenance, and commission. (Xue et al., 2007)

Coordinating the collaborative work between the supply chain parties in a hospital construction project is demanding because a hospital is a complex building to design and construct. A hospital construction project faces lots of uncertainty due to long project planning times and rapid societal, medical, and technological developments. Furthermore, numerous changes take place during the construction phase due to the technical complexity of the hospital and the owner's requirements for changes. For example, the owner may change the spatial program due to changes in hospital business models or models of care delivery, or the owners may have less financial resources than originally planned to build the hospital. This complexity requires continuous collaborative work between the project parties in the design as well as in the construction phases. (Sebastian, 2011)

The construction supply chain includes several reciprocal interdependences between different professionals, processes, and tools that need to be managed concurrently, thus they require coordination through the continuous adjustment of plans throughout the project (Bankvall et al., 2010). However, inter-organizational boundaries and the differing fields of expertise create hindrances to identifying the interdependencies between the work tasks of different companies and to understanding who should be involved in which tasks and in which order, in order to finish specialized tasks (Okhuysen and Bechky, 2009).

In this study, collaborative work entails relationships between all project parties (from the owner to the sub-contractor), their supply chain processes, and the technology they use (Shelbourn et al., 2007). Coordination of collaborative work in the construction industry is demanding because of the high uncertainty and complexity of construction projects, but also because of the prevailing culture where risks are transferred to other parties. The parties focus on protecting their own profits, thus creating distrust between each other. (Barlow,

2000) This study regards collaborative work as something to be planned and coordinated (Cassivi, 2006), but also acknowledges the possible spontaneous development of relationships between the parties in the course of working together (Bresnen and Marshall, 2002). Thus, collaborative work is seen as a process (Boddy et al., 2000).

1.2 Contractual coordination of collaborative work in a construction supply chain

Coordination is defined as the integration of an organization's different parts towards a common goal when uncertainty and task interdependence are present (Thompson, 1967; Van De Ven et al., 1976; Faraj and Xiao, 2006). Coordination is critical for successful collaborative work in a supply chain (Pilbeam et al., 2012) and for organizational performance (Kogut and Zander, 1992).

In a construction supply chain, collaborative work needs to be coordinated in order to specify the parties' rights, responsibilities, and duties (Wong et al., 2008). Additionally, financial incentives need to be specified. For example, the owner needs to provide financial incentives to motivate the contractor to strive to meet the owner's objectives and minimize the financial risks of a project (Turner, 2004). It is also essential to coordinate information sharing and to integrate inter-organizational knowledge throughout the construction supply chain (Barlow, 2000; Power, 2005; Xie et al., 2010; Huang et al., 2014).

Contractual coordination generally follows the logic of transaction cost economics and aims at legally distributing financial incentives and other rights between parties before project work is started (Williamson, 1979; Sobrero and Schrader, 1998; Simatupang et al., 2002). Usually the organization's top management determines the contractual coordination mechanisms to be applied (Sobrero and Schrader, 1998).

Contractual coordination through different types of written contracts is a way to manage the coordination needs of collaborative work. For example, the 'design-build' contract, where one company is responsible for both the design and the construction phases, and the 'design-bid-build' contract, where the owner makes separate contracts for the design and the construction phases, represent traditional, dyadic contracts. However, these dyadic contracts, which are signed between two parties, are not enough to coordinate the collaborative work between multiple construction project parties, when the projects are complex and face lots of uncertainty and interdependencies (Barlow, 2000; Bygballe et al., 2010). Dyadic contracts limit collaboration and innovation as well as lead to local sub-optimization and an inability to coordinate (Matthews and Howell, 2005).

The owner organization usually gives the coordination responsibility of the construction supply chain parties' collaborative work to the main contractor (Briscoe et al., 2004; Pala et al., 2014). When the project is complex and innovations are expected, the whole supply chain network needs to be managed, and the coordination responsibility cannot lie with a single company (Pilbeam et al., 2012).

As a result, multi-party contracts have been offered as a solution to coordinate construction parties' collaborative work in complex construction projects, such as hospital projects that require innovative solutions (Williamson, 1979; Sebastian, 2011; Lahdenperä, 2012). In a multi-party contract, risks and rewards are shared at least between the owner, the designers, and the contractor. In addition, the parties make decisions collaboratively and agree not to sue each other during or after the project. (Kent and Becerik-Gerber, 2010; Heidemann and Gehbauer, 2011; Lahdenperä, 2012) A multi-party contract can also specify organizational and/or technological mechanisms for information exchange between the parties. However, the mechanisms need to be implemented after contract negotiations to ensure effective coordination of collaborative work.

1.3 Procedural coordination of collaborative work in a construction supply chain

Procedural coordination aims at coordinating collaborative work between parties after the contract is signed. Attention needs now to be paid to the selection of project team members and the "building of a cohesive project team" to ensure the team has a shared goal (Love et al., 2004:48). Furthermore, developing trust between the parties of the team and coordinating the parties' collaborative work during the project are crucial issues (Barratt, 2004; Kale and Singh, 2009).

Procedural coordination relies on efficient information flow and learning. These can be realized through organizational and technological mechanisms employed in day-to-day interactions between project parties. (Sobrero and Schrader, 1998) The procedural coordination theory originates from the structural contingency theory (Thompson, 1967; Galbraith, 1977) and the organizational learning theory (Nonaka and Takeuchi, 1995; Levitt and March, 1998).

In principle, the efficient procedural coordination of information flow between the construction supply chain parties is easy to achieve using *information technology systems*, such as project management software (Lönngren et al., 2010; Cheng et al., 2014). Another procedural coordination mechanism is *building information modelling* which also enables efficient information flow between project parties (Eastman et al., 2011; Bryde et al., 2013).

However, in practice, procedural coordination through technological mechanisms is not a trivial task because each field of expertise in the construction industry has its own language and special skills and knowledge, which complicates the codification and sharing of knowledge (Bresnen et al., 2003). Especially, the codification of tacit knowledge has been challenging, since information technologies mainly help in sharing explicit knowledge across organizations (Dave and Koskela, 2009).

Thus, the sharing and usage of knowledge between parties do not happen automatically but require processes to facilitate knowledge sharing and usage across expertise and organizational boundaries (Lawson et al., 2009), especially if the parties are not willing to share knowledge. One of the procedural mechanisms that helps in sharing knowledge is *co-*

location of project parties (Scarbrough, 2004; Xie et al., 2010). Co-location enhances the sharing of tacit knowledge (Wagner, 2003) and enables problem-solving, because co-located parties can easily arrange *inter-organizational meetings* (Okhuysen and Bechky, 2009). This is partly because social networks tend to be formed when people work near each other. Social networks enable communication, the easy gathering of information, promote the building of trust, and reduce coordination costs between the organizations (Gulati et al., 2000; Davis and Love, 2011).

Defining *common goals* is also a procedural coordination mechanism which helps the parties in their collaborative work by developing trust and encouraging information sharing (Wagner et al., 2002; Khalfan et al., 2007; Sebastian, 2011). Using *a liaison* to bridge communication gaps between different parties is also a procedural mechanism for aligning information and knowledge flow (Mirani, 2007). Additionally, boundary objects, which are material artefacts, such as design drawings, can be used to ease communication between project parties. Boundary objects provide a common platform for discussion and help in creating a shared understanding about the objects of collaboration. (Carlile, 2004; Levina and Vaast, 2005)

Lean construction, which originates from lean thinking, is brought into the construction industry to achieve streamlined processes and short throughput times with less costs and higher quality. One of the procedural mechanisms of lean construction is the 'pull technique' of the Last Planner system to enhance production planning and control. Compared with the 'push technique' that pushes production information into the process according to a predetermined schedule, the 'pull technique' releases information into the production process as soon as the process is capable of processing it. Applying the 'pull technique' includes both face-to-face collaboration and the use of information technology to visualize interdependencies between project parties on a weekly basis. (c.f. Ballard and Howell, 2003; Eriksson, 2010)

2 COMPARATIVE CASE STUDY

This study compared the coordination of collaborative work in two hospital construction projects located in California, USA. The empirical analysis concentrated on the coordination differences of collaborative work in the two projects that applied different contract types. A case study strategy was chosen because it allowed the examination of the coordination of collaborative work during the two projects, which is a temporary phenomenon that is difficult to separate from its context (Yin, 1989; Eisenhardt and Graebner, 2007).

2.1 The differences and similarities of the studied projects

The projects differed in their contracts, which made their comparison theoretically interesting. One project applied multiple 'dyadic' contracts and the other project applied one ‘multi-party’ contract. The projects have been named in the analysis according to their contractual arrangements.

The ‘dyadic contracts’ project had a public owner and applied dyadic contracts which were signed between the owner and the main contractor, the owner and the architect, and the owner and the construction management consultant. Additionally, the main contractor had dyadic contracts with sub-contractors.

The ‘multi-party contract’ project had a private owner and one multi-party contract was signed between 12 design and construction companies. The project parties shared risk and reward and agreed not to sue each other during or after the project. In addition to the multi-party contract, the main contractor also signed dyadic contracts with sub-contractors that had minor design or construction tasks to accomplish in the project.

Both hospital projects featured state-of-the-art medical equipment and aimed at a Leadership in Energy and Environmental Design certification. In addition, both projects had the same main contractor company. The contractor company applies a matrix organization with low hierarchy. It invests in team building and communication by using open office co-location environments. The main contractor provides construction management and construction services and has previous experience on hospital projects.

In both projects, the owner and the main contractor knew that the coordination of parties’ collaborative work in a hospital project is demanding, and therefore they initiated and insisted on co-locating project parties in a shared facility during the projects. Additionally, both projects used building information modelling in the same way, mainly for coordinating mechanical, engineering, and plumbing design.

During the design and construction phases both projects created innovations, which reduced the construction costs of the projects. Both projects were also delivered on time and on budget. In addition, the owners were satisfied with project execution and quality control in both projects. Hence, both projects were regarded as successful.

Both projects were regulated by the Office of Statewide Health Planning and Development. The office regulates the design and construction of healthcare facilities to ensure they are seismically safe and capable of providing services to the public. Table 1 summarizes the characteristics of the projects.

Take in Table 1

2.2 Data collection and analysis process

The qualitative data was collected by three researchers, one of them the first author of this paper. Multiple techniques were used in order to increase the validity of data (Yin, 1989): observation, interviews, and background archival data collection. First, the researchers spent two days at each research site observing project parties and informally talking to them. Observation took place at different meetings held at the sites and during the parties’ daily work routine. The researchers observed how inter-organizational and multi-expertise work was organized during the construction phase of the projects.

In total, the researchers spent six weeks on the sites, three weeks on each site, which allowed the identification of the key project interviewees and access to rich empirical data. The researchers took a passive observer role rather than an active role in order to minimize their impact on site practices (Marshall and Rossman, 1995). The researchers attended inter-organizational meetings, observed the parties' work in the shared facility, and observed the work on the construction site. The researchers also took photos and drew maps of the facilities' seating layout, to memorize the context later during data analysis. Background data, from project documents stored in the databank of the project, was also examined.

Altogether 72 key project actors were interviewed. The interviewees represented several organizations. Semi-structured interviews were used to get rich and detailed real-life descriptions. Each interview lasted approximately 45 minutes. Three researchers were present at each interview, one taking the role of the main interviewer and two asking more detailed questions and taking notes. Table 2 summarizes the data collection methods and data.

Take in Table 2

The researchers asked about the following topics: inter-organizational coordination practices, communication practices, building information modelling and information technology, and management of co-location and experiences on working co-locatedly. Table 3 presents the linkages between the used theories and interview protocols.

Take in Table 3

Notes were taken during the interviews. In addition, interviews were audio-recorded with the permission of the interviewees. The analysis process of the interview data followed the recommendations of Miles and Huberman (1994): First, the interviews were transcribed word for word. Then the interviews were read through to get a preliminary understanding of the data collected. Thereafter, the interviews were encoded twice and analysed using qualitative data analysis software, Atlas.ti.

During the first round of encoding the transcriptions, two different codes were applied based on the literature review: contractual coordination and procedural coordination. The researchers tried to be open to topics related to contractual and procedural coordination emerging from the transcriptions during the analysis process, and three additional topics regarded to be important were found: cultural change, relationships, and trust. During the second round of analysis, the quotes selected during the first round of analysis were scrutinized, and the analysis focused on understanding how procedural coordination complemented contractual coordination in the parties' collaborative work.

The rich data was analysed using systematic combining (Dubois and Gadde, 2002) and abductive scientific reasoning (Danermark et al., 2002) to understand the coordination of collaborative work in two hospital projects. In this interpretive research, the analysis process progressed as a continuous dialogue between the theoretical pre-understanding and empirical data (Mantere and Ketokivi, 2013).

3 FINDINGS AND DISCUSSION

This section provides an answer to the research question of how to complement contractual coordination with procedural coordination of supply chain parties' collaborative work in hospital construction projects. First, coordination in the 'dyadic contracts' project is discussed. Then, coordination in the 'multi-party contract' project is discussed. Finally, the coordination of collaborative work in the projects is compared and the answer to the research question is provided. Illustrative quotations from the interview transcripts are drawn on to concretize the findings.

3.1 Coordination of collaborative work in the 'dyadic contracts' project

The owner signed separate dyadic contracts with the main contractor, the architect, and the construction management consultant for the design phase of the project. The owner assumed that the dyadic contracts alone would not align the interests of different project parties towards a common goal. Thus, to mitigate the fear of financial losses by opportunistic behaviour, the owner created *joint financial incentives* to produce better performance from all project parties.

> Everybody who is on the job in that phase for that milestone shares the incentive. The whole idea is to get the money out to the people in the field. Part of that agreement is that if you get that incentive, then you have to give it to the people who work here. (Owner)

However, it soon became evident that the dyadic contracts and the joint financial incentive were not enough either to coordinate the different interests of the project parties towards common interests. To overcome this challenge, the parties decided to organize a one-week boot camp during which the parties collaboratively defined an *organizational design* for the project. For example, the project was divided into building teams and clusters, which were charged with creating design and construction models and documents. During the boot camp, the parties also defined detailed *processes for collaborative working*.

> We were building a plan and some processes … the first thing we did was we recognized; hey we all have different interests. And we need to come together over our common interests and try to find a way to focus on those and build some processes and organizations, and some structure around those to be a successful

project. And so I think that started that process … we have some common language to work with now. (Main contractor)

The jointly defined organizational design and collaboration processes were updated throughout the project. During the boot camp, the parties also decided to *work co-locatedly* in a shared facility during the whole project. These findings support the premise of the study that contractual coordination alone is not enough for creating successful collaborative work, but procedural coordination is also needed during the project (Bresnen and Marshall, 2000; Sobrero and Roberts, 2002; Dossick and Neff, 2011).

During the boot camp, the project parties also jointly developed *shared project goals*. These goals were continuously updated throughout the project. According to the project parties, the shared goals and commitment to the project helped more than the contractual reinforcement in the collaborative work between the parties. This supports the earlier findings by Boddy et al. (2000) that parties need to be committed to shared goals in order to collaborate.

> The fact that we are doing this collaborative work and lending to this environment is more by shared goals and commitment to the project than contractually reinforced. (Architect)

As a result of the boot camp, the project parties started building *common definitions*, which improved communication between the construction supply chain parties. This supports the finding by Wagner (2003) that team interaction helps in the creation of a common language.

> …when you bring a team together … and you have 30 different firms together… they all have different experiences … they may have the same words but it may mean something different. … How do you get terminologies, common definitions between them? … Getting common definitions is a way to facilitate the communication, right? (Construction management)

During the design phase of the project, the parties jointly decided on the *visual metrics* to be used, such as the time used for processing requests for information, and placed these visual metrics on the walls of the co-located facility to increase transparency and collaboration spirit. In addition, the parties also organized *integrated concurrent engineering* sessions between different professionals to integrate the expert knowledge of different parties when the project faced difficult multi-expertise tasks. These sessions facilitated knowledge across the different professionals (c.f. Lawson et al., 2009).

> …you get all these people together and you try to come up with a solution that minimizes the impact to the job and allows you to get the same final product maybe in a slightly different way … but to do it as efficiently as possible. So it's just – the [integrated concurrent engineering] session is really a tool that's used to help collaboration and integration of the team. (Construction management)

When the project was in its early design phases, *building information modelling* was a new approach to designing buildings, let alone to collaborative design, but over the course of the project, the parties learned how to use it in their collaborative design processes. As hypothesized based on the findings by Bryde et al. (2013), building information modelling helped in the integration of different designers' design information.

> …the contractor was brought on board in the middle of design development. And so we kind of started having meetings and sharing our kind of building information model with them. And we did a lot of very early like use [software] to do a lot of clash detection and things like that. So that was good. (Architect)

Project management software was used throughout the project to improve information flow between the project parties. The easy access to information was regarded to help collaborative work, which corroborates the earlier similar findings (cf. Barratt, 2004; Cassivi, 2006; Lönngren et al., 2010).

> [Project management software] was a big help in… sharing information between trades in like real-time, without having to have some other server or emailing files back and forth. So that helps a lot. (Mechanical subcontractor)

Inter-organizational meetings were also arranged throughout the project to make decisions collaboratively. Lots of meetings were arranged to make sure information between individuals spread through over-communication. Thus, over-communication was not seen as a hindrance as earlier research suggests (Bresnen and Marshall, 2002) but rather a benefit.

> We try to over-communicate. So we have the coordination meetings. … We have the owner's meetings. We have the PSG [project solutions group] meetings. And all of those are supposed to make sure what is being talked about that information is spread out. (Main contractor)

The main contractor and the construction management acted as *liaisons* to ascertain that the right individuals were present in the right meetings, which supports the finding that a liaison is useful for knowledge sharing (Mirani, 2007). In the following, they explained their roles as liaisons.

> Helping set up the meetings and make sure they take place. Make sure that the right people show up to those meetings. (Main contractor)

> I know who on the team may have the best skills to help out with solving a given issue and I'll bring them in as needed. (Construction management)

During the construction phase, some of the parties faced a potential financial threat because the dyadic contracts signed for the construction phase did not provide enough financial resources to cover additional work due to changes in the project. This led to the situation that some of the parties (mainly subcontractors) had to be wary of any 'major' changes in order not to promise to do work that they were not compensated for. This finding illuminates the fact that it is difficult to design perfect contracts before project execution because of the humans' bounded rationality (Williamson, 1979; Turner, 2004).

> [During the design phase,] it was everybody – you did not care if it was going to cost you more money because you could do what you needed to do, so you are more open to make changes. Whereas now [during the construction phase], if I have to pick up someone else's scope, it is going to cost me more money, so now I have got to figure out how to balance that. (Mechanical subcontractor)

To tackle the potential problems brought by the dyadic contracts of the construction phase, the owner again created joint financial incentives for the project parties for the construction phase. The project parties also decided to define *common rules of conduct* for meeting behaviour to enable smooth collaboration as the number of individuals increased during the construction phase.

> Rules of conduct … Getting everybody involved in what's the best way of handling ourselves within meetings. That's the place where you'll find the most conflict. Within a meeting you need to be respectful to other people, to understand where they're coming from, and to listen to what they're saying. You're trying to solve the issues in the best interest of the project, and not in the best interest of any individual. … and getting more alignment between all of the team members out here. (Construction management)

Partly due to working co-locatedly, the parties learned to understand each other's working processes and built relationships that enhanced trust between the parties which corroborates earlier research (Scarbrough, 2004; Xie et al., 2010). Co-location was also found to reduce latency in decision-making.

> … building that trust that we are all trying to get the thing done. We all have our own interest … So just kind of building those relationships. (Architect)

> One big advantage I see is decision-making, and how fast it is to have decision making out here in an environment like this…. And very frequently just in talking to people about things, these issues get resolved. They don't get escalated into something that now suddenly needs a much higher level of decision-making to get it resolved. (Construction management)

The traditional project's 'push technique' was complemented by the 'pull technique' of *lean construction* to increase the transparency of the interdependencies between the construction activities of the project parties and to 'pull plan' the activities (c.f. Ballard and Howell, 2003; Eriksson, 2010).

> Using lean construction, [first] we will develop a [traditional] push plan, [then] sit down with the subcontractor then do a pull plan with them. Get everyone's buy-in in the coordination and duration and when everyone is starting. (Main contractor)

3.2 Coordination of collaborative work in the 'multi-party contract' project

The multi-party contract defined a joint financial incentive for the main twelve construction supply chain parties. In addition, the parties had defined *shared project goals* during the contract negotiations and the goals were updated throughout the project. The multi-party contract enabled the parties feel financially safe (c.f. Sebastian, 2011; Lahdenperä, 2012).

> …you are guaranteed your base price … everybody that is a partner is forced to work together, so that is a good thing. [When using dyadic contracts,] it is very uncommon to see the framer talking to the plumber or the sheet metal guy; it is usually everyone for themselves and whoever wants to be the first one in gets the most stuff up. So this [multi-party contract] works out well. I guess the downfall is if someone is not picking up their slack then everybody has to pay for it, so basically everybody is watching out for the other guy. (Mechanical contractor)

> I've noticed that people get along much better because in the end everybody is getting their share or piece so everybody tries to work together more as opposed to "this is my part, this is all I am worried about, I do not care about your part". So the job seems to run more happily. (Main contractor)

The parties also experienced that the multi-party contract enhanced experimenting with new ideas and information technology based tools in the project, because project risks were financially shared.

> [The multi-party contract] kind of protects us … So, it gives us more freedom to try new things, and not necessarily have that risk of if somebody builds something wrong it is not costing us individually with the contractor money. It is costing the team as a whole. But I think they understand that more often than not, we are saving money than spending money. (Main contractor)

> … bring everybody in, bring all the experts in, let's build this together and everybody has the same goals. We're all going to be profitable at it while let's bring in all those goals, everybody has the same most to make it happen as one, instead of everybody kind of fighting for themselves. (Electrician)

Additionally, the multi-party contract stated that the parties were required to arrange *inter-organizational meetings* where decisions were made collaboratively. These meetings were regularly held after the contract had been signed, and the parties regarded these face-to-face discussions important in understanding what the situation of the project was and what should be done next.

> …There's nothing that replaces – especially when you're talking about complex things, the face to face meetings. … the big thing that – that's difficult is the designer has five or six things that they're working on but they might not know which ones are the most important to work on and it might change week to week. (Main contractor)

The parties had started forming *common definitions* during the multi-party contract negotiations. Team work during the inter-organizational meetings helped in the further development of common definitions, which helped the collaborative work. The inter-organizational meetings were easy to arrange throughout the project because the parties were *working co-locatedly* since the beginning of the design phase. However, the architect was only partially co-located and for that reason some of the meetings had to be organized virtually. The meetings acted as established communication routines which helped in sharing the understanding about each party's goals and the needed sequence of activities, as suggested by Pilbeam et al. (2012) and Pilbeam (2013). The findings also corroborate the earlier finding that co-location improves the sharing of tacit knowledge (Wagner, 2003), and further, that procedural coordination after contract negotiations is important, even though the contract guarantees financial safety (Sobrero and Schrader, 1998; Nielsen, 2010).

During the design phase, the parties decided to put financial and schedule metrics on the walls of the co-located facility to visualize the progress of the project to different parties. These *visual metrics* were updated regularly and they increased the transparency of the project. The parties also collaboratively decided that the main contractor would act as a *liaison* who ascertains that information from the field gets spread to the owner throughout the project. In the following, he describes his role as a liaison.

> I am really kind of like the liaison between the field and the owner... like I say the guy in the middle so to speak between the owner and the field. (Main contractor)

Some of the parties had been working together in a previous project and the management thought that they would already share some common ways of working. However, those who had not worked in the previous project were suspicious towards the collaborative way of working in the beginning of the project. However, in the course of time, the parties learned to mutually adjust to each other's work processes (cf. Bankvall et al., 2010).

> Some people are still kind of holding their stuff to the vest because they have been trained so long to do what's best for them, not necessarily what's best for the electrician or best for the plumber. So it takes a little while for everybody to really truly understand the benefit of working more as a team. (Main contractor)

> We all need to take a step back every day and remember that we are being asked to do something different here... That is always a daily challenge, to work on those relationships... And that changes the way the communication happens. It requires that you are open to suggestions from a lot of people that you generally do not need to worry about. (Mechanical subcontractor)

Some of the parties considered that the collaborative way of working was time-consuming, whereas others thought that decision making was fast due to the co-location of the parties.

> Things take a little longer to resolve because ... it is a much more collaborative process... But that is what people have to begin to understand: how the process works and how to really use the process effectively. How to use everybody's talents and abilities much better than what we are doing now? (Architect)

> ...rather than decision making going from one to the next to the next to the next, everybody is in the room together. They talk about it. They make a decision and they go. So, I would say, overall decisions get made faster on a [multi-party contract] project, which is why these projects have been able to more or less, stay on schedule. (Main contractor)

The multi-party contract stated that *building information modelling* was to be used during the project. Intensive building information modelling between the parties took place throughout the project. However, it was not used without problems. For example, the level of detail and schedule of building information modelling were demanding to define during the design phase.

> So, it was hard to determine what the right level of detail to coordinate to was at any particular time in preconstruction [and during construction]. (Main contractor)

Additionally, *project management software* was applied throughout the project to improve information flow between the construction supply chain parties. The 'pull technique' of *lean construction* was applied in the planning of the commissioning process at the end of the project. It worked well in creating dialogue which revealed the interdependencies between the organizations.

> ...if anything, it [pull technique] does create good conversation and dialogue. It brings out some of the problems that they are having out there that in days prior you wouldn't have known, because all you care about is when they need it to be done, so that's been helpful. Yeah. Having them feel like they're more part of a team, but it's a very big cultural shift, because they are not used to sharing that information with the main contractor. (Main contractor)

3.3 Comparing the coordination mechanisms in contractually different projects

The dyadic contracts neither provided a shared goal for all the project parties nor specified the organizational or technological mechanisms to align information and knowledge flows between the parties during the project. This led to the parties to fear opportunism and experiencing lack of trust in the beginning of the project. To overcome these issues, the project parties defined an organizational design and processes for collaborative working and developed shared project goals in the beginning of the design phase. Furthermore, the owner created joint financial incentives and the parties started creating common definitions in the beginning of the design phase.

The multi-party contract aligned financial interests and built trust between the construction supply chain parties in the beginning of the project through the idea that 'the parties agree to solve problems in the interest of cooperation' (Blumberg, 2001) and through sharing financial risks and rewards (cf. Lahdenperä, 2012). The multi-party contract itself aligned information and knowledge flows between the project parties by specifying organizational and technological mechanisms, such as a joint financial incentive, shared project goals, common definitions, collaborative decision-making in inter-organizational meetings, and building information modelling, and project management software. In addition, the multi-party contract promoted the experimenting with new ideas and technological tools in the project, as the parties bore the financial risks together.

The parties in the 'dyadic contracts' project organized integrated concurrent engineering sessions when design challenges required the co-creation of innovative solutions. This was important during the design phase in order to build trust between the project parties and to facilitate collaborative working. In addition, common rules of conduct were collaboratively defined to help collaborative working during the construction phase. These findings suggest that when applying traditional dyadic contracts, procedural coordination has to be co-created by the supply chain parties in the beginning of the project. Thus, it can be argued that when the contract does not provide the required trust between the construction supply chain parties, inter-organizational structures for communication need to be co-created during the project (c.f. Wong et al., 2008).

When looking more closely at the coordination of collaborative work in both projects, it is revealed that both projects complemented contractual coordination with procedural coordination mechanisms. However, it seems that when applying dyadic contracts, more procedural coordination mechanisms were needed in the beginning of the design phase. Compared with the multi-party contract, the dyadic contracts needed to be complemented during the design phase with additional procedural coordination mechanisms: organizational design, processes for collaborative working, and integrated concurrent engineering sessions. These mechanisms were collaboratively created by the project parties. Additionally, common rules of conduct were collaboratively defined and taken into use during the construction phase. These mechanisms were not used when applying the multi-party contract.

Both projects applied the following procedural coordination mechanisms: co-location, collaborative decision making in inter-organizational meetings, a liaison role, building information modelling and project management software, visual metrics, and lean construction practices. Further, the findings hint that especially the co-location and the inter-organizational meetings had several beneficial effects on both projects, such as reducing latency in problem solving and decision making, and creating relationships and trust based on collaboration between the parties (c.f. Bresnen and Marshall, 2002). In addition, the visual metrics on both projects' walls of the co-located facility increased transparency and commitment to the project goals. These visual metrics supported information sharing between the parties. It can be argued that they acted as boundary objects in knowledge sharing across the inter-party boundaries (Carlile, 2004; Levina and Vaast, 2005).

Figure 1 summarizes the main differences in coordination between the projects. The figure illustrates at what phase of the project (contract, design, or construction) a particular coordination mechanism was in effect.

Take in Figure 1

4 IMPLICATIONS FOR SUPPLY CHAIN THEORY AND PRACTICE

The findings of the study contribute to the research on coordinating construction supply chain networks by revealing how procedural coordination successfully complemented contractual coordination in two contractually different construction projects. The study fills a research gap in understanding how to complement contractual coordination with procedural coordination of supply chain parties' collaborative work in the complex context of hospital construction projects.

The findings corroborate the earlier finding that contractual coordination is important in defining financial and other rights and that procedural coordination is needed during the project execution regardless of the contract type (Sobrero and Schrader, 1998; Nielsen, 2010). However, our findings suggest that when applying multiple dyadic contracts, additional procedural coordination mechanisms were needed compared with the use of one multi-party contract. The parties collaboratively defined an organizational design, processes for collaborative working, and organized integrated concurrent engineering sessions during the design phase of the 'dyadic contracts' project. During the construction phase, the parties collaboratively defined common rules of conduct to coordinate the collaborative work. Thus, the parties, applying dyadic contracts, co-created most of the procedural coordination mechanisms at the beginning of the design phase (c.f. Wong et al., 2008). The study hints that the boot camp played an important role in enabling the co-creation of procedural coordination mechanisms in the beginning of the 'dyadic contracts' project. Thus, further research should examine whether procedural coordination mechanisms can be co-created without temporal co-located working in a boot camp.

Based on the findings, it can be argued that in both contract types, the co-located working shifted the coordination emphasis from authority and contracts towards relationships based on collaboration and trust, which is needed in the construction industry (Barlow, 2000; Briscoe and Dainty, 2005; Davis and Love, 2011). This also supports the finding by Xie et al. (2010) that co-located working provides a free and friendly environment for communication and has a positive effect on social collaboration. However, it might have been that the parties selected to the project had collaborative attitudes to begin with which may have helped in the adjustment to the co-located working (cf. Bresnen and Marshall, 2002). The co-located working has probably led to the forming of common definitions, and also to the adoption of common rules of conduct in the 'dyadic contracts' project. These mechanisms contributed to the creation of a 'transient project culture', common to all project parties but different from their own corporate cultures.

The findings of the study have practical implications in terms of coordinating construction supply chain networks in complex projects; especially in the public sector because public organizations are often legally prohibited from applying multi-party contracts in public projects. The findings reveal how several procedural coordination mechanisms successfully complemented the contractual coordination of dyadic contracts. It is worth emphasizing that procedural coordination was felt to be demanding in terms of time and resource allocation, a finding suggested also by Sobrero and Roberts (2002). However, for example, the co-location of project parties brought benefits in the form of quicker problem solving and decision making. At the end of the day, the owners were highly satisfied with the quality of the hospital buildings, and the projects were delivered on time and on budget.

The findings also hint that the multi-party contract promoted the experimenting with new ideas and technological tools in the project, as the parties bore the financial risks together (c.f. Pala et al., 2014). Thus, the use of one multi-party contract seems to encourage more risk taking than the use of multiple dyadic contracts.

5 CONCLUSIONS

This paper explored how contractual coordination was successfully complemented with procedural coordination of construction supply chain networks. A comparative case study of the coordination of collaborative work in two, contractually different complex hospital construction projects was conducted. One of them applied multiple dyadic contracts, whereas the other applied one multi-party contract between all supply chain parties. The fact that the main contractor was the same organization in both projects provides 'control' over variation in the application of the two contracts, and reinforces the findings of the study.

The study showed that depending on the contract type, the timing and extent of complementary procedural coordination between the construction supply chain parties differ during the project. More procedural coordination is needed at the early design phase of the project when multiple dyadic contracts are applied. However, procedural coordination is still needed in both types of projects, and throughout the projects. The findings of the paper develop the understanding about the successful coordination of construction supply chain networks in complex projects.

The study indicates that the main contractor had a larger role in the coordination of collaborative work than the other project parties (c.f. Pala et al., 2014). The findings hint that the main contractor understood the importance of working towards the same project goals, and thus aimed at facilitating collaboration between all project parties using different procedural coordination mechanisms.

The procurement laws in California forbid the owner from applying a multi-party contract in public projects. Thus, the project with a public owner had to apply multiple dyadic contracts. The owners' effect on procedural coordination needs to be further studied but it seemed that both owners were attuned to the latest developments in the construction industry, and were also brave enough to try new collaborative ways of working together with all the supply chain parties.

The findings of this study have implications for information sharing in the extended supply chain, beyond the dyad, which is called for in recent research (Kembro et al., 2014). The co-located working allowed the project parties to easily arrange inter-organizational meetings where information was shared between all parties and decisions were made collaboratively and in an efficient manner (c.f. Xie et al., 2010).

The research also implies that the co-located working played an important role in complementing the contractual coordination in the projects by improving the relationships and trust between the construction supply chain parties. Future research should shed light on efficient procedural coordination mechanisms between construction supply chain parties when the possibility of co-located working is excluded.

The study has potential limitations from a methodological point of view, because observational data from the projects was collected only during a six-week time period. However, the researchers followed up the projects till the end of the construction phase to confirm that the projects were successful in terms of quality, cost, and schedule. Another limitation lies in external validity because the study compared only two hospital projects. Further research is needed to confirm the complementary combinations of contractual and procedural coordination of construction supply chain networks in other types of projects.

Future research should also examine which procedural coordination mechanisms best support the implementation of dyadic and multi-party contract types. Specifically, the role of joint financial incentives needs to be further studied since this study suggests that the joint financial incentives have an important role in creating a sense of financial safety, especially in the case of applying multiple dyadic contracts.

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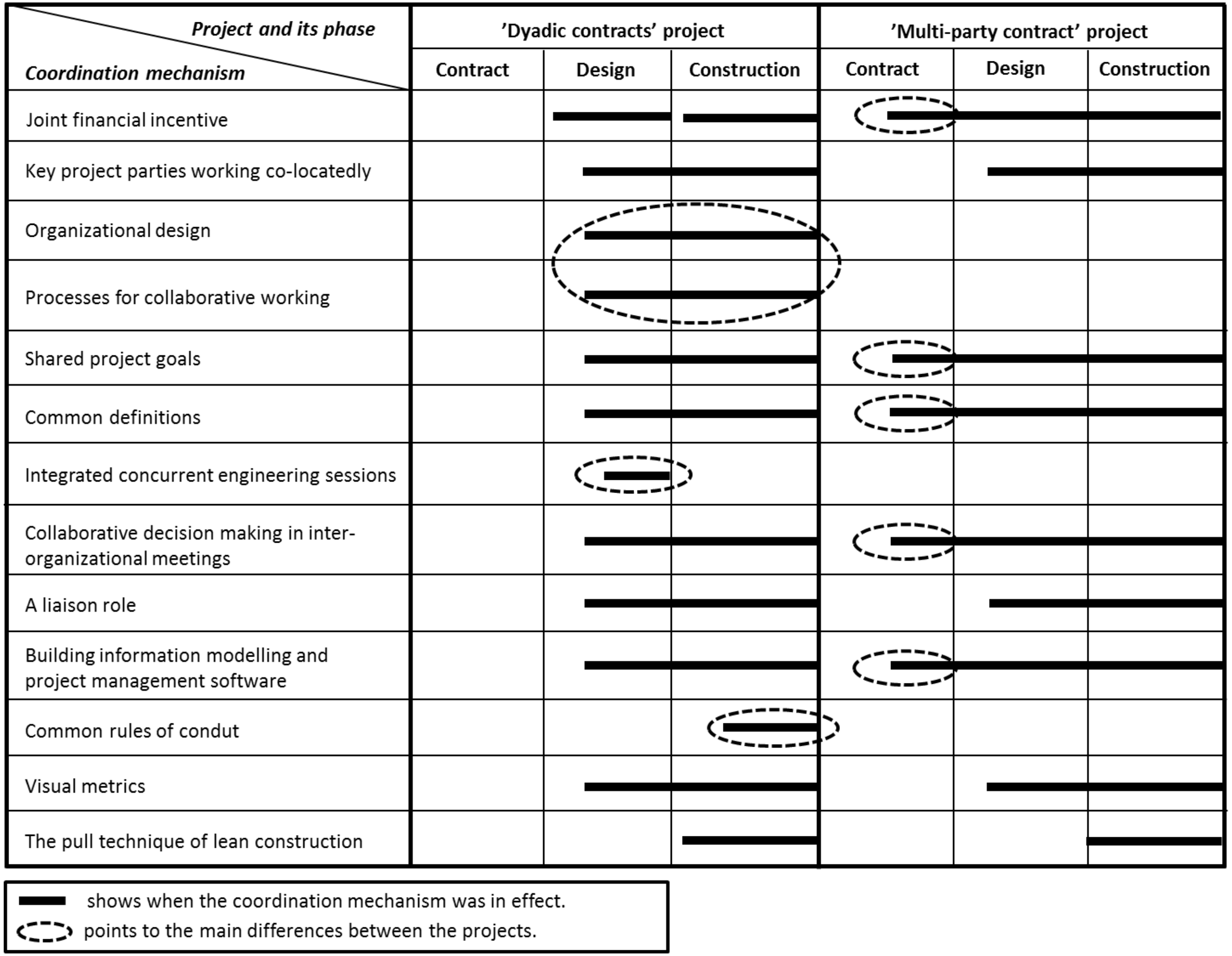

Figure 1. A summary of main coordination differences between the projects.

Table 1. The characteristics of the studied hospital projects.

	'Dyadic contracts' project	'Multi-party contract' project
Features of the hospital	- 289-bed children's, women's and cancer hospital: a 6-story hospital, outpatient building with helipad, and an energy centre. Opens in 2015. - LEED gold certification. - Regulated by the Office of Statewide Health Planning and Development	- 243-bed children hospital: an 11-story tower and rooftop utility plant. Opened in 2014. - LEED silver certification. - Regulated by the Office of Statewide Health Planning and Development
Cost and schedule	- 1.5 billion dollars. - Design started in August 2007; 4-year construction started in December 2010 and ended in 2014.	- 350 million dollars. - Design started in 2007; 3.5-year construction started in October 2010 and ended in 2014.
Owner and other main parties	A public organization and other main parties, which are the construction management consultant, architect, and main contractor. Altogether 29 parties in the project.	A private organization and altogether 12 parties: architect, main contractor, structural engineer, mechanical, engineering, and plumbing, and special design and construction companies for case work, rebar, and exterior skin.
Contract	- Design phase: the owner had dyadic contracts with the main contractor and other main parties and a joint financial incentive for better performance was implemented during the design phase of the project. -Construction phase: the owner had dyadic contracts with the main contractor and other main parties. The main contractor had also dyadic contracts with sub-contractors.	- 12 design and construction companies together signed one common multi-party contract where risks and rewards were shared between the parties. The parties have a shared target cost which forces the parties to collaboratively decide on the project's details in order to reach the target cost. - 26 other companies that had a minor task to accomplish during the project were included in the project with separate contracts.

Table 2. Data collection methods and data.

	'Dyadic contracts' project	'Multi-party contract' project
Observation	- Period: 10.9.-28.9.2012 - 11 meetings (~15 hours) - 40 pages of field notes	- Period: 4.10.-19.10.2012 - 5 meetings (~10 hours) - 32 pages of field notes
Audio-recorded, semi-structured interviews	41 interviews (1525 minutes): - Seven owner representatives - Five architect representatives - Four construction management consultant representatives - 20 main contractor representatives - Five sub-contractor representatives	31 interviews (1169 minutes): - Three owner representatives - Two architect representatives - 17 main contractor representatives - Six sub-contractor representatives - One OSHPD representative - One inspector of record - One independent equipment consultant
Archival documents	Organization charts, meeting minutes, communication plans, cost and scheduling plans, quality control plan, and BIM execution plan	Organization charts, meeting minutes, contract, cost and scheduling plans, quality control plan, and BIM execution plan

Table 3. Linkages between theoretical backgrounds and interview protocols.

Theoretical background (main references)	**Interview protocol** (topics of the interviews)
Supply chain coordination (Briscoe and Dainty, 2005; Lawson et al., 2009; Bankvall et al., 2010; Bygballe et al., 2010; Eriksson, 2010; Lahdenperä, 2012; Pilbeam et al., 2012)	Inter-organizational coordination practices
Supply chain communication (Barlow, 2000; Wagner et al., 2002; Power, 2005; Khalfan et al., 2007; Mirani, 2007; Eriksson, 2010; Xie et al., 2010; Huang et al., 2014)	Communication practices
Information management in supply chains (Lönngren et al., 2010; Eastman et al., 2011; Ghassemi and Becerik-Gerber, 2011; Sebastian, 2011; Bryde et al., 2013; Cheng et al., 2014)	Building information modelling and information technology
Collaboration (Wagner, 2003; Scarbrough, 2004; Petersen et al., 2005; Eriksson and Nilsson, 2008; Okhuysen and Bechky, 2009; Bankvall et al., 2010; Lönngren et al., 2010; Xie et al., 2010)	Management of co-location and experiences on working co-locatedly

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