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**DIMENSIONS OF DISTANCE IN A PROJECT NETWORK: EXPLORING
OLKILUOTO 3 NUCLEAR POWER PLANT PROJECT**

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Abstract

This paper proposes that many of the challenges of implementing large multi-firm projects are captured in the multi-dimensional concept of distance between firms in a large project's actor network. The paper develops a distance framework that includes three dimensions: firm attributes describing actors' characteristics, network attributes describing the distance in the relationships among the actors in the whole project network, and project practices increasing or decreasing distance among project network's actors. We draw empirical evidence from the project network of Olkiluoto 3, a nuclear power plant currently being built in Finland. We elaborate the distance framework by suggesting content for the framework that describes distance in Olkiluoto 3 nuclear power plant project. By addressing projects as multi-firm enterprises with specific distance characteristics, our research opens up a path towards novel management of a project that engages several firms in its sphere of governance.

Keywords: Large projects, project management, project implementation, project network, distance, nuclear power plant

1. Introduction

There is an extant literature on empirical and empirically based studies on large projects [1- 9]. The large projects literature uses terms such as complex projects, major projects, giant projects, and megaprojects. Examples of projects addressed by this literature are the Channel Tunnel, building of naval bases, constructing transportation systems in large cities, public buildings, bridges, Olympic Games projects, and considerable technical developments, such as the Concorde aircraft or space shuttles. According to these studies, the track record of large projects is fundamentally poor. The themes addressing and elaborating risks and success issues dominate in large projects research. Large projects can be viewed as networks of actors or stakeholders (firms and non-business actors). Based on the research on large projects, we *define a large project as* “a significant undertaking characterized by a) multiple organizations seeking success with different objectives, b) changing priorities of project objectives, and finally, c) the project being subject to the impacts of a wider socio-political environment.” (synthesized from [2, 7, 9]). The studies of large projects often address the international dimension in a large project. Organizations participating in a project include multiple firms, public organizations, authorities and political decision-making bodies – and even several owners [9]. The multiple organizations participating in a project all represent their own and potentially controversial and conflicting objectives and expectations from the project [10-12]. The challenge of the project lies in managing the project and coordinating the activities of various actors across this complex network of organizations.

We propose that many of the challenges of implementing large projects with multiple actors are captured in the multi-dimensional concept of distance. The research question of this paper is: *What are the dimensions of distance between the actors in a large project’s network with*

multiple firms? We address the research question by forming a distance framework. We examine the project network of Olkiluoto 3, the 5th nuclear power plant in Finland, which is currently in the middle of its implementation. The Olkiluoto 3 project is used in the framework formation to create understanding of the distance dimensions and to simultaneously analyze the framework's characteristics. The Olkiluoto 3 case involves multiple actors. The owner and the buyer of the plant is a Finnish electricity company TVO (Teollisuuden Voima), which is owned by several Finnish industrial companies. The French company Areva is the turnkey contractor of the plant. Olkiluoto 3 has faced several problems right from the beginning, resulting in considerable delays in the implementation. At present, in the beginning of 2008, the estimated deadline for the completion is 2011 - two years behind the originally planned schedule.

In this paper, we start by analyzing the literature on the concept of distance and its dimensions. We then address the theme of distance in project networks, and the ways of analyzing and reducing distance in large projects. We conclude the literature review by proposing a framework for analyzing distance between actors in the implementation of large projects. We then present the results of the case study on Olkiluoto 3 nuclear project plant project. Based on the empirical study, we suggest attributes and practices describing distance in the Olkiluoto 3 project. Finally, we discuss the implications of our analysis to the implementation of large projects and provide suggestions for further research.

2. Literature review

Distance

Different aspects of distance between actors have been discussed in the literature. *Geographical distance* refers to the situation when activities are spread over different geographical locations [13] and it is a measure of the effort of one actor to visit another [14]. *Temporal distance* measures the dislocation in time experienced by two actors [14] and may also refer to different time zones [15]. *Technological distance* occurs when activities are built on different technologies [13]. A cultural aspect is involved in distances, which brings forth the issue of *cultural distance*. Geographical distance means crossing, besides geographical, also cultural boundaries. Holmström et al. [14] argue that *sociocultural distance* reflects the level of understanding of another actor's values and normative practices. Sociocultural distance involves issues such as organizational culture, national culture and language, politics, and individual motivations and work ethics. Especially language might become a barrier in multicultural projects including, besides vocabulary, meanings [14]. Further, Holmström et al. [14] propose that sociocultural distance has implications for communication, coordination, and control, and additionally, it challenges the possibilities to create mutual understanding within and between various teams in the project. Similarly, Olson and Olson [15] discuss common ground that refers to the knowledge the actors have in common while being aware of it. The more common ground people can establish, the easier their communication becomes, leading to the greater productivity and reducing the distance between the actors. Olson and Olson [15] argue that the single biggest factor affecting global projects are the cultural differences, which include differences in process, differing between nationalities and cultures as well as distance in power, which reflects the relationship between different hierarchical levels in organizations. Evaristo et al. [16] discuss the

term *perceived distance* as a dimension of distributedness arguing that the term “distributed” can refer to different meanings, such as the distance between the actual projects, the team members, or coordinators.

Distance in project networks

Projects are temporary networks consisting of several organizations or actors [17, 18]. This may entail various forms of distance within the actors in the network. The network aspect emphasizes that no actor alone has total control over the network [19]. The temporary nature of project networks means that they exist in that specific form only during the time-line of a single project [12]. Hellgren and Stjernberg [11] emphasize that despite the common project task being the *raison d’être* of the network, there may be several conflicting interests and priorities among the parties. They argue that there are no common goals in the project network in the traditional business sense. Instead, there is an array of coexisting, partly supporting and partly conflicting, individual business goals. The multiple goals related to a project range from definitions of short-term deliverables to long-term societal impacts, and from explicitly communicated goals to hidden interests or identities of various stakeholders. Communication is important for clarifying the various goals, interests and identities of different actors related to the project, which contribute to the understanding of the project’s overall governance framework [20].

Analyzing and reducing distance in large projects

Literature on large projects lists various major challenges and suggestions in organizing and managing a project enterprise as a network of several participating organizations, especially related to analyzing risk, uncertainty and success issues. There are several reasons for dynamism in projects, for example, changing context, internal and external uncertainty, complexity or turbulence, asymmetries of interests and objectives among the involved actors.

Large project studies offer several suggestions that may serve as a way to decrease distance in projects. Organizational structure of a project with the use of contractors, the shaping of the project, the project's institutional framework and the capacity of governance and self-regulation are important [5, 6, 21]. The owner's competencies and the owner's interest to put resources in the process and carry responsibilities are essential [2, 9, 21]. It is the responsibility of the project owners to establish the project management structure [21]. An extensive use of contractors will release owner's capacity and enable the owner to concentrate on core tasks [9]. However, the owner should not mix firm price and reimbursable contract forms, i.e., the owner must not allocate such responsibilities or risks to the contractor that belong to the owner and which are more appropriate to keep under the owner's responsibility [2]. There should be balanced authority and responsibility among the different stakeholders [2, 9].

Based on the review of the existing literature, we created a loose framework for analyzing the attributes of actors and their relationships from the distance viewpoint as well as practices, which may either increase or decrease distance between the actors.

Distance framework

We propose a framework for analyzing the relevant dimensions of distance between actors in large project implementation (Figure 1). The distance framework includes three dimensions: firm attributes, network attributes, and project practices. Firm attributes represent the context through each participating actor's characteristics. Network attributes describe the distance in the relationships among the actors in the whole project network. They include social, physical, cultural, attitudinal, behavioral, or temporal types of distance. Project practices increase or decrease the distance among the project network's actors.

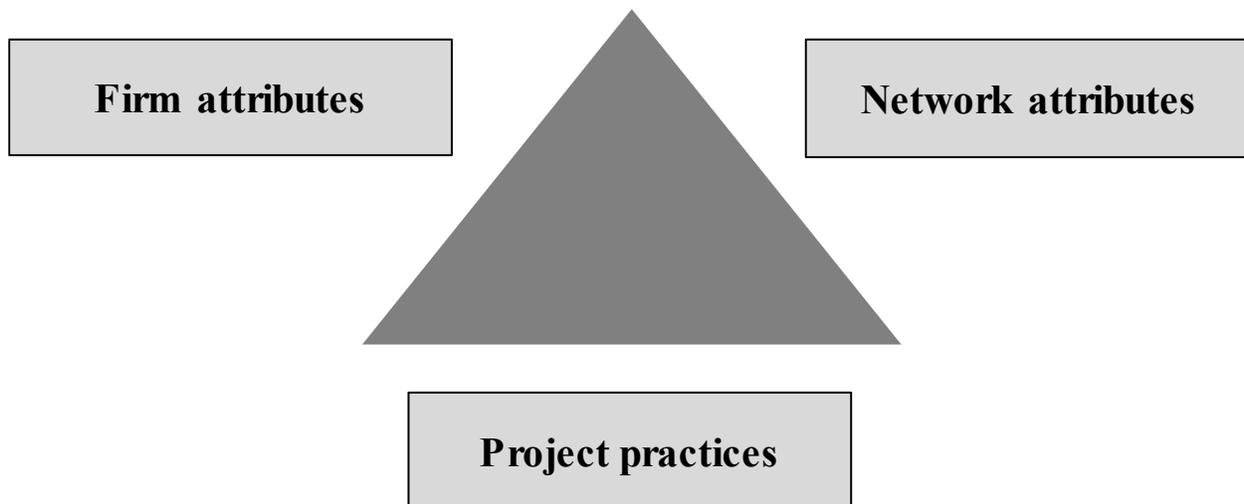


Figure 1. Distance framework.

3. Methodology

Our empirical study focuses on an ongoing nuclear plant project Olkiluoto 3. The project has been widely debated in the media and public discussion due to its significance and the reported challenges. To conduct our research we used an abductive research approach, implying that we started by identifying a particular phenomenon and then related that phenomenon to broader concepts [22, 23].

Our research data includes 1) total coverage of stories published in the Finnish leading financial periodicals and newspapers¹ about Olkiluoto 3 between years 2001-2007, 2) public information provided in the Internet sites of Areva, TVO and STUK (the Finnish national authority in radiation and nuclear safety) and broadcasted TV documents and news broadcasts on the plant and 3) the in-depth investigation report on the Olkiluoto 3 project's challenges published by STUK in June 2006 (STUK Investigation report 1/06: Management of safety requirements in subcontracting during the Olkiluoto 3 nuclear power plant construction phase). Our data is

¹ Kauppalehti, Talouselämä, Tekniikka ja Talous, Helsingin Sanomat

secondary public data described above, and the case analysis is conducted based on this rich public documentation.

We analyzed the documented and broadcasted material and drew a timeline of main events in the project to illustrate an overall view to the project. We then selected a specific concreting case for more in-depth analysis that we also report in more detail in this paper. For this specific concreting case, we used the STUK investigation report as the primary source for our data analysis. This case was analyzed using a text-analysis program Atlas.ti. Data was first classified into categories based on the preliminary framework and relevant quotations from the report were sorted under these categories. Codes then formed the basis for the emerging framework. When completed with the documented data we formed tables on the attributes and practices related to the main dimensions creating distance between the actors in the project network. These tables were then used to create an understanding of the content of the distance dimensions and to complete the suggested distance framework.

Since our empirical findings are based on one specific nuclear power plant case, and our analysis of existing knowledge is based mostly on literature addressing large projects in infrastructure, engineering construction, and heavy engineering industries, our results must not be generalized in a straightforward manner outside such projects or project contexts. Furthermore, concerning the validity and reliability of this research, the use of this type of rich public evidence, archival records and documentation, has both advantages and disadvantages. One advantage of the use of this kind of rich and public data is the fact that we can openly discuss the data and our findings in the analysis, by posing the data and the findings for public critique. Such public critique may help to test the correctness of our analysis and to position flaws in its content if any.

4. Case description and results

Nuclear power plant sector

There are altogether 435 nuclear power plants in the world, but currently several new ones are being built, especially in China. In Europe, building a nuclear plant is highly regulated both by EU acts and at the national level by countries' own regulations. In Finland, the regulations related to radiation safety and to the building of a nuclear power plant are extremely tight. The

compliance of the regulations is monitored and controlled by STUK, the national authority in radiation and nuclear safety.

The current European practice is that every country's own radiation safety authorities specify the safety standards. For example, the Finnish practice deviates in many ways from the practices in France: in Finland the designs need to be sent to STUK for approval already in the design phase. The dual approval process is not the protocol in some other countries, where the audits by radiation and nuclear authorities take place only after a certain part of the plant is built.

Olkiluoto 3 project

Olkiluoto 3, a 1600 Megawatt plant, is the fifth nuclear power plant built in Finland. The Olkiluoto project is conducted as a lump-sum turnkey project. The total employing effect of the plant is evaluated to be over 30 000 man years. French Areva acts in the position of the main contractor and the buyer and the owner of the plant is a Finnish company TVO (Teollisuuden Voima). TVO is a power company owned by a number of Finnish industrial companies.

The value of the contract between TVO and Areva is 3 billion Euros and the contract was signed in late 2003. The turnkey project was sold as a new technology project, since there was a new type of nuclear technology involved. Two other companies took part in the tender competition too. Finally, Areva, with a low bid, was selected.

Since the early phases of the project, Olkiluoto 3 has faced some serious trouble. At present, the plant is evaluated to be ready in 2011 - over two years behind the planned schedule. Various explanations for the problems faced by the network implementing the project have been presented. Among others, doubts about the reconciliation of dissimilar operational and communicational practices between the Finnish, German and French have been presented.

Main actors in the project

Olkiluoto 3 involves a group of diverse organizations with differing roles and responsibilities, which together form a complex multi-organizational project network. TVO as the buyer and owner and Areva, as the turnkey contractor are the main participants of the network. In addition, companies in Areva's subcontractor network, both from Finland and other countries, are important actors in terms of the construction works. STUK has an important role in overseeing

the project from the standpoint of radiation safety issues. In this study, especially the role of Forssan Betoni, a concrete supplier of Areva is examined in more detail as a specific ‘concreting case’. Figure 2 presents the network of actors in the concreting case.

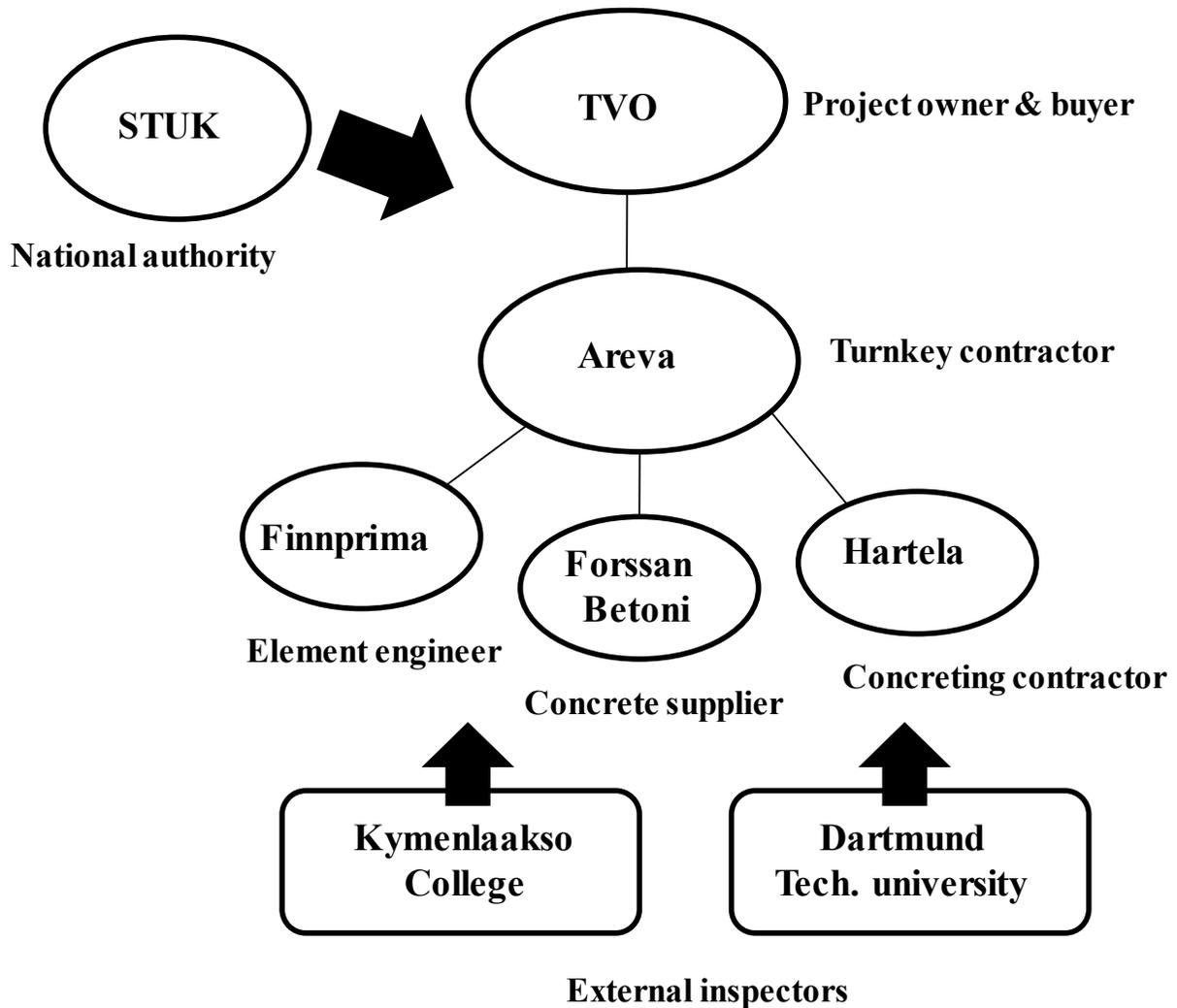


Figure 2. Network of actors in the concreting case of Olkiluoto 3.

Before Olkiluoto 3, TVO and Areva had no joint working experience. TVO is an experienced actor in the Finnish nuclear business, since it has been involved as a client and an owner in the

building of some earlier nuclear power plants in Finland. TVO entered the project with the strategy that the turnkey responsibility would be given to one company. Naturally, as the case concerned the building of a nuclear plant, safety and quality were on top of the priority list. However, speculations in the Finnish media maintained that the price of the deal was potentially emphasized at the expense of the quality. The director of the project at TVO was appointed to the project from early on. His industrial and project management experience was from the shipbuilding industry.

Areva is a nuclear power plant company, a French-German consortium, which was born in 2001 as a result of Framatome's and Siemens' nuclear technology division's merger. The company is owned by the state of France. At the time of the turnkey contractor selection of Olkiluoto 3, Framatome had a great track-record on building nuclear power plants; it had delivered altogether 93 nuclear power plants. As other nuclear power plant suppliers', also Areva's interests lie in the East, and the company is targeting China and India with its third generation nuclear reactors. At the time of selection it was even speculated that the Olkiluoto 3 project was considered at Areva as a flagship and strategic reference project.

Series of events in the Olkiluoto 3 project

In the following case description the main incidents and events related to the Olkiluoto 3 case are presented in a chronological order. Figure 3 summarizes the main incidents of the case.

The demand for electric power is in constant and steady rise in Finland. In August 2000, TVO, applied for a construction permission of the fifth nuclear power plant in Finland. Soon afterwards, in early 2001, STUK conducted its preliminary safety assessment of the plant.

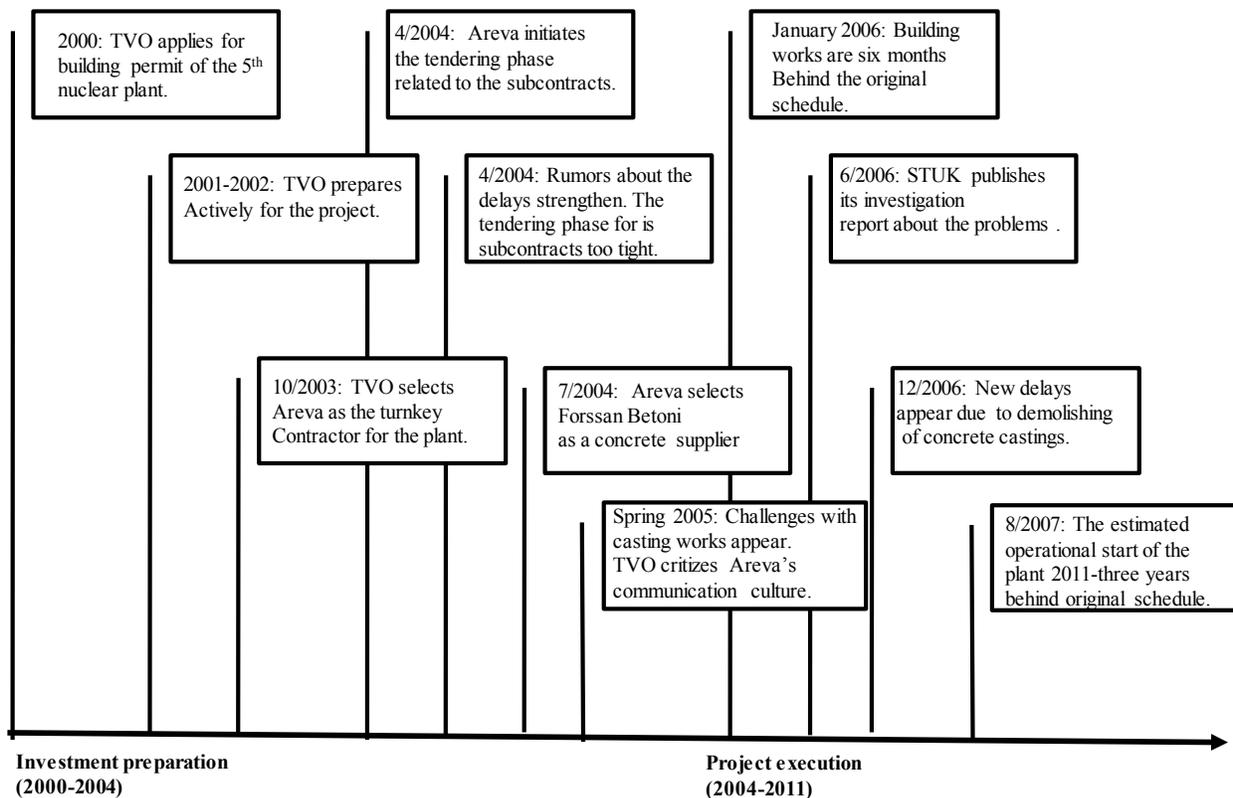


Figure 3. Timeline of Olkiluoto 3 with main events.

For TVO the year 2001 was an intensive period of preparation for the upcoming megaproject. However, at the end of the year, the type of the nuclear power plant and its location were still open. During 2002 new safety evaluations were executed by STUK, as the plant specifications and designs provided by TVO sharpened. Finally, the final permissions for the plant were received, as STUK gave its statement on the building permit application, and the Council of State approved the building permit application of the 5th nuclear plant. At this point the request for quotations was drafted at TVO, and negotiations started with three companies providing nuclear power plants. At the end of the year 2002, the building of the upcoming plant was divided into many separate subcontractable parts. After an intensive negotiation period, TVO finally made its preliminary selection in October 2003: Areva shall be the turnkey contractor of the plant. The final deal and signing of the contract took place in late December and was sealed with a comment provided by Areva's one representative: "remote actors in a remote place".

As Areva received the responsibility of the project, it initiated the competitive tendering phase related to the subcontracts of the project in March 2004. At the same time alarming news about the project started to pop up in the Finnish media: the design of the Olkiluoto 3 plant was already delayed. Areva had faced some unexpected challenges in the permission procedures with STUK, which were not taken into account in the original schedule.

At the time the competitive tendering phase was supposed to be ongoing, Finnish subcontractor companies became hesitated: they were wondering where the tender invitations were. There seemed to be a shared understanding between the Finnish subcontractor companies and TVO that Areva would use the existing and capable Finnish subcontractor network to its fullest, and hence the main share of the subcontractable work would be conducted by Finnish companies. However, there was no separate mention about this in the deal between TVO and Areva. Hence, as Areva selected more subcontractor firms outside the Finnish borders than planned, the Finnish company representatives started to publicly wonder, whether Areva truly understands the value of capable resources there are in Finland.

During the spring 2004, rumors about major delays strengthened. The schedule of the tendering phase provided by Areva was seen to be too tight. Subcontractors were tense, since the time provided for tender preparations was, according to their opinion, too short. In July 2004, the Finnish media speculated about the differences in the communication cultures between the French contractor and the Finnish companies, especially TVO. There seemed to be a lot of gaps in Areva's knowledge about the "Finnish way of building a nuclear plant". As a response, TVO assured that the spirit and cooperation with Areva is at an excellent level, and that there are no differing objectives between the companies. At this point, Areva representative admitted for the first time that the timetable of the project was really challenging.

In July 2004 an important subcontractor selection was made: a Finnish concrete casting company, Forssan Betoni, was selected as a concrete subcontractor. Also other material supply purchases were conducted: for example, pumps were supplied from abroad during the fall and the reactor subcontract was given to Bouygues.

As the building of the plant proceeded, the number of persons at the site increased steadily. Especially there were a lot of Polish workmen, while the supervision of work was conducted by

the French, Germans and Finns. Sometimes it was challenging to find a common language due to the multiple nationalities at the site. During the spring 2005 challenges with the casting works started: the elemental panel was first said to be delayed by one month and soon the delay was stated to be three months. The reason was explained to be the delayed basic engineering. At this point STUK wanted more specific explanations and descriptions on the planned casting works. A representative from Areva stated that the plant will not be ready before 2009. Areva's glibness about the problems with the plant was not welcomed by all. TVO stated that they do not even know how much the project is delayed and required more detailed schedule acceleration plans from Areva. Criticism was presented by TVO on the slow delivery of the clarification reports by Areva. Areva's response was to start accelerating the building of the plant with drastic moves, e.g., by utilizing concurrent engineering, overlapping the tasks, and increasing shift work. Furthermore, the responsible project manager at Areva was changed twice, which did not support information transfer and relationship building between Areva and TVO.

Early 2006 brought new delays. In January the building works were already six months behind the original schedule and in March problems with the concrete of the elemental panel started. This was related to the subcontract part of Forssan Betoni. TVO did not see any options: they could only compromise with the timetable but not with the quality. Payments to Areva were frozen. STUK was expressing its concerns about the selection process of subcontractors and management of subcontractors by Areva, as well as about the prerequisites of subcontractors to conduct their work well. Following this, a special committee was appointed by STUK to investigate the issue further. Also, the production site of the concrete was stopped for a while, as there were problems with the moisture content of the concrete particles. News about new delays came in March, as the project was stated to be nine months behind the schedule. Losses for TVO were speculated to be over 400 million Euros, while Areva was suffering from huge losses as well: an operating loss of 266 million Euros was reported, the main reason being Olkiluoto 3.

In July 2006, the investigation report of STUK was made public. The most significant problems were found to be related to project management. It was also stated that the organizations did not have a shared understanding on the project, and that the safety culture at the site was insufficient. The project director stated that "it has taken some time for Areva to adjust to the Finnish

requirement level. The same mistakes have been repeated by them all over again and too often.” Yet, TVO also stated that despite the delays, they still fully trusted Areva.

At the end of the year concrete castings needed to be demolished due to the lack of construction joints. The construction works were delayed again by six more months. During the spring, Olkiluoto 3 challenges also received increasing attention by the Finnish Greenpeace, which heavily criticized the safety issues and demanded the publication of the error and mistake list that TVO had been collecting. To demonstrate the safety deficiencies, Greenpeace activists succeeded in entering the site without any problems.

In the beginning of the year 2007, the dispute between Areva and TVO on the compensations of the significant delays became public. The representatives of TVO and Areva admitted in a news briefing that they have different views on the contractual penalties related to the delays. TVO’s project director emphasized that TVO as the buyer of the plant “has a clear contract on the price and the delivery schedule”. “Also penalties and the ways on how to settle the dispute are specified in the contract” the project director stated. Areva’s project director’s response was that “we understand that TVO as a buyer requires full compensation for the delays, but we are not ready for that”. Both TVO’s and Areva’s project directors referred to the juridical contract terms with obvious different interpretations about how responsibilities and liabilities were shared in the contract: “this is something for the lawyers to solve”.

During the summer 2007 STUK was forced to interfere with the building of the site again. The continuation of the welding of the steel cladding was denied. STUK representatives also stated in public that the main reason for the delay is Areva’s lack of experience and its incapability to lead the project. New delays were reported, and in August 2007, the new due date for the plant was announced to be in 2011. It had been more challenging than expected to take into account the safety regulations, stated Areva. At this point, Kauppalehti, the Finnish financial periodical, speculated that the cooperation between TVO and Areva is a dialogue between deaf ears, and that the project is becoming a national farce. The capabilities of TVO to act in the role of the buyer were also criticized.

During the fall 2007, the building of the plant continued as planned; no further delays have been announced so far.

Results of the specific concreting case analysis: Forssan Betoni as a concrete supplier

We use a specific concreting case from the STUK investigation report to elaborate the contents of the dimensions of distance in the Olkiluoto 3 project. This specific case relates to the challenges in the supply of concrete for the elemental panel of the plant. The concrete supply scheme caused significant delays for the project, elaborated major rework, created tensions between the participating firms, resulted in major financial losses and urged STUK to study the project in more detail.

The Finnish “Forssan Betoni” operated as a concrete supplier for Areva (see Figure 2). The attributes and practices of the distance framework’s three dimensions are derived from the empirical analysis. Tables 1, 2 and 3 summarize the findings by showing the firm attributes in Table 1, network attributes in Table 2, and project practices in Table 3. Quotations in the tables illustrating the attributes and dimensions are excerpts from the STUK investigation report 1/06.

Firm attributes represent the context through each participating actor’s characteristics.

Network attributes describe the distance through the relationships of the actors in terms of social, physical, cultural, attitudinal, behavioral or temporal dimensions of distance.

Project practices decrease or increase the distance in the network.

Table 1. Attributes content for the ‘firm attributes’ dimension

Firm attributes	Evidence from the case
Lack of experience and capabilities	<ul style="list-style-type: none"> • Concrete supplier’s lack of experience in nuclear power plant projects. • Individual actors’ lack of experience in construction projects. <p>“For large concreting jobs, the placing of an order two weeks in advance can be justified, but for smaller concreting jobs the requirement that [Areva] specified for itself is unusual. Another unusual aspect of the agreement was that no responsibility for the pumpability or castability of the concrete was defined for the concrete supplier. ... These factors suggest that the persons who concluded the agreement are not very familiar with the practical aspects of construction projects.”</p>
Firms’ incomplete systems and processes	<ul style="list-style-type: none"> • Concrete supplier lacks quality systems. <p>“TVO and [Areva] audited the main office of Forssan Betoni on 4.5.2005. Three critical non-conformancies were found in the performance of Forssan Betoni, which together with four minor non-conformancies prove that at the time of the audit the quality system of the company and compliance of operation with the quality system were partly still at design stage.”</p>
Potential hidden agendas	<ul style="list-style-type: none"> • Areva planned to use the project as a gateway to China’s nuclear power plant markets. • TVO was in favor of a lump-sum turnkey contract, which it interpreted as a way to pass the baton to someone else. Price-based competition was urged among the tendering companies, while quality would have been the most relevant dimension to be emphasized. • Among the Finnish subcontractor network and TVO there existed a shared understanding that the majority of the subcontractors Areva would use should be Finnish. This was not, however, stated in the contract between Areva and TVO.
Lack of knowledge of specific [local] requirements	<p>“No training related to safety culture was provided to the personnel of Forssan Betoni before the concreting of the base slab. All the parties [Areva], TVO, Forssan Betoni) considered the site introduction training and the occupational safety training included in it, which is required for the granting of an access permit, to be sufficient.”</p>

Table 2. Attributes content for the ‘network attributes’ dimension

Network attributes	Evidence from the case
Misaligned objectives (selection based on short-term focus)	<ul style="list-style-type: none"> • Areva had a short-term focus while TVO had a long-term focus. • Areva was accustomed to different types of methods and ways of actions in its previous nuclear plant projects than what TVO was used to and expected. <p>“[Areva] selected Forssan Betoni from the four potential concrete suppliers apparently on price grounds, although the small size of the company was considered a risk.”</p> <p>“The Contract Manager expressed his concern on the attitude of Forssan Betoni and its owner company.”</p>
Unclear roles and responsibilities	<ul style="list-style-type: none"> • A conflict occurred due to unclear responsibilities in defining the composition of the concrete: <p>“The mix of the base slab concrete was designed by a concrete specialist (expert A) employed by Finnprima [a Finnish company] with experience on massive concrete structures. ... Expert A did not determine the detailed final composition of the concrete, nor had [Areva] ordered it from Finnprima...The responsibility for the detailed design of the concrete composition was left to the concrete supplier.”</p> <p>According to the Project Manager responsible for the operation of the batching plant of Forssan Betoni, expert A determined the mix composition of the concrete in terms of the binders "to the kilogram". In his opinion Forssan Betoni had in practice no possibility at all to influence the composition of the concrete. In the interview the batching plant manager, however, questioned the requirements (primarily those concerning durability) set by expert A on the base slab and, based on this, he also questioned the whole design...”</p>
Lack of trust between parties	<ul style="list-style-type: none"> • Suspicion on other parties’ capabilities <p>“The Civil Work Contract Manager of [Areva] arrived at the site in mid-January to settle a contractual problem between [Areva] and Bouygues, the contractor of the containment. Bouygues had informed that they would terminate the contract because they did not trust the batching plant’s capability to deliver appropriate concrete.”</p> <ul style="list-style-type: none"> • Continuous inspections as an indicator of lacking trust <p>“Since [Areva] did not, despite several requests, submit the batch reports, TVO conducted on 14.10.2005 an inspection at the batching plant. In this inspection, the representative of TVO concluded that considerable changes had been made in the composition of concrete during the concreting of the UJA building.... [Areva] informed TVO by an official letter on 20.10.2005 that the batch reports would not be submitted until in connection with the completion of the plant”.</p>
Action or inaction based on assumptions, rather than facts	<ul style="list-style-type: none"> • Actors had groundless assumptions of each other’s behavior <p>“[Areva] believed that after Forssan Betoni had been contacted and criticism given, the variations in quality would be eliminated and the quality of the concrete would be as planned. According to Forssan Betoni, the problems were not, however, specified in a way that would have made it possible to correct them, and their written request to [Areva] for detailing the presented criticism was not replied.”</p> <p>“According to the Deputy Site Manager, [Areva]’s perception was that the changes made in the composition of concrete during the concreting of the reactor building base slab were not relevant.”</p>
No previous joint working experience	<ul style="list-style-type: none"> • TVO and Areva had not co-operated in a nuclear power plant project before Olkiluoto 3.
Diversity of actors	<ul style="list-style-type: none"> • There existed cultural differences between the French company Areva and the Finnish company TVO. • Areva was accustomed to different types of methods and ways of actions in its previous nuclear plant projects than what TVO was used to and expected.

Table 3. Practices content for the ‘project practices’ dimension

Project practices	Evidence from the case
Incomplete quotation information	<ul style="list-style-type: none"> Special requirements of nuclear power plant building were not emphasized in the call for tenders. <p>“No other requirements were specified in the call for tenders in terms of requirements concerning quality control in a nuclear power plant construction project (e.g. the requirement for a laboratory) or any other special requirements, such as reference to IAEA's safety standard IAEA 50-C-QA.”</p>
Inappropriate selection principles of suppliers and contractors	<ul style="list-style-type: none"> Selection of suppliers was based on price. <p>“[Areva] selected Forssan Betoni from the four potential concrete suppliers apparently on price grounds, although the small size of the company was considered a risk.”</p> <p>“Hartela [a Finnish construction company] was chosen by [Areva] as the concreting contractor from among several candidates. The selection was strongly influenced by TVO's request to employ Finnish contractors on the site.”</p>
Inadequate documentation procedures	<ul style="list-style-type: none"> There were several deficiencies in the way documents were processed and documented. <p>“The recording of documents received by Forssan Betoni or submitted by Forssan Betoni to the client or to the subcontractors, was not included in the document processing routine. Due to deficiencies in the definition of the interfaces Forssan Betoni was using a concrete specification that had not been officially approved by [Areva]. ... Deficiencies were also found in the documentation of the examination and approval of the results of tests performed by Forssan Betoni.</p>
Insufficient communication structures and mismatch between communication purpose and style	<p>“The minor non-conformancies detected in the audit included the lack of an official reporting practice related to quality issues between the [Olkiluoto 3] batching plant and the head office of Forssan Betoni in Forssa.”</p> <p>“The representative of Forssan Betoni told the investigating group that they also proposed pumpability tests to be arranged but here was no reply to their proposal. According to Forssan Betoni, they did not have the permission to be in direct contact with the designer but to deliver all information via [Areva].”</p> <p>“The site did not forward KyAMK's [Finnish college] preliminary report either to TVO or to STUK. According to the information that was received the report was not sent to [Areva]'s head office, either. The report was studied by [Areva]'s Site Manager and his deputy. [Areva] also asked the batching plant to provide the batch reports for making more detailed analyses as, according to them, no conclusions could be drawn without binding results. According to [Areva]'s Deputy Site Manager the report was not forwarded to the other parties due to its preliminary nature. [Areva] had decided to distribute the report only after the final results were available.”</p> <p>“After the concreting operation, TVO contacted [Areva] several times (by e-mail), trying to find out if the composition of concrete had been changed during the concreting operation. On 5.10.2005, for example, TVO asked [Areva] to submit the batch reports for the concrete fabrication batches. Despite several requests, these reports were not submitted to TVO.”</p>
Inappropriate contract types and adherence to contracts	<ul style="list-style-type: none"> Supplier had difficulties in the adherence of the contract. <p>“For the concreting of fuel building UFA in August, [Areva] issued the order to start concreting with a very short notice time. The two-week notice time specified in the agreement was not complied with in this case. Considerable difficulties were encountered in the concreting process, as the contractor (Hartela [a Finnish construction company]) did not have enough time to properly prepare for concreting. The levelling and the steel trowelling of the slab surface, in particular, were not done properly because the workers were too tired.”</p>

5. Discussion

We elaborated the concept of distance by identifying three dimensions of distance between the actors in large project implementation: firm attributes, network attributes, and project practices (Figure 4). Based on our analysis on the Olkiluoto 3 project, firm attributes affect the distance through each individual firm's characteristics, including: lack of experience and capabilities, incomplete systems and processes, potential hidden agendas, and lack of knowledge. Network attributes describe the distance through the relationships of the actors and they include: misaligned objectives, unclear roles and responsibilities, lack of trust, action or inaction based on assumptions (rather than facts), no previous joint working experience, and diversity of actors. Project practices decrease or increase the distance in the network. Project practices comprise incomplete quotation information, inappropriate selection principles of suppliers and contractors, inadequate documentation procedures, insufficient communication structures and mismatch between the communication purpose and style, and inappropriate contract types and adherence to the contracts.

We argue that the developed distance framework offers a holistic view to analyze complex multi-firm project networks and their management. Previous literature discusses individual elements related to the concept of distance as independent entities without simultaneously addressing various other attributes and practices that are interrelated in a complex manner. Literature on large projects can be seen as two-fold: the first stream discusses problems that increase distance, such as disruption and delay and risks [1, 24, 8, 25], differing interests [11, 12] and institutional and cultural differences [26]. The second stream discusses actions for reducing distance, such as project governance [27, 5, 6, 21, 28]. Our distance framework integrates the individual firm related and network related distance elements (c.f. the first stream referred to above), and practices that affect the distance either by increasing or reducing it (c.f. the second stream referred to above).

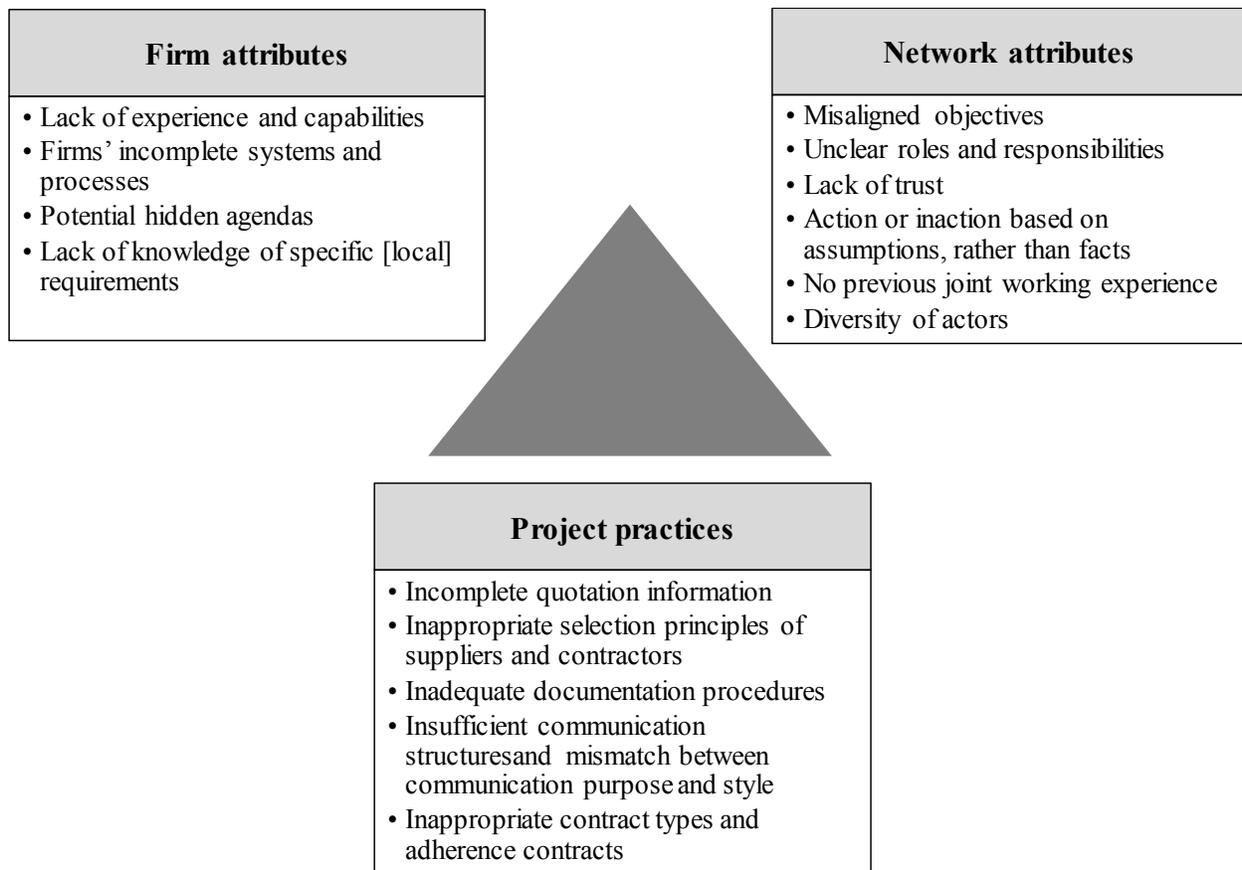


Figure 4. Distance framework with attributes and practices.

The Olkiluoto 3 project lacked coordination of several responsible firms in the project network, which led to problems in various fields that further increased the distance among the actors. The diversity of actors and the differences in their ways of operating and communication would have required clear governance and communication structures to ensure the mutual understanding of the project. Instead, TVO as the owner delegated all authority to the turn key contractor Areva, assuming that Areva would carry TVO's transferred responsibilities by managing the project as the owner would have managed.

Project literature introduces several cases of failures of large project implementation. Morris and Hough [2] discuss two projects where all the responsibility was allocated to the contractor. In the Thames Barrier, the technical specifications were prepared in a detailed manner, but the responsibility of the work was allocated to a contractor without mechanisms to ensure the early

commitment of skilled resources. In the Channel Tunnel, there was no one person 'objectively' representing the project's interests who would have had the aim, need and charter to discuss and interact with all parties [2]. In a similar manner, in the Olkiluoto 3, all the responsibility was allocated to the turnkey contractor Areva. TVO as the principal did not realize its responsibility as the owner of the project. TVO assumed that contracts will be a sufficient way to delegate authority to the turn key contractor. The case of the construction project of London Heathrow Terminal 5 presents a novel approach to project implementation with multiple involved firms. Brady [29], Brady, Davies, Gann, and Rush [30], and Brady [31] identified successful practices in the governance and the project process of the T5 project, although the disaster in the opening showed that the start of operations was not planned properly. The successful management principles in T5 included the following: the owner accepted all relevant risks in the framework agreement (the owner also agreed to partially bear the contractors' risks/concerns as to future projects), incentive-based contracts, and interest alignment and identity building of the core integrated team. We argue that the Thames Barrier and Channel Tunnel project cases by Morris and Hough [2] represent examples of failed projects where distance was increased among the actors while the Heathrow Terminal 5 had succeeded in decreasing the distance due to several practices used in the planning and the implementation of the project.

The need to achieve goal alignment between the client and contractor, and to reduce the chance and benefit for opportunism by the client or contractor has been considered as the most significant issue when choosing a governance structure for the contract [32]. According to Levitt and March [33], the purpose of project and contract organization is to create a cooperative system by achieving common objectives by properly incentivizing the contractors. According to Turner [34], such goal alignment comes from aligning the three P's: process, product and purpose. Lack of goal alignment will result in maladaptation of one or more of the three P's [32]. Yet members from diverse organizations have underlying differences in their behaviors, values, and attitudes while they not only notice different information, but perceive the same information differently [35]. As a result, diverse organizations tend to lack a shared social reality with members and their organizations failing to have a common "here-and-now" and perspective [36]. Additionally, individuals and their organizations may even have differing motives and these motives may change over time [37, 38]. This will all lead to the lack of goal alignment. In the case of Olkiluoto 3 there were no governance structures to achieve goal alignment. Actors

entered the project with misaligned goals and with different focuses. Communication was inadequate and misunderstandings arose. Ineffective communication leads to obstacles to effective performance [35, 38].

Monitoring of an agent's adherence to the principal's objectives is critical [16]. When knowledge or trust increases, monitoring can simultaneously decrease considerably. Monitoring requires higher bandwidth or effort from all stakeholders involved [16]. In the case of Olkiluoto 3 proper monitoring was neglected. Issues were dealt with as problems arose. The level of trust between the actors affects the degree of monitoring. If a group does not trust each other or also, if the members do not know each other well enough, they may engage in monitoring to the degree that overwhelms the actual production work to take place [16]. It may also increase the level of information required. The lack of trust was shown in Olkiluoto 3 with continuous inspections with the concrete supplier.

The extent to which policies and standards are in place and upheld has a significant effect on an organization's ability to maintain project integrity [16]. Evaristo et al. [16] emphasize both the existence of policies and standards and the extent to which the policies or standards are actually upheld in an organization. Critical standard areas include scope control, estimating methodology, communications standards, scheduling methodology and programming standards. Values of the existence of standards and policies may range from existent (strictly upheld, generally upheld, weakly upheld) to non-existent. Olkiluoto 3 lacked monitoring policies for ensuring of different organizations having the required safety and quality standards implemented. Further, the practices related to documentation transfer and the way of processing them were unsystematic.

In Olkiluoto 3 the investigation authority suspected that the price was heavily emphasized as the selection criterion both when TVO selected the turnkey contractor and when Areva selected the subcontractors. Emphasizing price as the main supplier selection criterion may increase the selection of a supplier with inadequate experience and capability profiles. Supplier's capabilities form part of the value creation potential for the buyer, and the buyer needs to be able to evaluate the value creation potential of the available supplier [39, 40]. However, the challenge lies in the fact that the value potential is based on several organizational capabilities that are at least partly tacit and therefore hard to evaluate [39].

Capabilities in a project network are aggregations of capabilities of various actors and dispersed in the network. Each actor possesses different and partly unique capabilities. Put together they form a collective capability, possessed by the network as a whole. Collective capability in a project network integrates various capabilities in the network creating collective capability possessed by the entire network [41]. The aim of the temporary project network is to achieve collective network capability. It consists of the combination of the contributed capabilities of the network actors and defines the strength or effectiveness of the network to achieve its business aims [41]. Shared understanding is the basis for collective capability [42, 43]. It was evident in Olkiluoto 3 that the mutual understanding between the actors concerning the objectives of the project was inadequate. Project as a joint enterprise should share a common purpose that promotes the achievement of common goals. We argue that failing in creating mutual understanding between the actors in Olkiluoto 3 increased the distance among the actors.

We suggest that our distance framework captures many relevant aspects of uncertainty and complexity that are caused by different actors with potentially different characteristics, business and other interests, working and collaborating practices and lines of thought. These aspects are often neglected in the existing project management research.

6. Further research

We suggest two major areas for further research. First, further empirical studies are needed to follow and verify the framework of this research. Such empirical studies would deepen understanding of the distance framework's dimensions and their attributes and practices with observations from projects implemented in different contexts, or observations from different project types and their specific contextual settings. Furthermore, such studies would help developing context-specific project management applications for managing projects as multi-firm enterprises.

Second, we suggest that our research should seek support and further avenues through project networks research, stakeholder research and governance of projects as multi-firm coalitions. Especially, empirical studies are needed on establishing a joint strategy between the network parties and its implications, and on the potentially controversial relation of performance of individual actors to the performance of the network as a whole.

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