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Governing technical and organizational complexity through supply chain integration: A dyadic perspective on performance in infrastructure projects

Per Erik Eriksson [a,*], Ossi Pesämaa [b], Johan Larsson [c]

[a] Department of Civil, Environmental and Natural Resources Engineering Luleå University of Technology, Luleå 97187, Sweden
[b] Department of Business Administration, Technology and Social Sciences, Luleå University of Technology, Luleå, Sweden
[c] Department of Civil, Environmental and Natural Resources Engineering, Luleå University of Technology, Luleå, Sweden

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ABSTRACT

Despite its declared importance for governing complexity in projects, few empirical studies have studied how different types of supply chain integration (SCI) activities (e.g., coordinative and collaborative integration) interplay and affect performance. To address this gap, the purpose of this paper is to study how complexity can be governed through coordinative and collaborative SCI, and how their interplay affects performance in project-based buyer-supplier relationships. We apply structural equation modeling, using dyadic empirical data from 102 infrastructure projects. The overall results verify our developed model and illuminate how the interplay between contractual and relational governance, in terms of coordinative and collaborative SCI, mediates the effect of technical and organizational complexity on project performance. This study contributes to theory and practice by distinguishing between contractual governance based on formal coordinative SCI and relational governance based on emerged collaborative SCI, as well as showing how their interplay affects performance in project-based supply chains.

1. Introduction

While project success reflects the attainment of goals set by the involved organization(s) and related stakeholders, project performance reflects the outcome of various activities undertaken to meet the goals and their control (governance) (Ika &, Pinto, 2022; Korhonen et al., 2023). Supply chain integration (SCI) refers to an organization's alignment with supply chain partners (Schoenherr & Swink, 2012; Wiengarten et al., 2014), which is a key element of project governance and project performance (Caldwell et al., 2017; Jagtap & Kamble, 2019). In prior SCI research, some conceptualizations have focused on the processes involved, that is, the integrative activities (Mackelprang et al., 2014). We build on this emerging research stream and follow scholars who distinguish between coordinative (i.e., contractually formalized activities that play important roles in operative interactions among partners) and collaborative (i.e., joint strategic processes in which the partners rely on relational aspects) forms of SCI (e.g., Ataseven & Nair, 2017; Wiengarten & Longoni, 2015; Wiengarten et al., 2014).

The governance literature offers a wide range of definitions and conceptualizations (Ahola et al., 2014). Similar to many other scholars (e.g., Cao & Lumineau, 2015; Haq et al., 2019; Roehrich et al., 2020), we follow Poppo and Zenger (2002) in conceptualizing governance by distinguishing between contractual and relational governance. Contractual governance contains written contractual clauses that specify roles and obligations to facilitate control and/or coordination, which are the two main functions of contractual governance (Malhotra & Lumineau, 2011; Roehrich et al., 2020; Schepker et al., 2014). Relational governance refers to more informal and emergent mechanisms based on trust and socially derived collaborative arrangements to facilitate joint action and "*adaptation to unforeseeable events*" (Poppo & Zenger, 2002: p. 710). As such, due to their respective contractual and relational natures, coordinative SCI is clearly related to the coordination function of contractual governance, whereas collaborative SCI is related to relational governance.

In a meta-analysis of 3349 articles about governance of dyadic relationships, Cao and Lumineau (2015) found that contractual and relational governance are complementary, rather than mutually exclusive. Many scholars have therefore seen a need to separate intertwined but independent elements (e.g., coordination and collaboration) of interorganizational relationships. However, as a result of a recent extensive literature review, Roehrich et al. (2020): p. 460) found that *"the impact of governance mechanisms' interplay on performance is poorly explored"*.

* Corresponding author.
E-mail address: pererik.eriksson@ltu.se (P.E. Eriksson).

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Following Oliveira and Lumineau (2017) and Gulati et al. (2012), we thus seek to disentangle the two prominent governance mechanisms (coordination and collaboration) and their mutual role in project performance. In project-based contexts, contractual governance is often emphasized, whereas relational aspects of governance are sometimes ignored. However, recent studies have shown that passive governance with little attention to relations is negatively associated with project performance (Mubarak et al., 2023). In fact, recent project studies highlight the importance of relational aspects, such as trust and collaboration, especially when governing large projects with high complexity (Cerić et al., 2021; Vukomanović et al., 2021).

The effects of contextual factors on SCI and performance have been emphasized in recent studies (Danese et al., 2020), and some have considered aspects of the supply chain environment (including its complexity) as key contextual factors (Gimenez et al., 2012; van der Vaart et al., 2012; Wong et al., 2021). Supply complexity is connected to the business conditions. For example, production in project-based industries is generally more temporary and complex (due to low volumes, high product variety, and long delivery times) than the generally standardized and continuous processes in manufacturing industries (Gimenez et al., 2012; van Donk & van der Vaart, 2004). In project-based industries (e.g., infrastructure, civil engineering, defense, and shipbuilding), one-off products are typically produced, and deliveries are designed to satisfy specific client requirements in highly complex, temporary and heterogeneous projects (Bonomi Santos & Cabral, 2022; Pero et al., 2015). Our study therefore "*builds on the assumption that unique projects require tailored – as opposed to standardized – governance arrangements*" (Ahola et al., 2014: p. 1325). As such, we seek to extend existing understanding in project governance research of complexity's impact as an antecedent that varies across projects, affecting project governance practices, in terms of SCI (Eriksson, 2015; Martinsuo & Ahola, 2010; Williams, 2005).

Furthermore, Roehrich et al. (2020) found that prior studies have mainly focused on governance of horizontal relationships (e.g., alliances), whereas further attention on governance of vertical buyer-supplier relationships is needed. In line with recent literature, we investigate interdependent vertical dyads when referring to the parties in governed relationships (Caldwell et al., 2017; Öberg et al., 2020; Patrucco et al., 2021). The purpose of this paper is thus to study how complexity can be governed through coordinative and collaborative SCI, and how their interplay affects performance in project-based buyer--supplier relationships.

We develop and empirically test a structural equation model (SEM) using a dataset of 204 matched responses (following a dyadic approach) to a questionnaire of representatives of both the public client and private consultants (service suppliers) involved in 102 infrastructure projects managed and governed by the Swedish Transport Administration (STA). Theoretically, we provide the first (to the best of our knowledge) distinctions between coordinative and collaborative SCI. We also provide measures of their antecedents, interconnections, and performance effects. Moreover, SCI and performance have mostly been studied at firm level, while contextual effects have been studied at industry or country level (e.g., Flynn et al., 2016; Liu et al., 2016). Thus, we address knowledge gaps by examining project-level relations between complexity, SCI, and project performance to enlighten project governance practices. By measuring all constructs at the project level and treating complexity as an antecedent affecting SCI-related managerial practices, we provide findings with clear managerial implications for project governance, particularly for governing complexity through SCI.

2. Theoretical model and hypotheses

2.1. Project governance and supply chain integration with a dyadic approach

Project performance reflects the degrees to which goals of a defined process are met (Eriksson et al., 2017), while project governance refers to the direction of efforts to meet those goals (Guo et al., 2014). Appropriate direction and establishment of goals for all the actors in each of the project stages is crucial for project management to control key activities and meet overall goals (Kivilä et al., 2017).

From a governance perspective, contractual parties are intertwined in different nexus of dependencies and "*the primary purpose of project governance is to ensure that the project will meet the goals and expectations subjected to it by various stakeholders*" (Ahola et al., 2014: p. 1328). A dyadic approach is highly valuable for detecting deviations in stakeholders' perceptions (i.e., goal incongruence) and if buyers and suppliers have the same views of specific goals and activities. Dyadic performance (Jagtap & Kamble, 2019) is expected to reflect the degree of contractual differences between buyers and their suppliers (Martinsuo & Ahola, 2010; Meng, 2010). Moreover, extant literature suggests that contractual and relational governance of dyadic relationships plays crucial roles in the interactions involved, establishment of mutual dependencies, and ultimately the direction and control of performance (Belhadi et al., 2021; Öberg et al., 2020).

To develop our model, and understand its hypothesized relationships, we mainly draw on prior SCI research. However, our project-based context necessitates adaptation of existing SCI concepts and scales in accordance with the supply chains involved. SCI activities in standardized production in manufacturing industry contexts are typically intended to promote standardization to smooth information and material flows across supply chains, while those in project-based industries often involve closer collaboration and joint problem-solving (van Donk & van der Vaart, 2004). Hence, to complement current knowledge on SCI (traditionally studied in standardized production-based manufacturing contexts), we reviewed research on project governance (Ahola et al., 2014; Caldwell et al., 2017; Guo et al., 2014; Kivilä et al., 2017) and buyer-supplier integration (often referred to as partnering) in project-based supply chains (e.g., Eriksson, 2015; Martinsuo & Ahola, 2010).

2.2. The key concepts of the model

2.2.1. Project performance

Prior SCI studies have mostly focused on manufacturing companies, assessing operational performance at the firm level, in terms of time, cost, and quality (Ataseven & Nair, 2017; Liu et al., 2016; Wiengarten et al., 2019). Traditionally, these three criteria, which form the so-called 'iron triangle', have also been the most prominent aspects addressed in assessments of projects' performance and success (Bukoye et al., 2022; Ika & Pinto, 2022; Oliveira & Lumineau, 2017). However, some authors have regarded the iron triangle as insufficient, and recognized a need to include other criteria when assessing project performance (Ika &, Pinto, 2022), such as client satisfaction (Shenhar et al., 2001) and relational or team success (Müller & Turner, 2007). Much of this criticism refers to governance focused on meeting short-term goals rather than using broader performance measures to learn, diagnose and foresee difficulties (Speklé et al., 2021). Shenhar et al. (2001) demonstrated that project success dimensions depend on project type, typically including the level of technological uncertainty. Furthermore, they found that assessments of projects with a low degree of technological uncertainty (e.g., infrastructure and civil engineering projects) traditionally rely on narrow performance measures of efficiency and meeting client requirements, whereas assessments of projects with high degrees of technological uncertainty often incorporate long-term perspectives (Shenhar et al., 2001). Accordingly, performance in the focal project-based context is generally measured in terms of the three independent but narrow dimensions of *time, cost*, and *quality* (Eriksson & Westerberg, 2011; Larsson et al., 2015; Shenhar et al., 2001).

2.2.2. Governance through supply chain integration (SCI)

Contractual and relational elements of governance strongly shape the nature of relationships between parties (Benítez-Ávila et al., 2018; Roehrich, 2009) in supply chains. One of the challenges of any inter-organizational dyad is to reach agreed contractual aims despite the often divergent nature of the organizations (Oliveira & Lumineau, 2017), and hence a need for coordination as well as collaboration. However, many empirical studies implicitly address both coordinative and collaborative SCI in their scales, without distinguishing between them or addressing their interconnections. In contrast, we follow calls by Chang et al. (2016) and Wiengarten et al. (2014) to distinguish, explicitly, between coordinative and collaborative SCI, and measure both their direct and indirect effects.

Whereas coordination is "*the process of managing interdependence and fitting together different activities*" (Gkeredakis, 2014: p. 1473), *coordinative SCI* may be defined as operational activities focused on information exchange to coordinate flows of materials and equipment, deployments of human resources, and activities (Mackelprang et al., 2014; Wiengarten & Longoni, 2015). Coordinative SCI refers to formalized tangible activities that play important roles in operative interaction, communication and information-sharing among partners (Gulati et al., 2012; Guo et al., 2014; Kim & Schoenherr, 2018; Zhang, Zhang, Gao & Ding, 2016). It is characterized by formal contractual compliance (Ho et al., 2002), and is thus related to what governance scholars have labeled the coordination function of contractual governance (Malhotra & Lumineau, 2011; Roehrich et al., 2020; Schepker et al., 2014). More specifically, the coordination function of contractual governance "*emphasizes delineation of roles/responsibilities, communication and information sharing*" (Roehrich et al., 2020: p. 458) and is therefore similar to coordinative SCI.

In project-based contexts, coordinative activities are contractual governance mechanisms (Oliveira & Lumineau, 2017), often referred to as partnering tools, which are supply chain participants' formal activities to 'engineer' the foundations for communication, information-sharing, and coordination of their goals and actions (Bresnen & Marshall, 2002; Bukoye et al., 2022; Nilsson Vestola & Eriksson, 2023). Common examples include initial workshops for the formulation of joint goals, continuous follow-up meetings to discuss progress and focus efforts on joint goals, assessment of measurable improvements, establishment of a joint project office to enhance face-to-face communication, and formal meetings for joint risk management (Bayliss et al., 2004; Cheung et al., 2003; Eriksson & Westerberg, 2011; Kadefors, 2004).

Collaborative SCI can be defined as "*the degree to which a manufacturer strategically collaborates with its supply chain partners and collaboratively manages intra- and inter-organizational processes*" (Flynn et al., 2010: p. 59). It consists of more strategic activities that involve "*shared action to improve processes and exploit resource complementarities, allowing partners to benefit from each other's knowledge bases by jointly creating new knowledge and innovations*" (Wiengarten et al., 2014: p. 52). Furthermore, collaborative SCI is characterized by voluntary collaboration and governance by relational means (Ho et al., 2002). It is thus similar to what governance scholars have labeled relational governance (Cao & Lumineau, 2015), referring to strategic processes in which the partners work collaboratively (Gimenez et al., 2012; Haq et al., 2019). The core of collaborative SCI is joint work in strategic processes, such as decision-making, product development, and problem-solving (Kim & Schoenherr, 2018; Mackelprang et al., 2014; van der Vaart et al., 2012; Wiengarten & Longoni, 2015). Some scholars have also highlighted the importance of trust and actors refraining from behaving opportunistically at each other's expense in supply chain collaboration (Cao & Lumineau, 2015; Cerić et al., 2021; Gulati et al., 2012; Vukomanović et al., 2021; Wong et al., 2017).

A few project studies on partnering have distinguished informal and emergent aspects of partnering (similar to collaborative SCI) from the more formal engineered tools of partnering (similar to coordinative SCI) (Bresnen & Marshall, 2002; Nilsson Vestola & Eriksson, 2023). Some of the relational aspects that often emerge during a collaborative project are joint decision-making and problem-solving in design and production processes (Bygballe & Swärd, 2019; Eriksson et al., 2017), as well as trust-building to deter opportunism and enhance joint conflict management (Bonomi Santos & Cabral, 2022; Kadefors, 2004). Prior research highlights the importance of combining engineered and emerged practices but there is little understanding of how these two inherently different aspects of partnering interplay and affect project performance (Bresnen & Marshall, 2002; Nilsson Vestola & Eriksson, 2023).

2.2.3. Project complexity

Project complexity is important in practice because it influences project governance (Crawford & Pollack, 2004). Project complexity is typically treated as a multi-dimensional concept (Baccarini, 1996; Bakhshi et al., 2016; Geraldi et al., 2011; He et al., 2015; Maylor et al., 2008). The most prominent aspects are technical and organizational (Nguyen, Le-Hoai, Tran, Dang & Nguyen, 2019; Vidal et al., 2011). Baccarini (1996: p. 202) proposed that project complexity consists "*of many varied interrelated parts' and can be operationalized in terms of differentiation and interdependency*" and is best managed by integration of actors and their competences.

Technical complexity includes the diversity of applied technologies (Baccarini, 1996; Maylor et al., 2008; Nguyen et al., 2019), and the interdependencies among tasks and technologies needed to complete a delivered system (Baccarini, 1996; He et al., 2015). Most projects involve application of technologies, some more advanced than others. Business projects in project-based contexts (e.g., infrastructure, civil engineering, shipbuilding) can thus vary in complexity (Bakhshi et al., 2016). For example, large infrastructure projects are often characterized by high complexity, high customization, joint produced by multiple actors, and high variability of cost and time performance (Love et al., 2021; Patrucco et al., 2021). Recent innovative and green technologies have further increased the complexity (He et al., 2015).

Organizational complexity essentially refers to the contextual aspects of projects (Maylor et al., 2008). Organizational complexity incorporates aspects such as numbers of actors and organizations involved, and their relationships (Baccarini, 1996; Gransberg et al., 2013; Maylor et al., 2008). In publicly procured infrastructure projects, the external context and actors are particularly important because "*the structure of participating stakeholders may lead to increased complexity*" from a socio-political perspective (Geraldi et al., 2011: p. 983).

2.3. Presentation of the model and its hypothesized relationships

Based on previous literature, we propose a context-SCI-performance model, graphically illustrated in Fig. 1, with a dyadic perspective of the buyer-supplier relationship (Caldwell et al., 2017; Öberg et al., 2020; Patrucco et al., 2021). Similar to Wiengarten et al. (2014) and Patrucco et al. (2021), we applied SEM to test the model, which includes five hypothetical relationships (H1-H5), to illuminate not only the SCI-performance relationship per se, but also antecedents and interconnections. The five hypotheses are discussed below.

2.3.1. Relationships between complexity and coordinative and collaborative SCI

Complexity increases the need for coordination and joint information processing in a supply chain Gkeredakis (2014); Kim and Schoenherr (2018); van Donk and van der Vaart (2004). In more complex products there are likely to be higher requirements for supply chain partners to share information about many interdependent technical aspects from several organizational sources to reduce information asymmetry and deter opportunistic behavior (Wong et al., 2021). Thus, as complexity rises there are stronger interdependencies and greater needs for coordination of contractual tasks and resources (Eriksson et al., 2017; Gulati et al., 2012; Schepker et al., 2014). Studies on partnering activities in project-based contexts have shown that they are especially

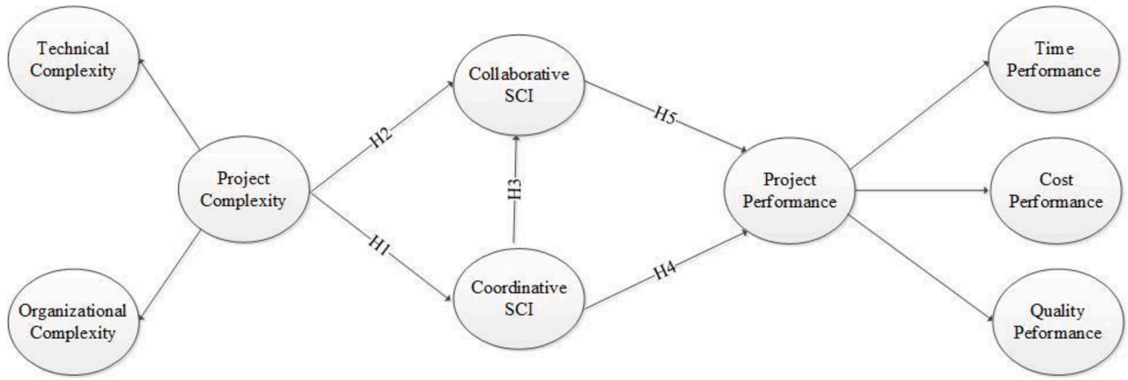

Fig. 1. The conceptual model.

beneficial when projects are facing high complexity (Bayliss et al., 2004; Eriksson, 2015) because the participants must share information to reach a mutual understanding and coordinate their goals and actions to manage joint challenges (Bayliss et al., 2004; Eriksson, 2015). In a project-based context, where every project is unique, project complexity thereby influences the managerial selection of coordinative SCI (Eriksson, 2015; Martinsuo & Ahola, 2010; Williams, 2005). Therefore, we propose that:

H1. Project complexity is positively related to coordinative SCI.

Complexity increases requirements for relational governance mechanisms or features that can handle adjustment (Patrucco et al., 2021). These include trust, which can deter opportunism and thus enable reductions in costly monitoring in complex contractual arrangements (Belhadi et al., 2021). Interdependencies among the subsystems of a complex and customized product require close collaboration between the client and supplier organizations in terms of joint development and problem-solving. Thus, increased complexity tends to increase uncertainty and needs to search for different knowledge sets and different types of expertise. In a project-based context, many studies have shown that collaboration is especially important when complexity is high, in large part due to the need to reconcile different views and knowledge sets (Bonomi Santos & Cabral, 2022; Eriksson et al., 2017). Crawford and Pollack (2004: p. 649) argue that projects with high complexity requires "*a participative and collaborative approach where many different views are sought on many issues and people are encouraged to cross professional boundaries*". Accordingly, project constellations in which the participants regularly interact and collaborate are better at searching for and creating new knowledge when managing complexity and project change (Whyte et al., 2016). This requires the involvement of clients and suppliers in collaborative SCI (Pero et al., 2015). Thus, we propose that:

H2. Project complexity is positively related to collaborative SCI.

2.3.2. *Relationships between coordinative SCI, collaborative SCI and project performance*

As already mentioned, several scholars (e.g., Cao & Lumineau, 2015; Poppo & Zenger, 2002) have studied the interplay between contractual and relational governance, finding that they are complementary rather than mutually exclusive. Generally, contractual mechanisms can be argued to enhance relational governance because "*the coordination function of contracts creates a common knowledge structure, which aids in the development of competence trust*" (Roehrich et al., 2020, p. 458). Furthermore, Malhotra and Lumineau (2011: p. 982), argue that "*coordination-oriented provisions in a contract are aimed at mitigating the risk that misunderstandings will disrupt collaboration*". Moreover, some SCI studies have also addressed the interaction between coordinative and collaborative SCI. Belhadi et al. (2021), for example, found that SCI based on coordination and information-sharing enables joint product and process design. In line with these arguments, Gimenez et al. (2012) claim that increasing coordinative SCI may facilitate collaborative SCI, while Wiengarten and Longoni (2015: p. 148) suggest that "*firms may consider adopting first a coordinative strategy and then build on it to adopt collaborative strategies*". Essentially, coordinative SCI may serve as a platform for collaborative SCI by providing partners with formal contractual mechanisms and activities to get to know each other and learn about each other's capabilities. Subsequently, this mutual knowledge and shared understanding can be used as relational foundations to merge the actors' complementary knowledge sets in joint development and problem-solving efforts in collaborative SCI. In a project-based context, previous studies have found that implementing formal partnering tools can provide platforms for collaboration to emerge in construction projects (e.g., Bayliss et al., 2004; Bygballe & Swärd, 2019). Partnering tools based on structured communication and transparent information sharing also reportedly facilitate trust development and the joint management of conflicts (Cheung et al., 2003; Kadefors, 2004). We therefore propose that:

H3. Coordinative SCI is positively related to collaborative SCI.

A mutual exchange of information about products, processes, and capabilities promotes a shared understanding that can help actors to adjust their plans and delivery to meet changing client requirements (Belhadi et al., 2021). Similarly, Chang et al. (2016) show that information-sharing promotes shared understanding and task coordination, which reduce redundancy and inefficient resource utilization in a supply chain. Accordingly, van der Vaart et al. (2012) have found that coordinative SCI (e.g., information-sharing) enhances performance. Empirical evidence also shows that coordinative SCI that involves information exchange may reduce information asymmetry, and thereby contracting costs (Wiengarten & Longoni, 2015). However, Kim and Schoenherr (2018: p. 45) argue that high levels of complexity incur "*high levels of coordination costs in terms of time, effort, and resources required across organizations, thereby increasing the total transaction costs*". Moreover, excessive coordination activities, stipulated in a contract, may reduce the actors' abilities to engage in other crucial activities for improving performance (Zhao, Feng & Wang, 2015). Therefore, increasing coordination can have negative aspects, which may substantially restrict the benefits of SCI (Chang et al., 2016; Wiengarten et al., 2019; Zhao et al., 2015). However, in a project-based context, several studies have found that implementing formal partnering tools stipulated in a contract can have positive performance effects (e.g., Bayliss et al., 2004; Cheung et al., 2003). Notably, improvements in communication and coordination may help reducing redundancies and improving time and cost efficiency. Consequently, although some scholars highlight the investment costs of implementing partnering tools (Eriksson, 2015), we propose that:

H4. Coordinative SCI is positively related to project performance.

Collaborative SCI has a number of knowledge-related benefits (Wiengarten et al., 2014). First, it enables organizations to access and leverage external complementary and strategic competences from supply chain partners (Wiengarten et al., 2019; Zhao et al., 2015). Thus, a firm may acquire and consolidate strategically critical knowledge through collaborative SCI (Wiengarten & Longoni, 2015). It also enhances synergies, and the creation and application of joint capabilities in collaborative problem-solving and development activities, which can improve performance (Wiengarten & Longoni, 2015; Wiengarten et al., 2019). Zhao et al. (2015) claim that collaborative interaction provides supply chain partners with opportunities to improve product design and shorten production planning times, which allows suppliers to create greater value by efficiently providing clients with products that satisfy their needs. Therefore, collaborative SCI, involving relational governance based on mutual trust and understanding, can reduce opportunism and conflicts (Wiengarten & Longoni, 2015; Zhang & Huo, 2013). In a project-based context, some studies, e.g. Eriksson et al. (2017) have verified the performance benefits of improved collaboration. Furthermore, some authors have highlighted the importance of the emergence of informal collaboration for the success of partnering projects (Bresnen & Marshall, 2002; Nilsson Vestola & Eriksson, 2023). Thus, we propose that:

H5. Collaborative SCI is positively related to project performance.

3. Research method

3.1. Sample and data collection

The infrastructure sector is a typical project-based context (Eriksson et al., 2017; Pero et al., 2015), often involving large and complex endeavors that are vital for sustainable development of any society, so elucidation of the actors' relationships and their impacts on performance is highly important for both practical and theoretical reasons. This paper is based on a survey of participants of infrastructure projects procured and managed by the Swedish Transport Administration (STA), focusing particularly on early phases of the projects. We chose the STA because it is the major public client of infrastructure (road and railway) investments in Sweden, and thus often serves as a benchmark that affects other (public) clients in this sector, both domestic and international. Restriction to these projects also reduced confounding factors associated with differences in country, industry, and organization by collecting data on projects involving just one client organization, thereby increasing the focus on project-level differences. Prior project studies have focused on buyer-supplier relationships during the production phase (i.e., client-contractor relationships) (Eriksson, 2015; Patrucco et al., 2021). However, there is a lack of studies on the early planning and design stages of infrastructure projects (Eriksson et al., 2017), in which a private engineering consultant and the public client jointly define and design the product, and hence have strong opportunities to affect performance.

Flynn et al. (2018) highlight limitations of the single-source research design frequently used and emphasize the need for more multiple-source surveys of supply chains. Due to the dyadic nature of our constructs, we follow this call for multiple-source data. While most studies have addressed the SCI-performance relationship by examining each side of the relationship (e.g., Danese et al., 2020), we follow a fully dyadic relationship approach, similar to one applied by Patrucco et al. (2021). Consequently, we targeted project managers in both the public client and the private consultant organizations as key informants because they are deemed most knowledgeable of critical project aspects in terms of complexity, integration, and performance.

Our initial sampling covered all of STA's consultancy contracts procured in the period 2014–2018 for road and railway projects (203 in total). Following validation, 13 projects were omitted due to lack of contact information, no contract being awarded, or a too recent project start that prohibited collection of pertinent data. In the first data collection step (starting in October 2018), questionnaires were sent to all 190 identified client project managers. After two reminders, 127 responses were received. In total, 14 were omitted due to missing data, leaving 113 completed responses, representing a response rate of 59% for the client project managers. In the second step (starting in January 2019), questionnaires were distributed to the 113 corresponding consultant project managers and after two reminders, a total of 102 completed consultant responses were received, representing a response rate of 90%. Thus, in total 215 completed responses were received, representing an overall response rate of 71%. However, as we wanted to study projects with responses from both sides of the supply chain dyad (client and consultant), this paper is based on 204 matched responses regarding 102 infrastructure projects, all involving a public-private relationship between the client (STA) and one private consultant organization. Most targeted consultant organizations are well-regarded domestic organizations that have past relationships with the public client, which reduces the confounding factors associated with differences in relationship history.

The respondents had extensive work experience of road/railway projects and the project manager's role. Most (81% of the clients and 85% of the consultants) had worked for more than six years on road/railway projects, and as a project manager (73% of the clients and 68% of the consultants). The 102 infrastructure projects varied in content, complexity, and size (Table 1).

The 102 client-consultant dyads were governed by similar standardized consultancy contracts based on fixed price or cost reimbursement. The contract work involved early planning, development, and design work, as well as preparation of tender documents, which provided the basis for the subsequent procurement for the construction phase. For example, the core content of the consultancy services may include environmental planning and preliminary design of system solutions in road and railway plans, as well as detailed designs prescribed in tender documents. Railway projects are often large and time-consuming investment projects or involve the reconstruction of relatively long tracks. Consequently, they are generally larger than road projects, which more often involve small amounts of reconstruction work. In monetary terms the size of the contracts varied between 0.1 and 70 million USD, with average values of the road and rail consultancy contracts of 3 and 11 million USD, respectively.

3.2. Operationalizations and scales

Overall, our measurement scales were conceptually inspired by, and to some extent explicitly derived from, prior firm-level SCI surveys. Following Schoenherr and Swink (2012), we developed the scales through close collaboration with practicing managers (at STA) in efforts to maximize both theoretical grounding and the ability to obtain adequate answers from both sides of the dyads. This approach was particularly important due to the lack of previous quantitative project-level SCI studies focused on early phases of infrastructure

Table 1
Project descriptions.

	Frequency	Percent
Type of project		
Road	52	51%
Railway	50	49%
Contractual reward system		
Cost reimbursement	49	48%
Fixed price	53	52%
Project size (million USD)		
0–2 (small projects)	61	60%
>2 (large projects)	41	40%
Change orders		
Yes	21	21%
No	81	79%

investments. To ensure practical relevance and detect potential ambiguities, a preliminary version of the questionnaire was piloted with six project and procurement managers from STA, which resulted in some minor revisions. All of the measures in the tested model were based on five-point Likert scales, but the anchors differed across scales to reduce the risk of common method bias. All scales and their items, as well as the sources that they are inspired by or adapted from, are presented in Appendix A.

Besides the measures used in the tested model, we also added three control variables to check the model's robustness. The chosen control variables are operationalized by project size (large versus small), reward system (fixed cost versus cost reimbursement), and the inclusion or non-inclusion of change orders (reflecting unforeseen customizations and defective deliveries). If inclusion of the control variables significantly affects the model, they apparently influence the dyadic relationships and thus warrant further attention.

3.3. Data analysis

To enable adequate tests of differences in responses of our two groups of respondents (client and consultant project managers), we assessed measurement properties using a multi-group SEM approach (Pesämaa et al., 2018; Zhang et al., 2016). Specifically, we calculated Goodness-of-Fit statistics, including Chi-square statistics with associated p-values, as well as Comparative Fit Index (CFI) and Root Mean Square Error of Approximation (RMSEA) values. We closely examined the Chi-square statistics to check the equivalence between the groups (Pesämaa et al., 2018), and thus validity of the comparisons. We also assessed the entire model's Goodness-of-Fit (Wiengarten et al., 2014; Zhang & Huo, 2013) with the following thresholds for satisfactory fit: CFI > 0.90, and both SRMR and RMSEA < 0.08. Following Pesämaa et al. (2018), we tested the measurement equivalence of an unconstrained model and a model where each parameter (i.e., loadings, second-order structural paths, and inter-correlations) was constrained to be equal. The first criterion ensured that a model with Chi-square differences could be rejected, highly sensitively (with a $p > 0.0005$ threshold). We also assessed the measurement properties by examining the model's convergent validity, discriminant validity, Cronbach's alpha, and composite reliability. To test the validity of the two respondent groups, we used a maximum likelihood estimation implemented in SPSS AMOS version 24.0. A confirmatory measurement model was tested to establish an equivalent model for both groups simultaneously. The subsequent model tests the structural order.

To improve face validity, we offered practitioners the opportunity to assess our entire model and concepts by presenting and discussing preliminary results at two workshops: in June 2019 for 10 procurement managers at STA, and in October 2019 for 16 client and consultant representatives. These workshops provided valuable learning opportunities that strengthened our practical understanding and interpretation of the statistical results, including their potential utility for clients and consultants in infrastructure projects.

3.4. Test of equivalence across groups and confirmatory factor analysis

The conceptual model contains nine latent constructs, including two second-order constructs. As it is relatively complex, between-group equivalence was tested by examining the major components separately and across both respondent groups. Initial tests of the entire unconstrained model indicated that the proposed baseline model has acceptable fit and is well represented by the data, with Goodness-of-Fit meeting our criteria: $\chi2= 799.656$, df=438, p=0.000, $\chi2/DF=1.826$, CFI=0.910, RMSEA=0.064 (see Table 2, Model 1).

Next, all loadings of the first order constructs were constrained to be equivalent across client and consultant groups (Table 2, Model 2). The difference test indicates that loadings of first order constructs are equivalent (p>0.0005). Therefore, Model 2 replaced Model 1 as the baseline model. The model rejects differences at the p<0.001 level, which is marginal but sufficient given the model's complexity. Next, loadings of the first and second-order constructs were constrained to be equal (Table 2, Model 3). Comparison of Model 2 vs Model 3 showed that differences can be rejected (p>0.000) and the loadings of first and second-order constructs are equivalent. Therefore, Model 3 became the baseline model. Finally, all constructs were inter-correlated and constrained to be equal across both groups. Our final model (Table 2, Model 4) also rejects between-group differences (p = 0.013). Measurement properties and inter-correlations between measurements are thus assumed to be equivalent across clients and consultants. Hence, both groups can be adequately compared and none of the minor measurement differences are fundamental.

3.5. Measurement property testing

The measurement invariance testing was followed by an examination of the individual measurement properties of the two second-order constructs and seven first order constructs across both respondent groups (see Table 3). Once equivalence had been established, we assumed that we could merge responses of clients and consultants to explore dyadic properties at a project level.

Each second-order construct is represented with a loading that is similar to a structural path, which is denoted with a γ symbol and number (γ_{1-5}) in Table 3. Project performance is represented by the three dimensions of time, cost, and quality, which converge well with the proposed theoretical construct across both groups of respondents (with 0.85–0.95 loadings for both groups). Loadings of the dyadic properties varied between 0.90 and 0.96. Table 3 also shows that both dimensions of project complexity (technical and organizational) converge well with the proposed theoretical construct (with 0.71–0.95

Table 3
Loadings of second-order constructs for clients, consultants, and projects.

Constructs	Clients	Consultants	Projects
Project performance			
γ_1: Time	0.95	0.94	0.96
γ_2: Cost	0.88	0,95	0.93
γ_3: Quality	0.90	0.85	0.90
Composite Reliability	0.92	0.93	0.94
AVE	83%	84%	0.87
Project complexity			
γ_4: Technical complexity	0.94	0.71	0.95
γ_5: Organizational complexity	0.95	0.95	0.85
Composite Reliability	0.94	0.77	0.88
AVE	89%	70%	0.81

Table 2
Goodness-of-fit and model comparison across client and consultants.

Model	Goodness-of-Fit of the models						Model comparison		
	χ^2	D.F	p-value	χ^2/D.F	CFI	RMSEA	Δ df	$\Delta\chi^2$	p-value
Model 1: Unconstrained	799	438	0.000	1.826	0.91	0.064			
Model 2: loadings first order constructs constrained	840	454	0.000	1.85	0.91	0.064	16	40.4	0.001
Model 3: loadings first and second-order constructs constrained	855	457	0.000	1.87	0.90	0.065	3	15.7	0.001
Model 4: Loadings first and second-order constructs and inter-correlations constrained	878	467	0.000	1.88	0.90	0.066	10	22.5	0.013

loadings for both groups, and 0.85–0.95 for the dyadic properties. Thus, all loadings exceeded the threshold for satisfactory convergence, 0.60, recommended by Pesämaa et al. (2021). This also ensured that average variance extracted (AVE) and composite reliability met the recommended thresholds of 0.50 and 0.60, respectively.

Table 4 presents the loadings for our seven first order latent constructs, each covered by three to five items. The entire model is based on 23 items, each represented here by a λ symbol and number. Summarizing Table 4, the loadings for all items converge well and vary between 0.63 and 0.96 for the client and consultant groups. Again, all loadings exceed the 0.60 threshold recommended by Pesämaa et al. (2021), and this also ensured that AVE and composite reliability meet the recommended thresholds of 0.50 and 0.60, respectively.

All AVE values for the four main constructs exceed 0.5 (Table 4). This indicates that most of the variance in each construct is explained by the common underlying factor rather than the measurement error. Furthermore, the AVE values of the model exceed the squared inter-correlations associated with the underlying constructs. In addition, all inter-correlations are lower than 0.90, so discriminant validity is apparently satisfactory, and AVE values exceed the highest squared inter-correlations associated with the underlying constructs (Table 5).

The conclusion from the confirmatory factor analysis (CFA) is that all of the latent constructs have satisfactory loadings (exceeding 0.60) and are well balanced across both respondent groups, as well as within each construct. In addition, AVE and composite reliability are all within recommended levels.

Table 4
Measurement properties (loadings) for the first order constructs.

Time performance	Clients	Consultants	Project
λ_1: Time1	0.86	0.73	0.87
λ_2: Time2	0.89	0.78	0.88
λ_3: Time3	0.92	0.85	0.92
Composite Reliability	0.90	0.75	0.90
AVE	0.79	0.62	0.79
Cost performance			
λ_4: Cost1	0.82	0.63	0.80
λ_5: Cost2	0.78	0.73	0.83
λ_6: Cost3	0.89	0.85	0.90
Composite Reliability	0.82	0.67	0.84
AVE	0.69	0.55	0.72
Quality performance			
λ_7: Quality 1	0.88	0.73	0.87
λ_8: Quality 2	0.79	0.69	0.81
λ_9: Quality 3	0.83	0.75	0.82
Composite Reliability	0.83	0.63	0.83
AVE	0.70	0.52	0.69
Technical complexity			
λ_{10}: Technical complexity 1	0.87	0.91	0.89
λ_{11}: Technical complexity 2	0.91	0.86	0.93
λ_{12}: Technical complexity 3	0.85	0.63	0.83
Composite Reliability	0.88	0.79	0.90
AVE	0.77	0.65	0.79
Organizational complexity			
λ_{13}: Organizational complexity 1	0.88	0.64	0.85
λ_{14}: Organizational complexity 2	0.71	0.77	0.83
λ_{15}: Organizational complexity 3	0.81	0.78	0.85
Composite Reliability	0.78	0.65	0.84
AVE	0.64	0.54	0.71
Coordinative SCI			
λ_{16}: Coordinative SCI 1	0.83	0.75	0.85
λ_{17}: Coordinative SCI 2	0.73	0.59	0.68
λ_{18}: Coordinative SCI 3	0.86	0.75	0.82
λ_{19}: Coordinative SCI 4	0.83	0.81	0.86
Composite Reliability	0.84	0.71	0.82
AVE	0.66	0.53	0.65
Collaborative SCI			
λ_{20}: Collaborative SCI 1	0.95	0.77	0.92
λ_{21}: Collaborative SCI 2	0.91	0.85	0.91
λ_{22}: Collaborative SCI 3	0.89	0.84	0.94
λ_{23}: Collaborative SCI 4	0.88	0.83	0.96
Composite Reliability	0.94	0.85	0.96
AVE	0.82	0.68	0.87

Table 5
Inter-correlations, squared correlations and AVE for dyads (project-level).

Construct	1	2	3	4
1. Project complexity	0.81	*0.37*	*0.01*	*0.03*
2. Coordinative SCI	0.37*	0.65	*0.27*	*0.23*
3. Collaborative SCI	−0.08	0.52**	0.87	*0.59*
4. Project performance	0.16	0.48**	0.77**	0.87

** $p<0.001$;.
* $p<0.05$; AVE bold values along the diagonal; italic coefficients squared correlations.

4. Results

The proposed dyadic model has distinct measurement properties for two second-order constructs (project complexity and project performance) and the full model has nine latent constructs and 23 variables. The measurement properties have already been summarized in the method section, so here we only report results regarding the hypothetical relationships (H1–H5). SEM also allows tests for multiple dependent constructs and although two (coordinative SCI and collaborative SCI) are depicted (see Fig. 1) as mediators, the output treats them as dependent constructs. By testing potential effects of the three project control variables (inclusion versus non-inclusion of change orders, small versus large projects, and fixed price versus cost reimbursement) not only on project performance but also on coordinative SCI and collaborative SCI, the robustness of the model is further tested.

As shown in Table 6, the four models explain 15.40–23.40% of the variance in coordinative SCI, 37.40–46.90% of the variance in collaborative SCI, and 58.20–61.30% of the variance in project performance.

Table 6 also presents data regarding the hypotheses and mediation summarized in this and the following paragraph. H1 (project complexity is positively related to coordinative SCI) is strongly supported by the entire sample (Model 1: $\beta = 0.40$, $p<0.001$). When adding the three control variables (inclusion versus non-inclusion of change orders, small versus large projects, and fixed price versus cost reimbursement), H1 remains significant, and the relationship is robust (Models 2–4: $\beta =$ 0.32–0.40, $p<0.01$). Regarding H2, contrary to the hypothesis that project complexity is positively related to collaborative SCI, the data show that it is negatively related to collaborative SCI and thus H2 is rejected (Model 1: $\beta = -0.34$, $p<0.001$). When adding the three controls, the significant negative relationship remains robust (Models 2–4: $\beta =$ - 0.34–0.36, $p<0.001$). The hypothesis that coordinative SCI is positively related to collaborative SCI (H3) is strongly supported by the entire sample (Model 1: $\beta= 0.66$, $p<0.01$). When adding the three controls, H3 remains significant, and the relationship is robust (Models 2–4: $\beta =$ 0.55–0.66, $p<0.001$). However, the hypothesis that coordinative SCI is positively related to project performance (H4) is rejected by the entire sample ($\beta = 0.12$, $p>0.05$). When adding the three controls, the weak and insignificant relationship remains (Models 2–4: $\beta =$ 0.06–0.13, $p>0.05$). Finally, the hypothesis that collaborative SCI is positively related to project performance (H5) is strongly supported by the entire sample ($\beta = 0.71$, $p<0.001$). When adding the three controls, H5 remains significant, and the relationship is robust (Models 2–4: $\beta=$ 0.70–0.71, $p<0.001$).

In the search for mediation, we followed Cheung's (2009) suggestion to test indirect effects instead of the traditional test of adding and removing variables. Table 6 shows that coordinative SCI has significant indirect effects on project performance ($\beta = 0.47$, $p<0.01$). This indirect relationship also remains robust when adding controls. However, the expected indirect effect of complexity on project performance is insignificant and weak ($\beta = -0.11$, $p>0.05$) and remains so when adding controls. Note that although control variables only have marginal additional effects on individual coefficients, the results show that

Table 6
Models for testing the hypothesized relationships.

Parameter	Model 1	Model 2	Model 3	Model 4
H1: Complexity–> Coordinative SCI (supported)	0.40***	0.39***	0.32*	0.40***
H2: Complexity–> Collaborative SCI (rejected)	−0.34***	−0.34***	−0.36***	−0.34***
H3: Coordinative SCI–> Collaborative SCI (supported)	0.66***	0.66***	0.66***	0.55***
H4: Coordinative SCI–> Project performance (rejected)	0.12N.S	0.06N.S	0.13N.S	0.11N.S
H5: Collaborative SCI–> Project performance (supported)	0.71***	0.70***	0.70***	0.71***
Control variables				
Change orders		−0.10N.S	−0.29**	−0.31***
Large projects		0.10N.S	0.13N.S	−0.02N.S
Fixed price		−0.20**	−0.15N.S	−0.32***
Indirect effects				
Complexity –> Coordinative SCI –> Collaborative SCI	0.26**	0.26**	0.21*	0.22**
Complexity–> Coordinative SCI; Collaborative SCI –> Project performance	−0.11N.S	0.03N.S	−0.06N.S	−0.05N.S
Coordinative SCI –> Collaborative SCI –> Project performance	0.47**	0.46**	0.47**	0.39**
R-square Coordinative SCI	15.70%	15.40%	23.40%	15.70%
R-square Collaborative SCI	37.40%	37.50%	41.30%	46.90%
R-square Project performance	61.10%	59.50%	61.30%	58.20%
$\chi2$/D.F.	1.91	1.97	1.96	1.91
p-value	0.000	0.000	0.000	0.000
CFI	0.91	0.90	0.90	0.91
RMSEA	0.09	0.09	0.09	0.09
SRMR	0.07	0.07	0.07	0.07

*** $p<0.001$;.
** $p<0.01$;.
* $p<0.05$
DV is performance in all models; Model 2 controls added to performance; Model 3 controls added to coordinative SCI; Model 4 controls added to collaborative SCI.

inclusion of change orders negatively affects both coordinative SCI (Model 3) and collaborative SCI (Model 4). Furthermore, adding the size variable (large versus small projects) has no significant effect on any of the models. However, the results show that a reward system based on fixed price (rather than cost reimbursement) negatively affects both project performance (Model 2) and collaborative SCI (Model 4).

We also addressed potential endogeneity issues related to the model and its hypotheses. As the model is based on cross-sectional data, one could argue that project performance may potentially be a major determinant of complexity, because complexity could potentially be handled better in well-coordinated projects with high performance than in projects with poorer performance). To test these endogeneity concerns, we reversed the relationships from performance to complexity and found they were non-significant.

5. Concluding discussion

5.1. Overall results

In their recent literature review, Danese et al. (2020) found a lack of mediation studies that treat variables of the supply chain environment (e.g., complexity) as antecedents to SCI. Our study is based on the argument that complexity in project-based contexts is an important antecedent at the project level, affecting governance arrangements in terms of SCI. To strengthen the project-level focus, we minimized potential confounding effects on SCI of variations in country, industry, and organization by following recommendations of Patrucco et al. (2021), collecting data on projects involving a single client organization (specifically, all of STA's consultancy contracts procured in 2014–2018). Our project-level mediation model illuminates how the interplay between contractual and relational governance (Benítez-Ávila et al., 2018; Haq et al., 2019; Roehrich, 2009) in terms of coordinative and collaborative SCI mediates the effect of complexity on project performance.

Furthermore, we followed the call by Flynn et al. (2018) and collected data from multiple sources, which resulted in 204 matched (dyadic) responses of client and consultant project managers who participated in 102 Swedish infrastructure projects. Our multiple-source data allowed us to apply a multi-group approach, following Pesämaa et al. (2018), to validate clients' and consultants' responses and establish acceptable measurement equivalence across both groups. We further verified our model and the central role of SCI in a project-based context by following a dyadic approach (Belhadi et al., 2021; Jagtap & Kamble, 2019; Öberg et al., 2020; Patrucco et al., 2021). Our novel approach of testing the proposed model separately for clients and consultants, and using a matched project-level dyadic sample, has allowed us to contribute to both theory and practice, as discussed below.

5.2. Theoretical contributions

This paper contributes to the literature on project governance and dyadic relationships (Caldwell et al., 2017; Öberg et al., 2020; Patrucco et al., 2021) in three ways related to our three main concepts of complexity, SCI, and performance. Starting with complexity, our research extends findings of Gimenez et al. (2012) who argued that (industry-level) complexity is a critical contextual factor of SCI, explaining variations in SCI across industries. Accordingly, comparative studies have shown that SCI is more important in project-based contexts than in traditional manufacturing contexts (Gimenez et al., 2012; van Donk & van der Vaart, 2004). Although interesting, these results do not give managerial guidance on how to govern complexity within a particular industry. In contrast, our study shows that project governance through SCI should be adapted to the degree of complexity (Gulati et al., 2012) within a project-based context. Our first theoretical contribution is therefore to the stream of project governance literature that emphasizes that unique project characteristics require tailored governance arrangements (Ahola et al., 2014). By treating complexity as a project-level antecedent to SCI, we shed further light on how governance may be tailored to project characteristics, hence explaining variations in SCI across projects. Furthermore, we also enhance existing knowledge on the role of complexity, by postulating that project complexity is a two-dimensional (technical and organizational) antecedent that affects SCI directly and performance indirectly. Hence, project governance in terms of coordinative and collaborative SCI should be adapted to project-specific degrees of technical and organizational complexity.

Second, we contribute to previous governance studies (e.g., Cao & Lumineau, 2015; Haq et al., 2019) arguing that there are interconnections between contractual and relational governance, and that they are complementary and interplay. To illuminate this interplay and extend prior understanding of how contractual and relational governance affect each other in a complementary way (Cao & Lumineau, 2015; Cerić et al., 2021), we followed Wiengarten et al. (2014) by distinguishing between coordinative and collaborative SCI. Our findings verify that the coordinative and collaborative dimensions of SCI have differing natures, antecedents, and effects. Thus, they should be jointly managed as two separate but interconnected governance mechanisms. In terms of antecedents, coordinative SCI is more strongly connected to managerial choices than collaborative SCI. Our project governance perspective has also illuminated the nature of these two dimensions. Prior partnering studies have emphasized the importance of distinguishing between formal engineering of integration (i.e., coordinative SCI) and informal emerging integration (i.e., collaborative SCI) (Bresnen & Marshall, 2002; Nilsson Vestola & Eriksson, 2023). Our findings contribute to this discussion by highlighting the interplay between the two SCI dimensions and their symbiotic relationship, showing that formal coordinative SCI (related to contractual governance) can be engineered by project management to facilitate the emergence of more informal collaboration (related to relational governance).

Third, our main theoretical contribution addresses the lack of understanding of how the interplay between contractual and relational governance affects performance (Roehrich et al., 2020). Our novel measurement of indirect effects indicates that coordinative SCI facilitates collaborative SCI, which in turn enhances project performance. This implies that the scarcity of analyses of interconnections between SCI processes, as highlighted by Chang et al. (2016) and Gimenez et al. (2012), is a potential reason for the mixed performance results in previous SCI studies. If one process dimension only affects performance indirectly, through another dimension, then it may appear to be non-significant if indirect effects are not considered. Our findings therefore verify that the interplay between contractual and relational governance improves performance much more than the two governance mechanisms do individually.

5.3. Managerial implications

Our findings provide project managers with more explicit knowledge of how complexity may be governed by tailoring SCI activities to the project's complexity level. Our operationalization of technical and organizational complexity also indicates which aspects that managers need to analyze and understand to grasp the complexity level of the project. Depending on the perceived complexity level, a client can then formally stipulate the terms regarding information-sharing and coordination in tendering documents and contracts. Thus, contractual governance based on formal coordinative SCI activities can be engineered by the client by assessing the level of complexity; the higher the complexity, the more coordinative SCI activities should be stipulated in the contract. However, it is important to point out that coordinative SCI does not improve project performance in a direct way. It is therefore not sufficient to only rely on contractual governance by stipulating coordination in the contract. On the contrary, contractual governance through coordinative SCI should only be seen as a first step, setting the stage for collaborative SCI to emerge. However, if coordinative SCI is absent, collaborative SCI will have smaller possibilities to emerge. Managed together in a symbiotic way, contractual and relational governance based on coordinative and collaborative SCI will facilitate improvements in project performance. Project managers can thereby adapt their SCI practices to their respective projects by harnessing the symbiotic relationship of engineered coordination and emerged collaboration.

5.4. Further research

This study may inspire future studies to help shed light on other gaps in knowledge of the relationships between project governance and project performance. First, we encourage scholars to adjust the antecedent variable(s) to investigate if managerial choices of SCI activities may be influenced by other contextual factors besides complexity. Second, similar multi-sources studies that distinguish between coordinative and collaborative SCI in other project-based contexts would be valuable for determining if the relationships between variables are similar or differ across contexts.

Declaration of Competing Interest

None.

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Appendix A

Project performance – Adopted from Rijsdijk and van den Ende (2011) and Larsson et al. (2015) with minor adjustments	
λ_1: Time1 – I would say that this project was characterized by time efficiency	(1=Never, to 5=Always)
λ_2: Time2 - Given the expectations I would say that the project proceeded as planned in terms of time schedule	(1=Worse than expected, to 5=Better than expected)
λ_3: Time3 - In comparison with similar projects, I would say that this project is an example of time efficiency	(1=much worse, to 5=much better)
$\lambda 4$: Cost1 - I would say that this project was characterized by cost efficiency	(1=Never, to 5=Always)
λ_5: Cost2 - Given the expectations I would say that the project kept within budgeted cost frames	(1=Worse than expected, to 5=Better than expected)
λ_6: Cost3 -In comparison with similar projects, I would say that this project is an example of cost efficiency	(1=much worse, to 5=much better)
$\lambda 7$: Quality 1 - I would say that this project was characterized by strong quality focus	(1=Never, to 5=Always)
λ_8: Quality 2 - Given the expectations, I would say that the project achieved the specified quality	(1=Worse than expected, to 5=Better than expected)
λ_9: Quality 3 – In comparison with similar projects, I would say that this project exemplifies high quality	(1=Much worse, to 5=much better)
Project complexity – *Technical complexity inspired by* Maylor et al. (2008) *and* Vidal et al. (2011). *Organizational complexity adopted from* Eriksson et al. (2017)	
λ_{10}: Technical complexity 1 – In this project, the number of advanced technical solutions were	(1=Very few, to 5=Very many)
λ_{11}: Technical complexity 2 – In this project, the number of technically demanding tasks were	(1=Very few, to 5=Very many)
λ_{12}: Technical complexity 3 – In this project, the number of interdependent areas of expertise were	(1=Very few, to 5=Very many)
λ_{13}: Organizational complexity 1 – In this project, the number of participants from both project actors were	(1=Very few, to 5=Very many)
λ_{14}: Organizational complexity 2 – In this project, the number of stakeholders to consider were	(1=Very few, to 5=Very many)
λ_{15}: Organizational complexity 3 – In this project, the number of interdependent goals were	(1=Very few, to 5=Very many)
Coordinative SCI – *Adapted from case study examples from* Bayliss et al. (2004), Cheung et al. (2003), Eriksson (2015), *and from STA's stipulated coordination activities*	
λ_{16}: Coordinative SCI 1 – To what extent have joint goal setting been implemented?	(1=Not at all, to 5=To a very high degree)
λ_{17}: Coordinative SCI 2 – To what extent have joint risk management been implemented?	(1=Not at all, to 5=To a very high degree)
λ_{18}: Coordinative SCI 3 – To what extent have continuous follow-up in coordination meetings been	(1=Not at all, to 5=To a very high degree)
λ_{19}: Coordinative SCI 4 – To what extent have continuous improvement and/or benchmarking been implemented?	(1=Not at all, to 5=To a very high degree)
Collaborative SCI – *Inspired from* Flynn et al. (2016), Gimenez et al. (2012), Ho et al. (2002), van der Vaart et al. (2012)	
λ_{20}: Collaborative SCI 1 – In this project, I felt that we worked together for the best of the project	(1= Totally disagree, to 5=Totally agree)
λ_{21}: Collaborative SCI 2 – In this project, I felt that we resolved disagreements in a constructive way	(1= Totally disagree, to 5=Totally agree)
λ_{22}: Collaborative SCI 3 – In this project, I felt that we were open and showed trust in each other	(1= Totally disagree, to 5=Totally agree)
λ_{23}: Collaborative SCI 4 – In this project, I felt that we collaborated in accordance with my expectations	(1= Totally disagree, to 5=Totally agree)

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