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Empirical Research Paper

Challenges for implementing collaborative practices in industrial engineering projects

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ABSTRACT

Collaborative project delivery models were introduced in North Sea oil and gas projects. Recently, they have been successfully applied in the context of construction and infrastructure projects but their application in industrial engineering project context has been limited. We analyze empirically which type of challenges there are in applying collaborative practices in two projects. The key challenges include the divergent objectives of the actors that hamper common goal setting; collaborative models and rewarding mechanisms which are perceived as inappropriate; the limited funding before investment decision when early involvement of key actors should be secured; the emphasis on collaboration capabilities with every actor which are not possible in tendering; and the collaboration with governmental authorities which needs a different approach from that with the other actors. Collaborative practices have a potential to improve project performance and identified challenges should be taken into account when implementing collaboration in industrial engineering projects.

1. Introduction

Industrial engineering projects are technology-intensive capital projects of private sector investors, and they are characterized by irreversible commitments, risks, uncertainties, and high probabilities for failure (Merrow, 2011). Suppliers and partners for these projects often bring their special expertise for a specific technology and they come from different geographical locations and institutional environments. In recent years also social and environmental issues are emphasized, which increases the role of governmental authorities (Sallinen et al., 2013). Despite recent positive developments in their performance outcomes, there is still significant room for improvement, particularly for the larger engineering projects (e.g., Merrow, 2011; Olaniran et al., 2015a, b). Industrial engineering projects are complex when they include technical, organizational, or environmental complexity (Bosch-Rekveldt et al., 2011) making interorganizational integration and collaboration particularly important for improving their delivery performance (Pekkinen and Kujala, 2014).

Collaborative project delivery models such as project partnering, project alliancing and integrated project delivery have been suggested as one solution to manage complex projects with high uncertainty (Lahdenperä, 2012). Although, project alliancing as one collaborative solution was introduced successfully already in the 1990s in the UK upstream oil and gas industry (Barlow, 2000; Green and Keogh, 2000) in recent decades it has been widely and very successfully used in public infrastructure and construction projects (Wood and Duffield, 2009; Walker and Lloyd-Walker, 2015, p. 178; Lahdenperä, 2019). Collaborative practices are an integral part of any collaborative project delivery model and they include, for example, key actor early involvement, co-location, team building exercises and informal processes to facilitate the building of relationships, trust, open communication, and common goal setting (Walker et al., 2002; Caniëls et al., 2012; Hietajärvi et al., 2017), risk and reward sharing that motivates the joint problem solving and the pursuit of innovate solutions and good project performance (Ross, 2003; Sanderson, 2012; Davies et al., 2014), and roles and responsibilities that enable flexible working, best-for-the-project decisions, and continuous development (Ross, 2003; Chakkol et al., 2018; Walker and Rowlinson, 2020, p. 20).

Major part of the industrial engineering projects are delivered with lump-sum or reimbursable arrangements (Merrow, 2011, p. 258). The coordination of these types of projects is mainly based on contracts or use of integrator to coordinate work among several participants (Oliveira and Lumineau, 2017). However, research has shown that more collaborative arrangements with risk and reward sharing structure,

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common goal setting, no-blame culture and integrated teams aiming at better teamwork quality, open communication, and positive relational attitudes may complement and/or lead to better results in projects (Green and Keogh, 2000; Ross, 2003; Berends, 2007; Cao and Lumineau, 2015; Suprapto et al., 2016), and owner–contractor collaboration in particular can improve project performance (Suprapto et al., 2015a). Interorganizational collaboration, early integration, positive relational attitudes, and quality teamwork have been found to be efficient ways to achieve good project outcomes (Aapaoja et al., 2013b; Suprapto et al., 2016) and decrease risks and uncertainty in complex environments (Dietrich et al., 2010).

However, applying the collaborative models can be challenging in different project contexts especially when multiple companies are involved (Bresnen and Marshall, 2002; Aarseth et al., 2012). Merrow (2011, p. 290–295) has argued that the use of project alliancing is problematic in engineering-intensive industrial engineering project contexts, especially for technically complex projects, without modifications because its liability clauses, conflict resolution practices, and incentivization schemes are not optimal, and in addition, there have been failures because project alliancing has been used to reduce owner involvement. Consequently, there is a need for an increased understanding of how a network of actors can use collaborative practices in industrial engineering project context.

The aim of the study is to identify the challenges in adopting collaborative practices in front-end loading of two projects. The following research question guided the research: *What kinds of challenges exist to implementing collaborative practices in industrial engineering projects?*

The main contribution of this paper is to literature on collaborative project delivery arrangements. Definitions of project delivery arrangements such as project alliancing, does not reveal the actual procedural practices or require that specific model should be used (Lahdenperä, 2012). For instance, Bresnen (2010) concludes that, for example, project partnering in any context is likely to be a highly specific combination of tools, techniques, processes and practices and it is hard to generalize it into a universally applicable model. We continue the discussion in industrial engineering project context by analyzing challenges related to implementation of collaborative practices that are typically used in collaborative projects.

The paper is organized as follows. First, we clarify the characteristics of industrial engineering projects, how they are managed, and potential reasons for their performance challenges. Next, we provide a brief review of literature on interorganizational collaboration in project networks and identify practices how collaboration can be implemented. Then a research framework to study challenges for implementing collaborative practices in industrial engineering context is presented. The research framework, collaborative governance in project networks, is based on existing research on governance mechanisms that support collaboration in project networks.

In the empirical part, practical challenges to implementing collaborative practices in two case projects are identified and discussed from the perspective of different stakeholders. The empirical research was conducted by qualitative multiple case research (Eisenhardt, 1989) in industrial plant and mining projects in Finland that were chosen based on theoretical sampling and literal replication (Yin, 2015). In both projects, the aim was to utilize more collaborative practices that the main actors had generally used in their earlier projects. The data were collected from unstructured interviews and observation studies of workshops and directed content analysis was used (Hsieh and Shannon, 2005). The main challenges of each collaborative practice are highlighted, and it is specified for which particular actor(s) the challenges are focused. Then the potential of collaborative practices and the impacts of identified challenges for the use of collaborative practices in industrial engineering projects are discussed. Finally, the research contribution and societal and practical implications are summarized, and suggestions for further research are provided.

2. Theoretical background

2.1. Characteristics of industrial engineering projects and reasons for their performance challenges

In this research, we use the term *industrial engineering project* because the focus is on capital projects that aim to deliver certain engineering-intensive technical solutions, such as an industrial plant, process or mine that produces products for sale and eventually makes a profit. Projects with purely public owners like military or public infrastructure projects might have more intangible and societal objectives than privately owned projects (Merrow, 2011, pp. 13–14). Characteristics and definitions of industrial engineering projects are similar to those of large or major engineering projects (Miller and Lessard, 2000; Floricel and Miller, 2001) and industrial megaprojects (Merrow, 2011). These different concepts emphasize different characteristics; for example, the term *industrial megaproject* implies a large capital cost, and the aim to make products for sale (Merrow, 2011, p. 13–15), and *large engineering project* emphasizes large-scale, long period of time, turbulent environment, and large irreversible commitments with potential and limited upside gain, but with the possibility of large downside loss (Floricel and Miller, 2001; Miller and Lessard, 2001).

Bosch-Rekveldt et al. (2011) explained that complexity in engineering projects consists of technical, organizational, and environmental complexity. Technical category includes complexities related to goals, scope, tasks, experience and technical risks, organizational category includes complexities related to size, resources, project team, trust and organizational risks, and environment category includes complexities related to stakeholders, location, market conditions and environmental risks (Bosch-Rekveldt et al., 2011). De Bruijn and Leijten (2008) argued that the complexity is due to technical complexity, social complexity, and complexities in the implementation of the project, which occur because technical and social complexities affect uncertainty. A clear strategic vision that is well communicated to all involved parties, a strong alignment of stakeholders, and an adaptation to different types of complexities and challenges have been found to be the three key factors that lead to success in large projects (Shenhar and Holzmann, 2017).

Various reasons for the unsuccessful outcomes of industrial engineering projects have been found in prior research. For example, Merrow (2012) found that oil and gas projects have weak track records and that one of the reasons for this is poor functional integration. Sanderson (2012) divided the explanations of weak project performance into three categories: strategic rent-seeking behavior, misaligned and underdeveloped governance, and diverse project culture and rationalities. Weak performance related to project governance arises from unsuccessful governance arrangements that are incapable of handling the uncertainties, risks, and turbulence of challenging projects (Sanderson, 2012). Van Marrewijk et al. (2016) concluded that, in addition to the project governance structure, micro-practices that weaken control over projects also affect challenges. These micro-practices might occur because the contractual arrangements, intercultural histories, and organizational traditions potentially prompt conflicting cultural identities, expectations, and interests (Van Marrewijk et al., 2016).

Complex interactions due to the project's organizational structure, technology, and project leadership have been identified as significant factors affecting cost overruns and delays (Olaniran et al., 2015a). Too much formality in the form of strict rules and only a small amount of flexibility typically prevent collaborative behavior (Chakkol et al., 2018). In complex projects with high levels of uncertainty, conventional control-oriented approaches prevent flexibility and novelty and can therefore lead to suboptimal decisions and failures (Brady et al., 2012). Risk transferring instead of risk sharing has also been found to be an inappropriate strategy for projects that are conducted in highly uncertain circumstances (Ross, 2003). In large and complex projects, collaboration among the main partners, such as the investor and main

contractor, has to be effective; however, many times it becomes conflict-ridden, and there might be significant challenges to governing the project together (Van Marrewijk et al., 2016).

2.2. Interorganizational collaboration in project networks

Interorganizational relationships have a central role in the procurement of complex performance because they enable organizations to develop mutual understanding about roles and responsibilities, uncover specific capabilities and entrust organizations to invest effort and time for co-innovation (Roehrich et al., 2019). Interorganizational relationships change over time depending on the evolution of ties among organizations, prior successful relationships (shadow of the past), and practices that maintain and promote relationships (shadow of the future), and it influences the collaboration between organizations (Poppo et al., 2008; Lumineau and Oliveira, 2018). In interorganizational relationships, contractual and relational governance complement each other, and they jointly affect the performance (Cao and Lumineau, 2015) and it has been stated that relational governance and trust do not even help to achieve good outcomes if they are not accompanied by contractual incentives and control systems (Caniëls et al., 2012). Various definitions for organization-level collaboration have been presented in the management literature. Bedwell et al. (2012) defined collaboration as an evolving process in which two or more social entities participate actively and reciprocally in joint activities aimed at achieving at least one common objective. In a project network, interorganizational collaboration can be understood as a process where different organizations or parts of them are linked together to work collaboratively with the aim of attaining the project's objectives (Ibrahim et al., 2013a; Hietajärvi et al., 2017).

Several scholars have argued that integrated project teams can reach project objectives better than fragmented project teams (e.g., Baiden et al., 2006; Khanzode and Senescu, 2012; Aapaoja et al., 2013a; Ibrahim et al., 2013a). Interorganizational collaboration, early integration, positive relational attitudes, and quality teamwork are efficient ways to achieve good project outcomes (Aapaoja et al., 2013b; Suprapto et al., 2016) and decrease risks and uncertainty in complex environments (Dietrich et al., 2010). Relational norms and trust together with contracts can also improve satisfaction and relationship performance and reduce opportunistic behavior (Cao and Lumineau, 2015). Comprehensive team integration and collaboration offer a much better understanding of project constraints and possibilities than there would be in a traditional project delivery, in which all the involved actors work independently under separate dyadic contracts, and the work is coordinated by the customer (Walker et al., 2017). Regarding the procurement processes of complex projects, some customers have even started to require that project actors have the ability to collaborate (Chakkol et al., 2018).

Interorganizational collaboration is not important *per se*, but it helps to facilitate communication and mutual trust among the parties and individuals and may thus enable better results and value creation (Ghassemi and Becerik-Gerber, 2011; Ibrahim et al., 2013b). The benefits of interorganizational collaboration may be realized through various integrative mechanisms. Integration enhances high levels of collaboration and open and intimate communication. It can help to reduce uncertainty, to resolve situational ambiguity, and facilitate the reduction of people and process ambiguity by reducing the likelihood of prejudices and restrictive thinking (Walker et al., 2017). Interorganizational collaboration in project networks helps align the targets of different subprojects and supports the pursuit of common project goals (Pekkinen and Kujala, 2014). However, interorganizational collaboration should be defined through its ability to improve team participation and communication during the tasks rather than the quality of its outcomes (Leicht et al., 2009).

Early involvement of the key actors is one prime element of the collaborative project. It means the inclusion of stakeholders into the project from its earliest moments to form project objectives and determine ways to reach them as an integrated team (American Institute of Architects (AIA), 2007, p. 5; Aapaoja et al., 2013a). The goal of the early involvement of designers and specialists with the customer is to achieve a shared understanding in the early phase of the design, when there is still flexibility to make changes (Wikström et al., 2010; Alhava et al., 2015). In the front-end loading of the project, the level of uncertainty as well as the possibility to find opportunities is at its highest; there are also better opportunities to affect and make changes (Kolltveit and Grønhaug, 2004; American Institute of Architects (AIA), 2007, p. 5). Early involvement can improve the possibilities for closer interorganizational integration and collaboration, and it has been shown to typically strengthen the commitment of participants to the project and helps to make better informed decisions (Lahdenperä, 2012). Governmental authorities also play a central role in industrial engineering projects, especially in the front-end loading before the actual work starts. Then the changes are easier to make and the communication among the authorities and investors is beneficial. However, governmental authorities have to treat all involved parties impartially; therefore, they face challenges in participating in practical project work or decision-making (Sallinen et al., 2011).

Interorganizational collaboration in project network entails challenges when it requires changes in established contracting practices and organizational cultures (Song et al., 2009; Saukko et al., 2020). There are multiple actors with divergent aims and incentives in the project network, projects are unique, and project transactions are temporally limited, which poses managerial challenges for the collaboration (Dietrich et al., 2010). Effective interorganizational collaboration in a project network requires good relationships and knowledge integration, but it is challenging to achieve them without previous mutual collaboration or extensive relationship development, and weak collaboration can lead to dysfunctional conflicts (Dietrich et al., 2010; Farrell and Sunindijo, 2020). Early involvement of actors also presents challenges because they have to have win-win attitudes so that they seek the best solutions for the project, and this often requires cultural change (Song et al., 2009; Rahman and Alhassan, 2012).

2.3. Research framework: collaborative governance in project networks

The research framework to study and structure findings from empirical case studies, and to understand how collaboration is organized, is based on literature on project governance. Drawing from Williamson (1979), we defined governance in the research as mechanisms used to coordinate, safeguard, and adapt exchanges. More specifically, we focus on literature on internal coordination among actors in project network. Governance mechanisms, such as standardized work practices, monitoring and reporting of work progress, and using incentives, are approaches and practices that are used to adapt, coordinate, and safeguard exchanges among the different actors involved in the project (Ahola et al., 2014; Kujala et al., 2020). In general, governance theories deal with situations in which goals for different actors are not aligned, there is information asymmetry between actors, and their risk bearing capacity varies. In the literature, transaction cost economics and agency theory views are used to explain project governance (Ahola et al., 2014). Transaction cost economics theory emphasizes the economic transactions between independent companies in a specific project and agency theory, in turn, underlines the relationship between the principal and the agent which may have divergent interests in project (Davis et al., 1997). Stewardship theory, in turn, indicates that stewards can be pro-organizational and collectivistic, and their motives can be aligned with their principals (Davis et al., 1997). Stewardship theory argues that managers want to do a good job, so they seek common goals and good results when they are empowered (Donaldson and Davis, 1991). Stewardship theory focuses on how to align interests between different actors in a project network. The focus in this research is on internal network of actors in a specific project, and the target is to understand how

coordination of activities could be conducted more collaboratively among the actors to achieve better project performance.

Project governance provides a method to control the project, articulate the project objectives, ensure the means to attain those objectives, and to produce good project performance by defining, documenting, and communicating reproducible and trustworthy project practices (Turner, 2009). However, coordination of work, in complex interorganizational networks such as industrial engineering projects, cannot be based only on control. It has to be complemented with relational mechanisms such as trust between multiple actors, who have to work together to accomplish a set of tasks in a limited time frame. Contractual and relational governance are two main types of governance to organize interorganizational relationships (Cao and Lumineau, 2015; Roehrich et al., 2020). Contractual governance consists of formal and usually written contracts that include binding agreements about incentive schemes, and market transactions to control physical capital independent of people while relational governance includes relational and more informal mechanisms that relies on social structures and shared norms and they aim to enhance mutual trust, open communication, and knowledge sharing via interactions among individuals (Cao and Lumineau, 2015; Chen and Manley, 2014). In collaborative project delivery models such as project alliancing, the focus is on relational governance, but formal contractual clauses are used to support it.

Kujala et al. (2020) developed a framework to analyze governance in project networks through a systematic literature review of project governance literature. In the framework, different mechanisms how to coordinate, control, and adapt exchanges in project networks are identified and categorized along six dimensions: goal setting, rewarding, monitoring, coordination, roles and decision-making, and capability building (Kujala et al., 2020). In each dimension, a specific objective for governing interorganizational project networks is addressed such how to set up realistic and achievable goals for the project or how to align interest of different project parties to create value for the project. In this research, we have selected this framework to identify collaborative practices and to divide them into separate categories to define collaborative governance in project networks. Collaborative governance in project networks refers to collaborative practices that enable and encourage collaborative working among project participants and are typically used in highly collaborative project delivery models, such as in project alliancing (Chen et al., 2018). Sanderson (2012) argued that in addition to focusing on project governance also focusing on project governing is important and one possible perspective is "project--as-practice" approach. Project-as-practice approach focuses on how the projects are carried out in practice and what is actually being done by people (Blomquist et al., 2010; Hällgren and Söderholm, 2011). Collaborative practices can be seen as a collection of practices that are done by project actors to promote their collaborative working (Suprapto et al., 2015a, b). Characteristics of collaborative project governance and related core practices are presented for each governance dimension in Table 1.

In a collaborative project, key actors are involved early to set and agree on the project's goals together as a team and to align their interests and objectives (Ruuska et al., 2011; Lahdenperä, 2012; Yeung et al., 2012) so that the best value for the project and all actors can be reached (Walker et al., 2002). Actors are committed to innovating flexibly (Chakkol et al., 2018; Walker and Rowlinson, 2020, p. 21) and to sharing risks and rewards (Sanderson, 2012; Davies et al., 2014). Then, they have a sense of risk ownership, and thus, risk management can be done more proactively (Guo et al., 2014). Incentives are based on the degree of collaboration in addition to cost, quality, and time (Walker and Rowlinson, 2020, p. 20).

Project monitoring is important as it enables control over the project's progress as agreed upon (Evaristo et al., 2004; Abednego and Ogunlana, 2006). When knowledge or trust among the actors is increased, the amount of monitoring can typically be decreased (Evaristo et al., 2004). However, even though collaborative projects aim to

Table 1
Collaborative governance in project networks.

Characteristics of collaborative governance in project networks	Core collaborative practices
Goal setting: Key actors are involved early to set and agree on common goals and objectives for the project (Walker et al., 2002; Ghassemi and Becerik-Gerber, 2011; Yeung et al., 2012).Project actors align their interests and objectives toward common project objectives (Ruuska et al., 2011; Lahdenperä, 2012), aiming to achieve successful collaborative teamwork (Rahman and Kumaraswamy, 2004), and the best value for all actors (Walker et al., 2002).Actors must be flexible to respond to changes (Chakkol et al., 2018).	**Shared goals:** Key actors are involved early to align their interests and define common project goals together, and they are motivated to achieve project goals as a team because it provides the best value for all.
Rewarding: Risks and rewards are shared by key actors (Rahman and Kumaraswamy, 2004; Lahdenperä, 2012).Actors are encouraged to find innovative solutions (Sanderson, 2012; Davies et al., 2014) and to seek the desired project outcomes (Caniëls et al., 2012) by contractual incentives and rewards.Sharing pain and gain and using target cost are used to reach project key performance areas (Sanderson, 2012; Davies et al., 2014).Actors have a sense of risk ownership (Sanderson, 2012; Guo et al., 2014).Risk management is proactive (Guo et al., 2014). Incentives are based on project outcomes and the degree of collaboration (Walker and Rowlinson, 2020, p. 20).	**Common rewarding:** Key actors have a shared risk and reward scheme that encourages them to find innovative best-for-the-project solutions and to solve challenges collaboratively.
Monitoring: Continuous monitoring and project control of work progress is necessary to see that the project objectives are achieved (Evaristo et al., 2004; Abednego and Ogunlana, 2006). Monitoring is essential because it enables that actors behave as expected so that performance-based incentives can be used (Kujala et al., 2020). Co-location, such as the Big Room and other means, are used to increase interaction among actors and conduct monitoring together (Matinheikki et al., 2019).Informal processes and relationships are developed to achieve a mutual understanding of each actor's performance (Hietajärvi et al., 2017).	**Mutual monitoring:** Continuous monitoring and control of work progress are needed to allow the use of performance-based incentives. Actors monitor together, preferably in co-location, combined with informal processes that help build relationships and mutual trust and develop a mutual understanding of each actor's capabilities.
Coordination: Early involvement of key actors is done to start collaborative working (Lahdenperä, 2012; Suprapto et al., 2015b).Structures and communication practices that encourage collaborative teamwork are used (Nisar, 2013).Team-building events are held to create trust among actors (Caniëls et al., 2012). Joint problem-solving and coping with unanticipated events are used (Walker et al., 2017).Collaborative meetings to facilitate communication and joint working are held to build trust (Pekkinen and Kujala, 2014; Hietajärvi et al., 2017).Open discussion and collaborative conflict resolution are encouraged (Nisar, 2013).Coordination is based on shared values and culture (Hietajärvi et al., 2017).	**Mutual coordination:** Key actors are involved early, and collaborative meetings are held to create trust among actors and facilitate communication, team building, and joint working. Actors should coordinate based on open discussion and shared values and culture, and they should be able to cope with unanticipated events and solve problems jointly.
Roles and decision-making: Roles and responsibilities should be designed in a way that allow flexible working and building mutual trust (Chakkol et al.,	**Roles and common decision-making:** Roles and responsibilities should allow flexible working, and actors should handle responsibilities

(*continued on next page*)

Table 1 (*continued*)

Characteristics of collaborative governance in project networks	Core collaborative practices
2018).Responsibilities are allocated to actors that have the competencies and risk-carrying capacity to handle them (Ruuska et al., 2011).Common and unanimous decision-making and decisions are made so they are best-for-the-project (Ross, 2003; Walker and Lloyd-Walker, 2016).Decision makers consider themselves as a part of project organization, and authority for decision-making is at the project level to enable best-for-the-project decisions (American Institute of Architects (AIA), 2007, p. 9).	they have competencies and risk-carrying capacity to handle. Key actors should be involved in decision-making, and decisions should be made so they are best-for-the-project at the project level when possible.
Capability building: Actors are selected based on ability to collaborate early enough to find optimal solutions and better project delivery (Rahman and Kumaraswamy, 2004; Ruuska et al., 2011; Davies et al., 2014).In the contract, there are coordination and adaption-oriented provisions that enable the use of collaborative practices (Chakkol et al., 2018).Investors should put effort into building collaborative competencies early in the project (Saukko et al., 2020).Practices and collaboration among actors are systematically developed (Ruuska et al., 2011).Continuous improvement and learning practices are essential (Walker and Rowlinson, 2020, p. 20).	**Collaboration capabilities:** Capability to work collaboratively is one of the criteria when selecting actors and building capabilities to work efficiently together is important. Collaboration is started early on and continuously developed.

have high levels of trust among actors, monitoring is also essential because it enables that actors behave as expected and that performance-based incentives can be used (Kujala et al., 2020). In collaborative projects, co-location in a collaborative space and other means to increase interaction and to conduct monitoring are used (Matinheikki et al., 2019). Interaction and informal processes help to create relationships and achieve mutual understanding about each actor's performance, which is important in collaborative projects (Hietajärvi et al., 2017).

Key actors are involved early to start collaborative working (Lahdenperä, 2012; Suprapto et al., 2015b). Structures and communication practices encouraging collaborative teamwork (Nisar, 2013) and team-building events to create trust among actors (Caniëls et al., 2012) are important. Actors coordinate projects and solve problems and unanticipated events together (Walker et al., 2017) by using, for example, collaborative meetings that help to facilitate open communication and trust building (Pekkinen and Kujala, 2014; Hietajärvi et al., 2017). Open discussion and collaborative conflict resolution help to coordinate projects successfully (Nisar, 2013), and coordination based on shared values and culture is one of the features of collaborative projects (Hietajärvi et al., 2017).

In collaborative project, roles, and responsibilities are designed in a way that allows flexible working and building mutual trust (Chakkol et al., 2018), with responsibilities allocated to actors that have competencies and the risk-carrying capacity to handle them (Ruuska et al., 2011). Decisions are made best-for-the-project together and unanimously (Ross, 2003; Walker and Lloyd-Walker, 2016). It is important that people who make decisions consider themselves as a part of the project organization. In addition, authority for decision-making should be at as low a level as possible, preferably at the project level, to enable best-for-the-project decisions (American Institute of Architects (AIA), 2007, p. 9).

In the contracts of collaborative projects, coordination and adaption-oriented provisions enable and foster the use of collaborative practices (Chakkol et al., 2018). In collaborative projects, it is important that the investor puts effort into building collaborative competencies early enough, because early team integration and collaboration increases commitment, and successful collaboration in the early phases benefits the project design and planning (Saukko et al., 2020). Collaboration and project practices are systematically developed throughout the project (Ruuska et al., 2011), and actors focus on continuous improvement and learning practices (Walker and Rowlinson, 2020, p. 20).

In collaborative projects, selecting the project team is not based solely on price because the tendering process where actors are incentivized to bring their innovations and practices into the project and to share their risk and rewards helps to find innovative solutions (Ruuska et al., 2011; Davies et al., 2014). While price is often an important decision criterion in supplier selection, Rahman and Kumaraswamy (2004) suggested that non-price-based project team selection, innovative procurement strategies, and early involvement help enhance teamworking and improve project delivery. Relational governance and trust are not beneficial for the project performance if they are not accompanied with contracts and authority (Caniëls et al., 2012), and the use of formal mechanisms also fosters positive relational attitudes and the use of informal mechanisms (Chakkol et al., 2018).

3. Research method and data

Theoretical knowledge about collaboration in interorganizational context is abundant, but there is a need for a more thorough understanding of how a network of actors can use collaborative practices in industrial engineering projects. More specifically, it is important to develop the understanding of practical implementation of collaborative practices and to recognize the challenges different actors face. For these reasons, we employed a qualitative multiple case research design (Eisenhardt, 1989) with theory elaboration approach in which central element is abductive reasoning (Ketokivi and Choi, 2014). The core collaborative practices were identified from the literature and presented for each dimension of project governance framework by Kujala et al. (2020). Then the identified challenges from empirical analysis were categorized according to that framework to elaborate the understanding of how these challenges affect the use of the core collaborative practices.

The unit of analysis was the project during the front-end loading phase. Using theoretical sampling (Eisenhardt, 1989), industrial engineering projects in which investors had the aims to find ways to use collaborative practices were identified as appropriate case projects. Two chosen case projects had some differences but, however, they both were private investors' projects with a network of actors that had not implemented a collaborative project together before and most of the actors were not very familiar with the collaborative practices. Investors were interested in finding out the possibilities to use more collaborative practices in their projects and in project A, collaboration between investor, financiers and key subcontractors and suppliers, and in project B collaboration between investor, governmental authorities and key subcontractors and suppliers were considered especially interesting and useful. In both cases, the organizations involved were open to consider whether collaborative practices could be used in the project and what are the main challenges to implement them. It was expected that the selected case projects yield similar findings related to the challenges in implementation of collaborative practices, so selection was based on literal replication logic (Yin, 2015).

3.1. Empirical context

Project A of this study is a greenfield project, and its goal was to build a metal product plant with a unique circular economy solution. That kind of solution was implemented never before, and during front-end loading there existed technical risks and uncertainties how subprocesses and technologies from several different suppliers can be connected in order to build the production process and make it work

optimally. The suppliers that were capable to offer and develop suitable technology were from all around the world (Finland, India, South-Africa, and Sweden). Thus, there existed especially technical and organizational complexity. The project was in the front-end loading 3 at the time of the study but was terminated before the final investment decision. The project followed an Engineering, Procurement and Construction Management (EPCM) implementation model. In the EPCM model, the responsibilities and roles of project actors are agreed upon in detail, and important decisions are made by the investor with the help of the EPCM contractor.

The project was intended to be conducted with a collaborative mindset because during the front-end loading the project management team realized that it would be beneficial for the project's performance and could help to shorten the project schedule. Collaborative practices were not familiar to all key project actors. Therefore, an idea to use collaborative practices was presented to them, and discussions on practical arrangements were begun. In addition, a week-long workshop on a collaborative co-locational space (Big Room) was arranged to train the key project actors in collaborative practices, to execute project scheduling together with the last planner system (a collaborative project scheduling method), and to present and discuss the project milestones and goals. Similar types of collaborative meetings and workshops among the key actors were planned to be continued as the project progressed.

It was observed that collaborative working needs incentives and rules. So, a bonus model was created, initially approved by the investor's board, and then introduced to the key actors. In addition to bilateral contracts that defined the delivered items, responsibilities, roles, warranties, and possible sanctions, a multiparty agreement that defined how bonuses would be distributed and how the project would be governed together was going to be used. The bonus model would have consisted of money saved in the project contingency fund and additional profits from an earlier start-up of the project and would have been distributed to all key actors.

Project B of this study is a mining project with the aim to expand operations to a new ore deposit and expand the mining concession. It was in the front-end loading 1 at the time of the study. It was challenging because the ore body was located under a lake, but the exact location and size were unknown, and more test drilling was needed. The bottom of the lake was challenging for the dam that was needed and it was essential to combine the extensive exploitation of the deposit in an environmentally and economically viable way. In addition, in mining sector, social and environmental issues have become more emphasized, and roles of external stakeholders have become more important (Prno and Slocombe, 2012). Overall, the water management issues were found to be challenging and there were several different stakeholders with different views on the project. Thus, there existed especially environmental complexity. Basically, project planning and design were started before research and continued during research activities, the environmental impact assessment (EIA) program was finished, and related studies started during the research.

It was noted that early involvement of key actors, such as earthworks, infrastructure, and piping contractors, and water management, and earthworks designers, and their collaborative work together with investors' project team and governmental authorities would help to identify important issues to consider during the EIA process and the project front-end loading. For that reason, the early involvement and collaborative workshops among the key actors including the investors' project management team, governmental authorities, consultants, designers, and various suppliers were started to find the optimal solutions and risks related to the permitting process and project implementation so that they could be handled as early as possible to get a good project.

3.2. Data collection

We employed two data collection methods: interviews and observations. These data collection methods are appropriate in qualitative case-based research (Yin, 2015). Data collection took place from 2018 to 2020 and two to five researchers participated in each data collection session. Data were collected through six unstructured interviews that took place from 2018 to 2019, involving altogether 13 different interviewees and observation studies of one week-long workshop of project A held in 2019, and two workshops of project B that took place from 2019 to 2020. Unstructured interviews were used to understand the phenomenon from the perspectives of interviewees (Zhang and Wildemuth, 2009), and even though we had a pre-defined theme we allowed the conversations to be mutually shaped. There were one to five interviewees per interview, so interviews were partly group interviews and partly individual interviews. Observations of workshop in project A and two workshops in project B were done by direct observations (Yin, 2015). They were interpretive by nature (Martinsuo and Huemann, 2021) and researchers aimed to understand the start of the use of collaborative practices and its challenges. In addition, there were four general workshops with participants from several different companies also external to the case projects that took place in 2019 with the aim to further develop and understand the case study findings. Observations in these general workshops were participant-observations (Yin, 2015) and the role of the researchers was interpretive but with some interventional elements because essential issues of collaboration from literature and initial research results were presented by the researchers and then discussed together.

In project A, a total of three unstructured interviews were organized that lasted 7 h altogether. Six interviewees including three from the investors' management team and three from EPCM contractors' project management team participated in interviews. In project A, a five-day workshop where all key actors participated was observed. The researchers did not affect the practical work but discussed and exchanged ideas with the participants. The researchers observed how the adoption of collaborative activities started and focused on the challenges and possibilities for the use of collaborative practices in that project.

In project B, a total of three unstructured interviews were organized that lasted 7 h altogether. Seven interviewees participated in the interviews, five were managers of the investor, one was environmental specialist from governmental authorities, and one was an environmental engineer from the investor's environmental consultant. A 5-h long workshop with investors' project management, designers, consultants, investors' potential suppliers and contractors, environmental engineers, governmental authorities, and other industrial experts was organized to advance the project design and plans collaboratively, and we observed how such collaboration in the very early phases of the project worked and what the related challenges were. The second observed workshop with the investors' managers, environmental engineer, and governmental authorities lasted 3 h and it was organized to discuss how the environmental permitting process and project planning and design could be better integrated and the collaboration between the investor and the authorities enhanced.

In addition to the interviews and the observation of workshops in the case projects, four more general workshops within the framework of ongoing research were also organized. In these workshops, case projects were used as examples but there were also more general discussions related to the collaboration, and the researchers participated actively and presented earlier research on collaboration and initial research results. Three 3-h workshops with 12–20 industrial experts were organized to develop findings. One 3-h workshop with around 25 participants, including members from the case project B investors' project management team, governmental authorities, and industrial experts, was organized to find and discuss the challenges in the front-end loading of industrial engineering projects, especially those related to the environmental permitting process, and which actors should be involved early and how they should be involved. Participated industrial experts represented different companies and had extensive project experience. They helped to develop the research findings and they were also interested in learning more about collaboration to be able to use the findings

in their own organizations if they felt them to be useful.

The researchers were able to follow some project-specific work onsite in both case projects to learn more about the projects, and the challenges there existed. Supporting discussions and informal meetings were organized through the research process regularly in which initial research results and other novel scientific knowledge were presented by the researchers and researchers gave suggestions for improvement related especially to the collaborative practices and their implementation. These discussions and meetings were interventional by nature (Martinsuo and Huemann, 2021) and researchers shared their knowledge about collaborative practices and gave suggestions about actions that would be beneficial for the projects. Data collection during the research process is presented in Table 2.

3.3. Data analysis

Qualitative content analysis was used (Hsieh and Shannon, 2005) and there were two main stages of data analysis: within-case and cross-case analyses. First, all research data, including researcher notes and meeting memos from several researchers, were compiled. Within case-analysis was started by familiarization with the data to create an understanding of the situation. The main author re-read the data to form initial ideas and codes that were commented by other authors and in addition, case descriptions were written. Then the data were transferred to MS Excel for coding.

The main author made the content analysis and other authors commented. On the first round of coding, the data were organized to challenges of implementing collaborative practices and issues that were not related to challenges. Challenges were identified from a broad perspective so any issue that could be considered as challenge was included and totally 74 challenges were found. On the second round, challenges were coded according to the six dimensions of Kujala et al. (2020) project governance analysis framework in accordance with the directed content analysis (Hsieh and Shannon, 2005). The framework was used as a means to categorize the findings because it allowed structured way to identify the relevant challenges and to present challenges for each dimension and related core collaborative practice. Every identified challenge had a connection to at least one of the categories and the category that was the most relevant was chosen. Challenges were then cross-case analyzed inside the categories. The aim was to identify similarities between the cases and the challenges that were similar or complementary were compiled following the replication logic (Yin, 2015). Governance framework was used to support the identification of challenges with similarities. Conflicting unilateral findings were eliminated (Yin, 2015) but, however, the challenges that were more related to either case but did not conflict with another case were included. In the end, there were 27 challenges. After that each challenge was carefully analyzed with the help of interview and workshop materials and it was defined for which actor(s) the specific challenge was a challenge.

4. Empirical results

4.1. Challenges to implementing collaborative practices in industrial engineering projects

Collaborative governance should be introduced and initiated during the early stages of the project so that, for example, early involvement, design integration, socialization, communication, and information sharing can be started. When parties are not familiar with collaborative project settings, such as project alliancing, there can be challenges in reaching an agreement on ways of working that differ from those used in the past. In addition, it was observed, especially in project A, that a highly collaborative delivery model was not possible, and, for example, bilateral contracts to indicate responsibilities and warranties in the traditional way were needed. Introducing lesser-known methods to

Table 2
Data collection.

Context and type of data collection	Number of participants	Interviewee or workshop participant roles	Date and length
Project A: Unstructured group interview	3	Investor: CEO, Project manager, Project control manager	12.12.2018 2 h
Project A: Unstructured group interview	5	Investor: Project manager, Project control manager EPCM: Project manager, Scheduling manager, Infrastructure Business unit Leader	21.1.2019 3 h
Project A: Unstructured group interview	4	Investor: Project manager, Project control manager EPCM: Project manager, Scheduling manager	22.1.2019 2 h
Project A: Workshop	30–40 depending on the day	Investor: CEO, Project Manager, and discipline managers EPCM: Project manager, discipline managers, representation of designers from all disciplines Other key actors: Managers and other relevant experts such as designers from Original Equipment Manufacturers (OEMs), automation system supplier, electrification and instrumentation supplier, infrastructure and construction contractor, construction subcontractor, and external lean and last planner consultants	28.01.-01.02.2019 35 h
Project B: Unstructured group interview	4	Investor: CEO, Head of design department, two Project managers	15.05.2019 2 h
Project B: Unstructured group interview	5	Investor: CEO, Sustainability manager, Head of design department, Project manager Governmental authorities: Environmental specialist	06.09.2019 3 h
Project B: Unstructured individual interview	1	Investor's environmental consultant: Environmental engineer	20.12.2019 2 h
Project B: Workshop	40	Investor: Sustainability manager, Head of design department, project managers, designers Investor's environmental consultant: Environmental engineer Investor's potential suppliers and contractors. Governmental authorities: three environmental specialists Industrial experts from various companies	09.12.2019 5 h
Project B: Workshop	6	Investor: Sustainability manager, Head of design department Investor's environmental consultant: Environmental engineer Governmental authorities: three Environmental specialists	15.01.2020 3 h
Research project: General Workshop	20	Industrial experts from various companies	15.04.2019 3 h
	12		

(continued on next page)

Table 2 (*continued*)

Context and type of data collection	Number of participants	Interviewee or workshop participant roles	Date and length
Research project: General Workshop		Industrial experts from various companies	04.06.2019 3 h
Research project: General Workshop	15	Industrial experts from various companies	25.06.2019 3 h
Research project: General Workshop	25	Investor of case project B: Sustainability manager, Head of design department Governmental authorities: three environmental specialists Industrial experts from various companies	16.10.2019 3 h

complement and replace better-known methods in the industry but not changing the mindset completely represented the possibility of simply maintaining the old ways.

Several challenges to implementing collaborative practices in the industrial engineering project context were identified in the front-end loading of two different projects based on the observations and interviews. We categorized the challenges according to governance dimensions to indicate the tensions of moving toward a more collaborative way of working. We also specify for which actor(s) the specific challenge is the most relevant. Table 3 summarizes the different challenges based on the data.

4.1.1. Shared goals

In project A, the goals of collaborative development were set by the investor together with the EPCM contractor, and then the goals were discussed, and a search for solutions to meet them was started in the first workshops. However, in collaborative projects, there should be a possibility to define performance goals together, so they can be understood in similar ways and every actor can agree and commit to them completely. In industrial engineering projects, schedules might be hard to predict, and in project A, one of the goals was to conduct the project faster than initially planned. However, the investor wondered: "How can we do flexible rescheduling without unnecessary work and violating of existing contracts?" The EPCM contractor agreed that it is a challenge. For example, OEMs had promised that they could deliver certain documents so that early work could be started, but after the workshops, the timetable for their information delivery changed. Mutual understanding about what to do and what to provide so that the planned goals would be possible to reach had to be found, but this was challenging because there existed uncertainty and the actors had to be flexible to change the goals later on.

The goals of the authorities include, for example, an impartial permitting process, realized legality, and smooth interaction with the parties involved. Authorities cannot participate in joint goal setting similarly to others, and they cannot flexibly change, for example, emission limits. Nevertheless, their decisions significantly affect the project work and goals. The authorities involved in research stated that: "Investors' own intentions can be unclear if they are dealing only through consultants, and many times, investors do not put enough effort into design in the early phases to also be used in the permitting process." Thus, the permitting process should be taken more seriously, which would decrease the problems later.

4.1.2. Common rewarding

Based on our data, it seemed that private investors and financiers were not willing to use project alliancing or other highly collaborative models they considered too risky, and that realized cost risks remained to be borne by the investor or ultimately by the financiers. In project A, the project alliancing model was first introduced, but it was abandoned.

Table 3
Challenges to implementing collaborative practices.

Observed challenges for collaborative practices	Specific to which actor
• Shared goals:	
In project A, the goals were not formed and agreed upon together before the start of the discussion on how to reach them.	All key actors
It can be challenging to flexibly develop existing schedules when some of them are initially set with some actors in project A.	Investor and EPCM contractor
The goals of the authorities differ from the goals of the others, and on many issues, there is no room for joint goal setting or flexibility.	Authorities
• Common rewarding:	
Some private investors and financiers are not willing to accept project alliancing or other highly collaborative delivery models because they are considered too risky.	Investor and financiers
How to define a bonus model and its key result areas, and how it affects the pricing of the suppliers and contractors are challenging questions.	Investor
It must be determined how collaborative practices benefit the EPCM contractor because they increase the costs in design and scheduling activities.	EPCM contractor
Not all parties are ready to make collaborative design work motivated by the promise to participate in the bonus model without straight compensation or binding contract, so what is a sufficient motivator?	Contractors and suppliers
Sharing cost and revenue structures and participation in the collaborative project design with the aim of reducing project costs when the motivator is a bonus model might not be interesting.	OEMs
Rewards for authorities differ from others because they are not monetary, but it is essential for authorities' that laws are obeyed, permit conditions are met, the permitting process is smooth, and their impartiality is not endangered.	Authorities
• Mutual monitoring:	
Collaborative working has to be continued regularly, but it is uncertain how it should be organized without a contract defining the practices in project A.	All key actors
Co-location that enables informal activities affects extra costs, and there is limited amount of funding available before the final investment decision in project A.	Investor
The monitoring process of authorities is not transparent in nature, feedback is shared with other project actors according to a specific protocol, and the official comment are typically given after submission of written applications.	Investor
• Mutual coordination:	
Early involvement of key actors to work together and to give their expertise for the use of project design and scheduling is not the usual way to do, and it is more efficient if the EPCM contractor coordinates project design and scheduling.	EPCM contractor
Early involvement of OEMs is found to be important in project A, but they are not willing to share information openly because they are competitors.	OEMs
It is not clear how to coordinate project actors and by what methods when collaborative practices are used.	Investor and EPCM contractor
In project A, it was noted that information sharing among key actors is beneficial because even minor deficiencies in the input data can cause long delays and problems, but it did not work optimally in the early phases.	Investor and EPCM contractor
Authorities have to coordinate their permit-related activities in a neutral and impartial manner, and their information sharing with other project actors is limited.	Authorities
Under the current advance guidance practice, open dialogue and information sharing does not work as well as would be possible even on behalf of the authorities.	Investor and authorities
• Roles and common decision-making	
The expectation is that it will be challenging to make decisions together related to money in project A.	All key actors
Deeper integration of equipment supply planning could be beneficial, but maintaining fixed interfaces among suppliers is desired in project A.	EPCM contractor and OEMs
Contractual interfaces affect the protecting of one's own interests instead of the common project's interests.	All key actors

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Table 3 (*continued*)

Observed challenges for collaborative practices	Specific to which actor
Authorities have to keep their role external and not participate in meetings that consider practical project work to any significant degree.	Authorities
• Collaboration capabilities:	
How to select the project actors because in addition to functional capability and motivation to work with best-for-the-project mindset, technical capability is also important.	Investor
Competitive tendering of technology suppliers based on price and ability to work collaboratively is not suitable when an ability to develop high-end technology is needed.	Investor and OEMs
There are actors who are not familiar with collaborative practices, and they might be reluctant to change the practices used.	Investor
In the early phases of project A, it was found that there was no ability to implement collaborative practices effectively with the current project workers.	Investor
In the collaborative workshops of project A, interlocking issues were handled in the silos, and the focus was not on the right issues all the time, which indicated that collaborative practices needed more training and good preparation, but limited funding was a constraint.	Investor

The common bonus model has not been a typical way to reward parties in industrial engineering projects, and it was uncertain how an economical model that included jointly managed use of money and a "winning or losing together" mindset would affect the pricing of the suppliers and contractors. It was challenging to define how the model and its key result areas should be formed. In both case projects, the management was sure that the collaboration would not work well without a common bonus model, and that some actors might not be ready to participate in the collaborative project design work without monetary compensation before a binding contract, which is usually made only after the final investment decision.

An EPCM contractor argued that: "The coordination of collaborative working related to design and scheduling activities, increases our costs, and it has to be determined also how the collaboration can benefit us on this project." One member from the subcontracting company said: "hard to see that our company would do design work without binding contract for the whole project." For example, in project A, compensation was paid for the parties participating in the workshops. However, sufficient motivation was different depending on the actor, the type of the project, and the investor of the project. For example, in project A, the investor was a new company, and in project B, the investor was company known for its local partners and potential suppliers, and they were ready to give their expertise with the motivation of getting a deal later on.

The role of OEMs is important, especially in technically complex projects, but an experienced project manager argued that: "OEMs might not be willing to share cost and revenue structures or to participate in a model where they also try to lower the costs motivated by bonus model." It is a challenge that OEMs might not be ready for a reward scheme similar to the other actors because their business logic is so different. Other actors might be ready to participate in tendering to develop a project together with a motivation to win a contract and to get involved in a bonus model, but industrial experts agreed in the workshops that OEMs are not necessarily motivated by that.

Better collaboration and information sharing between authorities and the project investor would help minimize the problems related to environmental issues, for example, but the results confirmed that the authorities were not motivated by the same rewards as other actors. Their reward was that the public interest was realized, and successful projects are consistent with the public interest. Our data showed that the authorities were willing to help and give instructions, for example, under advance guidance practice, and it was also in their interest that the investor focused on the right issues, the permitting process was smooth, the permit applications included all the needed information presented in the correct way, and the projects did not face major problems that would lead to accidents, changes or new permit applications.

4.1.3. Mutual monitoring

During the workshops for project A, participating actors agreed that the workshops were useful, and similar activities should be continued regularly, but it was a challenge that they did not yet know how to facilitate the collaborative work in the future. It was noted that the practices should be developed quickly and then agreed upon by all so that all actors would know what is to be done together, when, and by which methods. However, the investor raised a concern: "There is limited amount of funding available before final investment decision." Physical co-location would have enabled informal monitoring, but it would have increased the expenses, and some actors raised a concern that it was problematic to introduce new methods, for example, co-location and collaborative schedule planning with already scarce resources.

The monitoring process of the authorities differed from that of the others, and it was not transparent in nature because the authorities handle many issues internally and give their feedback afterwards. The authorities admitted that "the current process is quite formal," and that especially official comments and requests for further clarification are given after they have evaluated the written application. The authorities could also have participated in more informal monitoring, but the current process did not enable that very well. However, they are not allowed to share information that gives the investor an unfair advantage over other stakeholders.

4.1.4. Mutual coordination

For EPCM contractors, the early involvement of other contractors and suppliers in project scheduling and design together was not the usual way to do. According to our results, an experienced EPCM contractor can coordinate project design efficiently and achieve good performance without collaborative coordination which decreases the need for collaborative practices. In project A, an EPCM contractor's manager argued that "all the same issues that are done in last planner scheduling are done already when we manage projects." Thus, it appeared that it could be hard to change the approach if the current approach is considered good.

The early involvement of OEMs in collaborative development and more open information sharing, especially among OEMs, designers, and installation contractors, could help to find the most optimal solutions and to reduce the occurrence of problems in the equipment installation phase. However, it was argued by one industrial expert that "in the early phases technology suppliers are most probably not willing to discuss with each other about their technical solutions in detail." In addition, an OEM said that "we have buffers in our delivery schedules so that problems are not faced if we have delays in our production." The OEMs were willing to discuss their time buffers and maybe reveal how long they were, but still their mode of operation was not going to be as open as that of others.

The results demonstrated that, in the case projects, actors were not familiar with collaborative coordination, and it would have required more training and orientation to new practices. Both investors noticed that it was important to share information and to have workshops together with key actors before design solutions are locked because then the optimal solutions that can help to decrease risks and to shorten the project schedule can be found. In particular, the collaboration between equipment suppliers and structural designers was noted as important in the project A because it helped designers advance the plans that infrastructure contractors needed when they started the early work. In project B, water management issues were critical, and collaboration related to them was considered useful. However, it was a challenge to define which actors were needed, which personnel from their

organizations should participate, and how to coordinate that collaboration.

Information sharing among key actors should happen before design solutions are locked, but it is very project-specific as to whom to involve, where, and how. In the project A, an EPCM contractor argued that: "Information sharing between equipment suppliers and structural designers has to be ensured because minor deficiencies in the input data can affect long delays." However, information sharing, especially among different disciplines, had not worked optimally, and one of the investor's managers said: "There are problems with the flow of information and the information conveying by memos do not work optimally." Weak information sharing is a problem in any project, but especially in collaborative projects, and the development of well-functioning information sharing practices should be started at the very beginning of the project.

Authorities have restrictions in information sharing, and, for example, after an investor has submitted an environmental permit application, authorities cannot participate in meetings where project-related issues are discussed with the investor or its representatives. We found that the current advance guidance protocol is quite formal, and it does not allow for open dialogue and information sharing during EIA unless the investor requests meetings for more informal discussions. One authority stated that: "There could be more open dialogue on our behalf." It would help both the investor and the authorities to note risks and potential problems early on. Moreover, then the authorities would have a chance to hear about the details of the project and to give their suggestions, which could help the investor to create a better EIA program and thus enable a better and more fluent permitting process and project.

4.1.5. Roles and common decision-making

In project A, the EPCM contractor and investor expected that it would be challenging to make decisions related to money together mostly because it was a new way of working. Deeper integration of equipment supply planning could have helped to shorten the project schedule and to find optimal solutions, but interfaces of different supplies needed to be fixed because, for EPCM contractors, it would be easier to handle coordination of design and scheduling of different entities separately because they were used to this kind of practice. Contractual interfaces affect the protecting of one's own interests, and in project A, there were bilateral contracts, so situations where mutual understanding was not found could have existed.

The role of the authorities in project success is significant because problems in permitting can delay or kill the project. However, the authorities have to keep their role external, and they do not have time or resources to participate in everything, so one of them emphasized that: "We can participate only in activities required by our role." In addition, they cannot participate in meetings where practical project work is done; instead, there should be separate meetings where the project team can present issues that might require some dialogue with authorities.

4.1.6. Collaboration capabilities

In collaborative projects, it is important to find actors that have good functional capability and motivation to work with a best-for-the-project mindset, but in industrial engineering projects, technical capability is also emphasized. In industrial engineering projects, such as project A, when a technically novel solution is needed, the ability to develop high-end technology is the priority. Then, selection of technology suppliers cannot be done early because their selection requires more information about the process, which makes it harder to do early integration and collaborative development of the project.

Our results revealed that not all the actors were familiar with collaborative practices, and the project manager in project A noted that "there are some actors that are not interested in changing their practices, but there are actors that are willing to use collaborative practices and models because they have faced problems in the traditional way of working." Many of the actors considered collaborative practices to be good, but they did not have experience, and there was not adequate training so the new practices could not be fully implemented. In project A, one manager noted that "there is not enough knowledge about collaborative practices to implement them effectively so there is need for training." In addition, during the workshops, every actor had a good attitude and collaborative mindset, but the practices were not familiar, and one participant stated afterwards that "the focus was not on right issues all the time." Therefore, repetitions, regularity, and the possibility of giving anonymous feedback were needed. However, the limited funding in the front-end loading is a fundamental challenge. It prevents the hiring of new workers to deploy and to provide training in collaboration techniques, and when there is more funding to be used, typically after investment decisions, collaboration training is too late. The industrial experts stated that it is a typical problem in projects that front-end loading cannot be too costly because of the lack of funding before a binding investment decision is made and the costs in collaborative projects tend to be more frontloaded. The decision about the delivery model is often postponed, which makes it challenging to start collaborative activities early enough.

5. Discussion

Prior literature has claimed that there is potential to improve the performance of industrial engineering projects (e.g., Merrow, 2011; Olaniran et al., 2015a, b). We identified collaborative practices, defined in the literature as a collection of practices that promote collaborative working (Suprapto et al., 2015a, b). Collaborative practices can improve the performance of industrial engineering projects, but it has also been stated that they are not suitable for the industrial engineering project context. Our research showed that the practitioners consider the collaborative practices to be suitable and that they have the potential to improve performance if they are implemented correctly, but there exist challenges. The main contributions of this study are the definition of collaborative practices that can be used to implement collaboration and identification of several challenges to implementing them in industrial engineering projects. These challenges help to define how collaborative practices should be implemented and how collaborative governance in project network can be done. The core collaborative practices of collaborative governance in project network from Table 1 and key challenges for them based on our empirical analysis are presented in Table 4.

Industrial engineering projects have a network of actors with divergent objectives (Dietrich et al., 2010), so common and flexible goal setting can be challenging. Research results indicated that mutual decisions regarding money or rescheduling are considered to be difficult by practitioners because, when there are contractual interfaces, actors might seek their own benefits. However, interests of actors can be aligned and, for example, Suprapto et al. (2016) argued that contractual incentives can lead to better and more collaborative relationships and thus ease the best-for-the-project decisions and improve the project performance. In addition, contractual and relational governance complement each other (Cao and Lumineau, 2015) and relational governance and trust have to be accompanied by contractual incentives to enable good project outcomes (Caniëls et al., 2012). Our empirical research pointed out that some of the private investors and financiers consider project alliancing and other collaborative models with purely multi-party contractual structures that include clear practices for rewarding too risky and inappropriate. There are certain rules in financing that emphasize the limitation of maximum liability and practices in contracting that define the financial management of the projects, and they are considered safe because responsibilities and liabilities are strictly defined in the contracts. Thus, the shared risk and reward system should be tailored to the context of the industrial engineering projects so that it is accepted, but it sufficiently aligns the interests and motivates the actors to achieve them together.

Suprapto et al. (2015a) argued that teamworking can be initiated

Table 4
Key challenges for implementing collaborative practices in industrial engineering projects.

Core collaborative practices	Key challenges
Shared goals: Key actors are involved early to align their interests and define common project goals together, and they are motivated to achieve project goals as a team because it provides the best value for all.	**Shared goals**: Common and flexible goal setting and related decision-making are challenging because actors have divergent objectives.
Common rewarding: Key actors have a shared risk and reward scheme that encourages them to find innovative best-for-the-project solutions and to solve challenges collaboratively.	**Common rewarding:** Some of the private investors and financiers do not accept highly collaborative models that include clear practices for motivating and rewarding different actors to work collaboratively because they are considered too risky and inappropriate.
Mutual monitoring: Continuous monitoring and control of work progress are needed to allow the use of performance-based incentives. Monitoring is done together, preferably in co-location combined with informal processes that help build relationships and mutual trust and develop mutual understanding of each actor's capabilities.	**Mutual monitoring:** Some of the work processes by different actors are carried independently and there is little visibility to work progress.
Mutual coordination: Key actors are involved early, and collaborative meetings are held to create trust among actors and facilitate communication, team building, and joint working. Actors should coordinate based on open discussion and shared values and culture, and they should be able to cope with unanticipated events and solve problems jointly.	**Mutual coordination:** Early involvement of key actors and implementation and training of collaborative practices require more frontloaded use of funding, but typically there is limited funding available before final investment decisions are made in industrial engineering projects. In addition, there are challenges for open dialogue and information-sharing between different actors during the project implementation.
Roles and common decision-making: Roles and responsibilities of the actors should allow flexible working, and actors should handle responsibilities they have competencies and risk-carrying capacity to handle. Key actors should be involved in decision-making, and decisions should be made so they are best-for-the-project at the project level when possible.	**Roles and common decision-making:** The roles, objectives, and risk-carrying capacity of different actors is different which makes it difficult to achieve best-for-the-project decisions.
Collaboration capabilities: Capability to work collaboratively is one of the criteria when selecting actors and building capabilities to work efficiently together is important. Collaboration is started early on and continuously developed.	**Collaboration capabilities:** Early involvement enables building collaboration capabilities. However, tendering cannot be based solely on collaboration capabilities because in industrial engineering projects, for example, technical capability is very important, and in some projects the use of collaborative practices might not work if some important actors are not willing to use them.

during the project front-end loading by using collaborative practices that aim for team building and integration and that teamworking quality contributes positively to the project performance. In addition, project-as-practice approach suggests that collaboration is an ongoing accomplishment, which needs to be actively constituted and potentially renegotiated and revised, and not an end point to be achieved (Marshall, 2014). If project actors are early involved and they coordinate and monitor project together as a team, there is a potential to cope better with the uncertainty and to find optimal solutions.

Industrial engineering projects are often broken down into technically independent modules, which have clearly defined interfaces. This decreases the complexity of the project and enables technology suppliers to work independently. When project actors independently carry some of the work processes, there is little visibility to work progress. These issues should be taken into account when selecting monitoring practices for the project. The early involvement of key actors is considered a precondition for interorganizational collaboration (Suprapto et al., 2015b; Saukko et al., 2020). The implementation of collaborative practices requires training (Ruuska et al., 2011; Davies et al., 2014) and the use of resources. However, the empirical results of this study highlighted that investors are typically not committed to and do not use resources for front-end loading phase before investment decisions. The organizing of collaborative workshops and related trainings for actors to build collaboration capabilities and integrate the team requires committing resources early, and investors and financiers should have trust and confidence in new practices so that they are ready to change established ways.

There are challenges in open dialogue and information-sharing between different actors and it is challenging to achieve best-for-the-project decisions because the roles, objectives, and risk-carrying capacity are different between the actors. For example, the role of the governmental authorities is objective and independent, and they cannot engage too much in practical project work such as meetings and workshops (Sallinen et al., 2011). However, they can be involved in dialogue and information sharing meetings with the investor, and according to our empirical study, that possibility is not used optimally at the moment in Finnish industrial projects. In Finland, there is already an advance guidance practice that allows the investor to set meetings with authorities where issues related to the environmental permitting process can be discussed and authorities are allowed to give non-binding opinions and suggestions to help the investor to focus on the right issues at the very beginning, but that possibility is not used by every investor. Our findings revealed that meetings between the investor and authorities enabled them to identify several important issues that helped to steer the planning so that environmental requirements and how they could be fulfilled with cost-effective technical solutions were considered.

Some investors have started to require evidence of collaboration competence in the tendering process of complex projects as a response to prior performance failures associated with fragmented and adversarial relationships (Chakkol et al., 2018), but in industrial engineering projects, the technical capability of actors is essential and the ability to offer the best technology is often needed, which creates some tensions. In some cases, it might be possible to tender actors by highlighting functional and collaboration capabilities, but it requires that the technology is well established. If one key actor with the required technical capability is not willing to adopt collaborative practices, then conducting the whole project together collaboratively with the key actors will not be possible. Then, the project could be partly governed collaboratively, or at least some collaborative practices could be used in some tasks where they would be identified as useful.

6. Conclusions

In conclusion, this research contributed to literature on collaborative project delivery arrangements and identified collaborative practices to be used and challenges to implementing them in industrial engineering projects. First, we defined the concept of collaborative governance in project networks and presented practices to implementing it based on the literature. We also extended previous discussion on collaborative practices to include actors that are typically not considered as internal to a project network such as investors, financiers, and authorities, which have a key role in deciding which type of collaborative practices are used in projects. Then the observed challenges to implementing collaborative practices in case projects were presented. These challenges were divided into different categories, and it was specified which actors are facing these challenges and how the challenges appear in practice and affect the implementation of collaborative practices. The key challenges include the divergent objectives of the actors, inappropriateness of the existing collaborative models and their rewarding mechanisms, and the limited funding before investment decision when early

involvement and start of collaborative activities should be secured. Further challenges include the impossibility to emphasize the collaboration capabilities with every actor in tendering, different roles, objectives, and risk-carrying capacity of the actors that hamper best-for-the-project decision-making, and collaboration with governmental authorities, which is important and required but needs to be organized in a different way than with the other actors. The identified challenges restrict or hinder the implementation of collaborative practices and the collaborative governance of the project. The decisions on how widely collaborative practices can be used depend on the details of the project, and collaborative arrangements need project-specific tailoring. This research provided novel insights into how the characteristics of industrial engineering projects affect the implementation of collaboration, and the results can be used when developing and defining optimal collaborative delivery arrangement for industrial engineering projects.

Implementing a project by using collaborative governance requires new skills as compared to governance that has relied on "traditional" control and coordination methods. For example, the EPCM contractor could be an important position in facilitating the selection, use, and development of the most appropriate collaborative practices that benefit the project. However, this would require EPCM contractor to develop new skills required in this type of role. Moreover, mutual monitoring and coordination of the entire project collaboratively might not be the optimal way to govern all industrial engineering projects, but rather, we should carefully consider which phases or tasks in the project would benefit from this type of monitoring and coordination. Our research results indicate that there are challenges to implementing collaborative practices in industrial engineering projects, but we suggest that our research results can be used to select collaborative practices, which are most functional for each project. These collaborative practices can complement coordination practices in projects implemented in any type of contractual arrangements, thus enabling re-introduction of collaborative practices in industrial engineering project setting.

The research results also have important societal implications, as industrial engineering projects typically have significant social and environmental impacts, which can be positive or negative such as potential for creating jobs and harmful effects on nature. Collaborative practices could potentially improve coordination of work between authorities and other project actors especially during permitting processes, which are important phases to ensure sustainability of the projects from environmental and societal perspective. However, this would require authorities to re-consider their role as they would be more integrated to project design processes, which may sacrifice their independence. To which extent authorities can take more collaborate role may also be limited by local legislation.

An important issue also to consider is who should act as a change agent to facilitate the use of collaborative practices in industrial engineering projects. In the construction and infrastructure sector, strong public owners have played an important role in shaping practices. In industrial engineering project there is no single actor having a similar role. With increasing public funding supporting projects to solve important environmental challenges such as climate change, there is an opportunity for public financing organizations to act as change agents and to require consideration of whether project design and implementation could benefit from the use of collaborative practices.

This study does have some recognized limitations. The research focused purely on the early phases of the projects and the challenges in later phases of the projects were not considered. In the case projects, collaborative practices were used to a rather limited extent and supporting contractual structures were not used. In addition, different types of industrial engineering projects could have had different challenges, so transferability to other contexts is not straightforward. Further research on the challenges from a wider set of industrial engineering projects would help to build a more comprehensive understanding of the challenges. Moreover, further empirical research is required to develop the understanding of the collaborative practices in industrial engineering project context by researching the projects in which collaborative practices are implemented, with the aim of finding out how they affect the project performance and success. The role of authorities and how legislation may influence their opportunity to engage in collaborative practices should be further studied in different country and institutional context.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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