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Construction Contractors in Cross-Industry Innovation Networks: An Interactive Perspective

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Abstract

This licentiate thesis examines the involvement of construction contractors in cross-industry innovation networks aimed at developing digital solutions. While cross-industry innovation has become increasingly relevant in the context of digitalization, few studies have investigated it in construction. Furthermore, in construction, innovation often emerges in projects for problem-solving, but scaling through embedding in more permanent organizational structures is challenging, which hampers renewal in the industry. This calls for a deeper understanding of how the innovation process evolves within the cross-industry network across project, organizational, and industry boundaries.

This study employs the Industrial Network Approach (INA) as theoretical framework and draws on the Activities-Resources-Actors (ARA) model to study how cross-industry innovation emerges through interaction, understood as an ongoing process through which actors mutually adapt by linking activities and combining resources. Accordingly, the aim of this thesis is to explore cross-industry innovation networks in the construction industry. The study pays particular attention to how the role of the construction contractor is shaped through interaction.This research is guided by two research questions: (1) How does interaction unfold in cross-industry innovation networks within and across project, organizational, and industry levels? and (2) How is the role of the construction contractor characterized in innovation processes within cross-industry innovation networks?

A qualitative case study approach is used to examine cross-industry innovation networks. The case study draws on two empirical sub-studies involving a large Swedish construction contractor. The first sub-study, Efficient Load Out (ELO), covers a cross-industry innovation process with the automotive industry to develop an app that optimizes the loading of materials in construction projects. The second sub-study, Smart Vests, examines a cross-industry innovation process involving the technology development industry, aimed at developing smart vests to enhance safety in road construction. Data collection involved 27 semi-structured interviews and site observations. The thesis builds on two appended papers.

The thesis shows that cross-industry innovation in the construction industry is a multi-level, evolving network configuration shaped by temporal and spatial interdependencies. The interaction between actors addresses particular issues across initiation, development, pilot, and scaling phases, where the actors' previous experiences and future expectations of the innovation process affect how they manage interdependencies. Accordingly, a key characteristic of the construction contractor's role, in the form of research and innovation teams, is dynamic role shifting. Also, these teams perform multiple roles simultaneously through diverse boundary-spanning activities aimed at connecting and integrating within and across project, organizational and industry levels. Thus, the construction contractor's role in cross-industry innovation is highly context-dependent, varying in time and space.

Keywords: collaborative innovation, construction contractor, cross-industry innovation, digital innovation, Industrial Network Approach, interaction

Acknowledgements

In true **Industrial Network Approach** fashion, I would like to structure my gratitude using the **ARA (Activity-Resource-Actor) model**, reflecting my PhD network as a process shaped by *actors, resources, and activities.*

Actors
Every network needs its key players, and I've been fortunate to have the best. To my supervisors, **Petra Bosch-Sijtsema**, **Viktoria Sundquist**, thank you both for believing in me, for giving me this opportunity to taking up PhD education! Your guidance and patience have been the steady anchor through this construction (and occasional reconstruction) of ideas. My sincere thanks also go to my examiner, **Frida Lind**. Thank you, **Christina Claesson Jonsson** for your reflections and discussion which have shaped my work. Thank you, **Malena Havenvid**, for your constant support and encouragement and thank you **Lars Erik Gadde** for your guidance and the thought-provoking questions at my research proposal seminar. To my **colleagues at the CME division and fellow PhDs**, thank you for sharing the collective confusion that somehow made this journey feel easier. You all remind me that research may be individual, but survival is a team effort.

Resources
No network thrives without its resources. I am deeply grateful to **SBUF (The development fund of the Swedish construction industry)**, that made this research possible and the foundation on which my 2.5 years and this thesis stands. The academic courses I took along the way were another vital resource, shaping not just my thinking but also my habit of always asking the crucial question: *"So what?"* (sometimes muttered aloud, often at inconvenient hours). And, academic writing itself, thank you **Christine Räisänen** for the course, a skill that simultaneously humbled and empowered me in equal measure.

Activities
Research doesn't happen in isolation; it happens through interaction and collaboration. The **workshops, conferences, and reference group meetings** that I participated in provided spaces, where my ideas were tested, challenged, and rebuilt (occasionally from scratch). I owe much to everyone who shared their insights and questions, and to those who reminded me that "constructive criticism" really can be constructive. As a budding researcher, teaching as an activity has fueled my confidence, and I sincerely thank **Dilek** and **Ahmet** for your support in this journey. Beyond academia, my most cherished activity has been my daily **painting sessions**, my personal "me time" where splashes of color helped drain away the stress and, in their own way, sparked creative connections that I'd later sneak into my research work.

Most important, to my **family and friends**, who have very little idea of what I actually do, or some still make effort to understand it, nevertheless still see value in my work and cheer me on without hesitation thank you. Your love, and unwavering support will always be my favorite kind of network. Finally, I thank myself for being kind to myself, and understanding a core lesson that, doing a PhD is mostly learning to function while confused and calling it "research" 😀! Yet, together these actors, resources, and activities have shaped not just this thesis, but the person I've become, a slightly more seasoned, occasionally sleep-deprived, but endlessly a curious researcher. Onward to the second half of PhD journey where my network continues to grow……

Madhushree Happalad, Gothenburg, February 2026.

List of appended papers

Paper 1:

Happalad, M.M., Bosch Sijtsema, P.M., Claeson Jonsson, C. and Sundquist, V. (2026) Cross-industry innovation: Exploring the dynamics of an innovation network in construction. *Construction Management and Economics*, pp.1-17.

A previous version of this paper, with the title "A collaborative innovation process for a digital solution in infrastructure construction: Dynamics of the innovation network", was co-authored with Petra Bosch-Sijtsema. This paper was peer reviewed and submitted for the 40th annual ARCOM Conference, September 2-4, 2024, London South Bank University, United Kingdom, but was eventually withdrawn from the conference and was not presented at the conference.

Paper 2:

Happalad, M.M., Sundquist,V., Bosch-Sijtsema, P.M., and Havenvid, M. (2026) An interactive perspective on the activities of construction contractors' innovation champions: Boundary spanning in cross-industry innovation networks, *working paper to be submitted to Industrial Marketing Management.*

A previous version of this paper, with the title "An interactive perspective on the activities of innovation champions in contractor organization", was peer reviewed and presented at the 41st annual IMP (The Industrial Marketing and Purchasing Group) conference, August 20-22, 2025, Chalmers University, Gothenburg, Sweden. The paper was co-authored with Malena Havenvid and Viktoria Sundquist. The conference paper has been invited for submission to a special issue of the journal Industrial Marketing Management following the IMP conference and has been developed into a full paper (paper 2).

Another previous version of this paper, with the title "Driving collaborative innovation: activities of innovation champion teams in contractor organization", was peer-reviewed and presented at the 41st annual ARCOM conference, September 1-3, 2025, Abertay University, Dundee, United Kingdom. The paper was co-authored with Petra Bosch-Sijtsema.

The researcher's contributions to the papers

Paper 1:

The idea for paper 1 was jointly developed by all the authors. The initial data collection was conducted by Bosch-Sijtsema and Sundquist and further data collection was carried out by Happalad. Happalad took a leading role in the development of the initial "raw" case description. The analysis was jointly done by Happalad, Bosch-Sijtsema and Sundquist, while supervised and reviewed by Claeson-Jonsson. Although different authors at different times during the processes focused more on certain parts of the manuscript, all researchers shared the writing. Happalad had the responsibility for the journal submission process and correspondence with the editor.

Paper 2:

The idea for the paper 2 was jointly developed by all the authors. The paper is based on two sub-studies. For sub-study one, the initial data collection was carried out Sundquist and Bosch-Sijtsema and further data collection was conducted by Happalad. For sub-study two, Happalad had sole responsibility for data collection. Happalad took a leading role in writing the case which is based on the two sub-studies, empirical analysis and methodology. All authors contributed to the paper's planning, analysis, and writing (irrespective of section). Happalad has the responsibility for the journal submission process and correspondence with the editor.

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1. Introduction

This thesis deals with the involvement of construction contractors in cross-industry innovation networks aimed at developing digital solutions. This introductory chapter provides the background to the study in terms of its theoretical and empirical contexts. This is followed by the aim and research questions. Finally, the structure and outline of the thesis are presented.

1.1 Background and research context

Innovation has become a central theme in construction management literature over the past few decades (Bygballe and Ingemansson 2014, Larsson *et al.* 2022, Vosman *et al.* 2023, Valkokari *et al.* 2024). Innovation can be seen as something new that is implemented and utilized, that is novel to the organization developing it, to improve a process, product or system (Slaughter 1993, 1998). Innovation in construction is understood as an inherently inter-organizational phenomenon, requiring collaboration among diverse actors to develop and implement new solutions, processes, or technologies (Bygballe and Ingemansson 2014, Vosman *et al.* 2023). These inter-organizational relationships enable essential knowledge exchange, resource mobilisation, and collective problem-solving in construction projects, as innovation development depends on combining knowledge bases across various partners and organizations (Malherbe 2022, Wang *et al.* 2023). Thus, collaboration becomes both a prerequisite and a defining feature for innovation management (Zhang *et al.* 2020). Despite projects serving as key learning arenas, innovation outcomes within projects are frequently constrained by differing motives, perspectives, and power relations among actors (Gadde and Dubois 2010, Bygballe and Ingemansson 2014).

Furthermore, the project-based nature of the construction industry often limits the diffusion and scaling of innovation beyond the project time frame. This hampers not only the exploitation of the potential of the innovation for the involved organizations but also, the renewal of the construction industry (Bygballe and Ingemansson 2014). Innovation manifests differently between permanent organizational networks and temporary project networks, raising compelling questions regarding how these two network levels interplay (Bygballe and Ingemansson 2014, Havenvid *et al.* 2019). The transient and fragmented nature of project teams, characterised by short-term and loosely coupled collaborations, creates persistent challenges for long-term learning and renewal (Dubois and Gadde 2002a, Gadde and Dubois 2010). This so-called "project trap" (Slaughter 1993, Harty 2008), limits sustainable industry transformation precisely when construction faces mounting pressures for digitalisation, sustainability, and efficiency. Overcoming such fragmentation calls for a deeper understanding of how inter-organizational collaboration can connect activities and knowledge across projects and also, even extend beyond the boundaries of the construction industry itself (Valkokari *et al.* 2024). Previous research identifies that; this broader perspective becomes increasingly relevant as the construction industry's persistent lag in digitalisation (Agarwal et al. 2016). It exposes limitations in internally developed innovations and highlights the need to draw on external expertise, technologies and working practices, facilitating innovation related knowledge to flow across industries for innovation (Reichstein *et al.* 2005, Shi and Xiao 2024).

Accordingly, this implies that construction industry actors would collaborate in innovation processes with actors from other industries, so called cross-industry innovation.

Cross-industry innovation (CII) involves the adaptation of ideas, knowledge, or technologies from outside a firm's industry boundaries (Carmona-Lavado *et al*. 2023). It may take the form of importing ideas from other industries, exporting ideas to other industries, or joint innovation efforts across industries. Although studies in the field of cross-industry innovation management research involving construction remain limited, existing evidence suggests that adapting external ideas can lead to gains in efficiency, competitiveness, and digital transformation (Enkel and Mezger 2013).

While clients have traditionally been seen as the primary drivers of innovation (Hartmann *et al.* 2008, Vennström and Eriksson 2010, Lindblad and Guerrero 2020, Guerrero and Engström 2023, Winkler *et al.* 2025) some studies focus on contractors' efforts for innovation in projects (Eriksson 2013, Eriksson *et al.* 2017), and some on the role of the contractor in an innovation process (Slaughter 1993, Langston 2023). What remains less explored is the contractor's proactive role in terms of role characteristics in relation to other actor roles when collaborating in cross-industry innovation. Moreover, Bygballe and Ingemansson (2014) highlight the importance of construction companies recognising their dual role as both customers and innovation developers.

In relation to the above arguments, empirically, this study takes as its starting point a construction contractor who engage in inter-organizational innovation processes with actors within the construction industry and actors from other industries to develop digital solutions. Thus, the study addresses so called cross-industry innovation (CII), involving parties from two, or more, different industries. The Industrial Network Approach (INA) (Håkansson and Snehota, 1995; Håkansson *et al*., 2009) is used as theoretical framework. INA acknowledges interdependencies and adaptations in networks that are shaped and constantly reshaped due to interaction among the actors (Håkansson *et al*. 2009). INA is suitable for studying inter-organizational innovation because it conceptualizes innovation as an outcome of interaction, resource combinations, and relationships among interconnected actors (Håkansson and Waluszewski 2002a). Accordingly, innovation in interaction is considered a dynamic, relational process where technological change and value creation emerge from interconnected, collaborative networks rather than solitary efforts.

By emphasising interdependencies as adaptive processes in networks, the evolvement of innovation through the dynamics of business relationships across industries can be studied. This perspective allows for an assessment of how innovations are developed and implemented in relation to not only individual projects, but may be scaled beyond their immediate context, ultimately contributing to broader industry practises and business opportunities. This research thereby responds to the call by Havenvid *et al*. (2019), Bygballe and Ingemansson (2014) and Reichstein *et al*. (2005) for studies of inter-organizational interaction patterns and innovation processes in construction. Thus, this research is based on an interplay between a phenomenon driven and a theory driven research, with interaction within cross-industry innovation networks in the construction industry being the research phenomenon and the Industrial Network Approach (INA) being the theoretical framework.

1.2 Aim and research questions of the thesis

The aim of this thesis is to explore cross-industry innovation networks in the construction industry. By using the Industrial Network Approach (INA) (Håkansson and Snehota 1995, Håkansson *et al*. 2009) as the theoretical framework, this study captures dynamic interdependencies within the cross-industry innovation network, focusing on the linking of activities, the combining of resources and the interacting among the actors in innovation processes. In relation to the aim, two research questions are formulated in this study.

RQ1 examines how cross-industry innovation networks evolve through interaction in innovation processes, taking into account project, organizational, and industry levels to address not only the development of an innovation, but also its implementation and scaling over time. Accordingly, research question 1 is formulated as follows:

> RQ 1: How does interaction unfold in cross-industry innovation networks within and across project, organizational, and industry levels?

In INA, a central aspect of actors is that the actor's function in the network is not given, instead, actor roles are shaped in interaction, while simultaneously influencing the characteristics and dynamics of interaction (Håkansson *et al*., 2009). The contractor role in cross-industry innovation networks, including the dynamics of innovation activities within and across project, organizational, and industry levels, is of particular interest to this study. Accordingly, research question 2 is formulated as follows:

> RQ 2: How is the role of the construction contractor characterized in innovation processes within cross-industry innovation networks?

1.3 Structure and outline of the thesis

This thesis is structured as follows. In Chapter 1, the background, aim of the thesis, research questions and structure of the thesis are described. In Chapter 2, the theoretical frame of reference, including the theoretical concepts linked to the Industrial Network Approach, is presented. In Chapter 3, the research methodology is detailed, describing the research context, research approach, data collection, research process including the timeline and analysis along with a reflection on the research quality. In Chapter 4, the included two papers are summarised. In Chapter 5, the results and the discussion are provided, structured around the research questions. Chapter 5 is concluded by providing the theoretical and practical contributions of the research. Finally, in Chapter 6, the thesis ends by presenting the conclusion section and suggestions for further research.

2. Theoretical frame of reference

This chapter outlines the theoretical frame of reference for this study. First, inter-organizational innovation in the construction industry is presented. Second, cross-industry innovation is discussed. Third, the actor roles in construction innovation are presented. Fourth, the theoretical framework applied in this thesis is introduced, i.e., the Industrial Network Approach (INA), by providing an overview of its core concepts, including interaction in time and space, and the Activities-Resources-Actors (ARA) model is explained and interaction conceptualizing for construction innovation. Finally, the chapter ends with the conceptual framework for conceptualizing the phenomenon of this thesis: interaction within cross-industry innovation networks in the construction industry.

2.1 Inter-organizational innovation in construction

Innovation in the construction industry is not simply about adopting new technologies or improving efficiency, it is about how organizations learn to innovate together across organizational boundaries(Winch 1998, Slaughter 2000, Blayse and Manley 2004, Havenvid *et al.* 2019, p. 33). In construction management literature, innovation is a key research area, with the construction industry recognized as a distinctive setting for the adoption of new technologies and the achievement of innovation (Linné 2019). A special focus has been paid to how the inter-organizational interaction between actors or organizations, with different skills, knowledge and experience, affect innovation (Håkansson and Ingemansson 2013, Bygballe and Ingemansson 2014, Linné 2019). These interactions form the foundation on which construction innovation is built. The inter-organizational connections are viewed as assets for exchanging resources and information that can foster innovation (Satheesh *et al.* 2024).

However, the very nature of construction, being a project-based industry, involving diverse actors and marked by differing standards, practises and objectives add complexity to innovation efforts. This is because the temporary nature of project organizations in construction means that cooperation is often short-lived and purpose-driven, making it hard for learning and innovation to persist beyond the project´s life cycle. Slaughter (1998) explains that construction innovations sit within temporary alliances of independent organizations, with links among multiple components and systems that can complicate implementation and coordination. As Dubois and Gadde (2002a) point out, the industry's structure and nature of loose couplings between parties/actors/organizations can limit long-term knowledge sharing and hinder the diffusion of new ideas across projects. This challenge is further emphasized by Håkansson and Ingemansson (2013) highlighting the fragmented nature of construction as a barrier for renewal. Authors define “renewal” as innovation that lasts i.e., a change or a new solution that becomes institutionalised and integrated into ongoing industry practises rather than remaining an isolated occurrence within one project. Yet, as Larsson *et al*. (2022) note, project specific innovative solutions can create challenges for diffusion, since what works in one context may not easily transfer to another.

In this context, the inter-organizational interfaces, where different organizations, teams and professions interact become critical. These interactions affect the type of innovation that takes place and how it unfolds. Organizational interfaces, which refer to the points of contact and collaboration between different actors, functions, organizations, are crucial for fostering innovation in construction by facilitating interaction and knowledge exchange among diverse stakeholders (Araujo *et al.* 1999). The four types of interfaces explained in this study are, Interactive interfaces, based on open-ended dialogue and joint problem solving, create strong conditions for learning and exploratory innovation. Second type is translational interfaces, where actors reinterpret and adapt requirements, support innovation by enabling local experimentation while meeting client needs, third and fourth type are standardized and specified interfaces, built on formal specifications and limited mutual adjustment, mainly favour efficiency an incremental innovation (Araujo *et al.* 1999). Through these organizational interfaces actors come together to initiate and develop new solutions, and this happens through negotiation between the different actors. Building on these insights, recent research by Nezami *et al*. (2022) examine collaboration dynamics within horizontal inter-organizational infrastructure projects, i.e., where multiple infrastructure owners coordinate the design and execution of interconnected assets. Their study identifies that data sharing between infrastructure owners was essential for innovation in inter-organizational collaboration. However, limited trust, coordination, and process maturity often hinder such exchanges. The specific characteristics of the inter-organizational nature of construction thus adds to both potential and complexity of innovation.

Moreover, as Harty (2008) observes, outcomes from innovation differ for different actors and are inherently context based, influenced by each other's goals, resources and relationships. This means that the same innovation can be beneficial for one organization while posing challenges for another, i.e., a concept known as relative boundedness of innovation. Given these differences, innovation often depends on how effectively organizations manage interactions and align their efforts with others in their network. This relates to "openness," as described by Laage-Hellman *et al*. (2021) from an industrial network approach (INA) perspective, openness has also been recognized as an important concept, emphasizing how firms innovate by exchanging and combining resources with others, forming activity links, resource ties, and actor bonds. This is similar to open innovation (OI) literature, which focuses more on knowledge flows across firm boundaries, (Chesbrough 2003, Dahlander and Gann 2010). The degree of openness varies with context: It is higher when firms can build on existing links, ties and bonds, and lower when they must create new relationships from scratch (Laage-Hellman *et al*. 2021). In construction, this view of openness, and particularly its application to joint R&D activities is underexplored, despite being vital for sustained interactions beyond single projects (Slaughter 2000, Bygballe and Ingemansson 2014). The next section presents the concept of cross-industry innovation.

2.2 Cross-industry innovation

Cross-industry innovation (CII) research focuses on how organizations connect across different industries to enable innovation (Carmona-Lavado *et al.* 2023). Thus, CII refers to the adaptation of ideas or knowledge outside a firm´s traditional industry boundary. Carmona-Lavado *et al.* (2023) describe CII as a particular form of open innovation, emphasizing that its success largely depends on the diversity and heterogeneity of actors involved, specifically their different knowledge bases, professional experiences, and exposure to various functional areas, markets and businesses.

Three main types of cross-industry innovation are identified (Carmona-Lavado *et al*., 2023): inbound, outbound, and coupled. Inbound CII occurs when an organization in one industry has a problem and searches for a solution in another industry to reuse it. Outbound CII comes about when an organization in one industry has a solution and approaches potential users and customers in another industry. Finally, coupled cross-industry innovation takes place when organizations from different industries jointly innovate to solve a problem or adapt a solution (Carmona-Lavado *et al.* 2023). The various types of cross-industry collaborative innovation have implications for the organization and governance of the innovation process. CII is sometimes referred to as "Inter-industry innovation" that involves cooperation between different industries, achieving technological, resource and informational complementary and synergy through collaboration (Shi and Xiao 2024). Similarly, Zhang *et al.* (2021) describe CII as a form of cross-boundary alliance, where companies share knowledge and co-innovate by bridging organizational and industrial divides. New products or solutions are in most cases not purely technologically new but rather new to the context that is using it, such as one application in one industry and a different application in another industry (Gassmann *et al.* 2011). This reapplication implies a process of transferring knowledge from a familiar setting to an unfamiliar one, thereby generating new meaning and opportunities in novel contexts.

Studies of CII cover many different industries, such as, medicine, petroleum, automotive and manufacturing (Carmona-Lavado *et al.* 2023), where knowledge transfer and recombination have led to new products, technologies and business models. However, studies examining CII within the construction industry remain scarce. The notable exception is the work by Enkel and Mezger (2013), who investigate how cross-industry imitation operates in construction. They found that imitation is not a simple act of copying but rather a process of adaptation and contextual integration, where external ideas are reinterpreted to suit the complexities of construction projects. In their study, construction firms benefited from applying cross-industry thinking to break out of traditional boundaries, adopting innovative practises that enhanced efficiency competitiveness and value creation. More recently, Shi and Xiao (2024) identify the impact of network configurations in facilitating CII, since how inter-industry relationships are structured can significantly shape innovation outcomes. Network composition, diversity and positioning of actors all influence how innovation develops due to connections between industries. Taken together, this body of work positions CII networks as a powerful yet underexplored research area in relation to construction. Additionally, how the roles of various actors' interplay in cross-industry innovation, of which construction is one industry, remains less explored. Accordingly, actor roles in construction innovation are considered next, as they impact on the innovation process and the crossing of industrial boundaries.

2.3 Actor roles in construction innovation

Actors in construction innovation do not operate in isolation. Their respective position, motives and relationships influence how innovation emerges, the innovation process and how innovation is implemented. Construction projects are considered learning arenas, yet innovation may be hampered by the different views and motives of the involved actors (Slaughter 2000), as well as by the distribution of power amongst them (Harty 2005). Clients, contractors and other suppliers in construction each occupy distinct roles that can either unlock or constrain opportunities for change. Often clients are positioned centrally in projects, able to shape demand, set quality and innovation requirements, enforce or hinder risk sharing, knowledge flow and supplier engagement (Vennström and Eriksson 2010). Several studies also point at intra-organizational abilities of clients to drive innovation (Guerrero and Engström 2023, Winkler *et al.* 2025), where the study from Havenvid *et al.* (2016) examine how clients contribute to innovation by making specific requirements in relation to the execution of construction projects. Additionally, Lindblad and Guerrero (2020) highlight the decisive role of public clients in promoting innovative collaborative practices, illustrating how leadership and procurement strategies can steer the direction of technological and organizational change.

Research demonstrates that contractors can also be sources of innovation (Slaughter 2000, Langston 2023.Slaughter (2000) discusses various roles for construction companies in the implementation of a construction innovation process. In the early phases (identification and evaluation in the idea phase) construction companies can take on roles like idea generators and gate keepers, in the commitment phase a “champion” can shepherd the innovation and promote the innovation, while in the preparation for implementation, a project leader can coordinate resources and activities in line with the project. In the use phase, Slaughter (2000) discusses the role of a coach to guide, train and support internal resources for diffusion. In other construction and innovation literature the champion role does not only present itself in the commitment phase but also in other phases of the innovation process to facilitate inter-organizational collaboration, which includes informal communication and interpersonal coordination (Sergeeva and Zanello 2018, Melander and Pazirandeh 2019). Thus, innovation champions can influence organizational learning by managing internal and external knowledge flows (Drechsler *et al.* 2021). Building on this the study from Langston (2023) reveals that construction contractors hold a critical role in driving innovation within projects and project success and in turn affect their outcomes on innovation success. Their frontline position allows them to identify inefficiencies an experiment with innovations under real world conditions. Through empirical investigation their study demonstrates that contractors who actively pursue innovation can deliver superior project outcomes by adopting digitalization or sustainable building practises. In a similar vein, Keung and Shen (2017) emphasize the contractors' role as not just as executers but as active innovation agents who use strategic networking to foster continuous innovation and business growth.

Alongside clients and contractors, intermediaries or brokers can be equally important for innovation. Winch and Courtney (2007) argue that innovation brokers play crucial bridging and boundary-spanning roles within innovation systems, connecting organizations and groups that are otherwise unlinked. Their primary contribution is to facilitate the sharing and transfer of knowledge and resources necessary for innovation, thereby reducing fragmentation and helping ideas travel across organizational and project boundaries.

In cross-industry innovation literature, stakeholders who can be the sources of innovation, for example, lead users, experts, suppliers and researchers, are discussed (Carmona-Lavado *et al.* 2023). But, with some exceptions (Enkel and Mezger, 2013), very few studies examine such roles in relation to the stakeholders within construction. Taken together, these studies show that the functions different actors have are crucial and portray varied roles in driving innovation in construction, shaping not only the setting in which new ideas are developed but also determining how innovations are adapted in projects, organizations and also within industries. However, the roles of actors, whether contractors, clients, or other actors are not independent but interdependent and formed through their connections and interactions. Accordingly, in the next section an overview of this study´s theoretical framework, the Industrial Network Approach, is presented.

2.4 The Industrial Network Approach: An overview

The Industrial Network Approach (INA) framework features a strong stability over time with the four decades of research based on Håkansson & Gadde (2018). The core concepts of INA are interdependencies, interaction and business relationships. INA conceptualizes business as a system of interconnected firms embedded in long-term relationships and networks, rather than as a series of isolated, short-term market transactions (Håkansson *et al.* 2009). INA adopts a dynamic view of economic exchange, focusing on interaction processes between actors and how these interactions shape, and are shaped by, the development of relationships over time. Within this perspective, business relationships encompass not only economic exchanges but also social, informational, and technological aspects that influence how firms learn, adapt and innovate. Thus, business relationships form dynamic network structures, characterised by complex interdependencies that shape how construction innovations are developed, implemented and diffused. These interdependencies are vividly captured by the "rainforest" metaphor in INA, where firms, like interdependent species, co-exist and evolve through interconnected resources, activities and relationships, rather than competing in isolation (Håkansson *et al*., 2009). This relational perspective frames innovation as a networked process, where changes in one relationship affect many others, highlighting why business outcomes depend on mutual adjustment and interconnection rather than individual firms acting alone. Therefore, applying the characteristics of a rainforest to the business world implies that interaction is a process of the business landscape and more profoundly, it means that no actor exists alone or act alone. Consequently, taking account of other parties is key in terms of business, as one actor only exists in relation to its direct and indirect interdependent relationships within business interaction This relational perspective sets the stage for understanding innovation as a networked process.

2.4.1 The concept of interaction: Time and space

"Interaction is an important economic process through which all of the aspects of business, including physical, financial and human resources, take their form, are changed and are transformed" (Håkansson *et al.* 2009, p. 33). Interaction is a cumulative process evolving over time where actors affect and are affected by each other, in the linking of activities and combining of resources Interaction is strongly connected with time: for instance, at a specific point in time in a business relationship two companies will be dealing with particular issues. Accordingly, an interaction episode is a discrete event where actors (companies, organizations, individuals) connect resources (such as knowledge, technology and physical assets) to create value, innovate or solve problems, with outcomes feeding into subsequent episodes and interpreted differently by each party (Håkansson *et al*., 2009). Interaction is not merely another organizational activity but a fundamental mechanism through which firms combine resources and coordinate processes and co-create new technical and organizational solutions across project and firm boundaries. Interaction in business network are embedded in time and space; Time refers to sequential, historical built up of episodes shaping path-dependant innovation. Space denotes actors positioning in the network, with specific organizational structures forming "a space". Projects can be considered one such space when it comes to construction. In a network, several such "spaces" are interconnected, and "what is good in one point in space may not work in another" (Håkansson *et al*., 2009, p. 39). This spatial and temporal (time-related) aspects can be used to conceptualize interaction to examine how innovation develops in construction. The following section on the ARA model provides a structured lens to conceptualise interaction in business networks at the organizational, relationship and network levels.

2.4.2 The Activitiy-Resource-Actor (ARA) model

(Håkansson and Snehota 1995) argue that interaction is inherently complex and dynamic, composed of three interrelated layers: activities, resources and actors. The activity layer encompasses actions coordinated by actors through activity links to generate value (Håkansson and Snehota, 1995). Activity interdependencies can be serial (one activity depends on another activity´s completion), dyadic (output of one activity serves as input to another activity) or joint (shared dependencies or the performance of one activity is dependent on another, because both of them are related to a third activity) (Håkansson *et al.* 2009, pp. 105–107). The resource layer covers both tangible (products and technologies) and intangible resources (knowledge, capabilities), exchanged and transformed through resource ties. Through combining and adapting these resources, actors create new value, strengthen relationships, and foster innovation across the network. The actor layer refers to organizations and individuals driven by specific motives who influence and are influenced by others through actor bonds. How actors relate depends on their perception of the context, behaviours undertaken, and results expected (Håkansson *et al*., 2009). This layer highlights cognitive, social and strategic aspects shaping interactions and decision making within networks.

The ARA model (see Figure 1) explicates the interwoven nature of relationships, showing how activities, resources and actors are interconnected. In reality, these three ARA dimensions are intertwined, but for analytical reasons it is useful to separate them into: activities dimension, resource dimension and actor dimension.

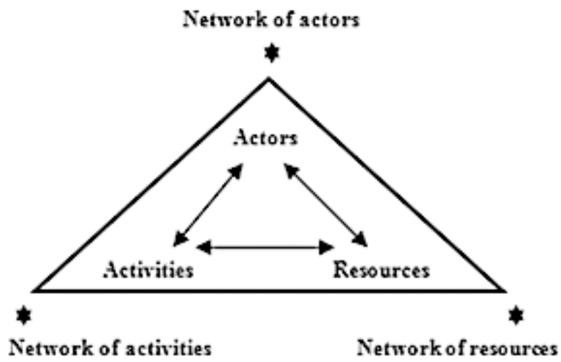

Figure 1- The ARA model
(Adapted from: Håkansson and Snehota 1995, p. 45, Håkansson et al. 2009, p. 33)

The ARA model by Håkansson and Snehota (1995) conceptualizes business relationships and networks at three interconnected layers within the ARA dimensions: the single company layer, the dyadic relationship layer and the wider network layers. Key aspects of each layer are presented in detail below.

The company layer: activity structure, resource collection and organizational structure (for actors)

The ARA model views the firm as an actor with an internal activity structure, resource collection and organization structure. The activity structure concerns how technical, administrative and commercial activities are organised and linked internally. The resource collection denotes the firm´s physical, financial, technological and human resources that it can control and access through interaction. While the organization structure describes how individuals and units are grouped, coordinated and governed. The actor layer is important as it provides each company with an orientation, identity and position vis-à-vis important counterparts. Together these elements define what a company can do on its own and how it can adapt and connect to external counterparts.

The relationship layer: activity links, resource ties and actor bonds

The interaction between two companies is characterised by activity links, resource ties and actor bonds, which together describe the substance of a business relationship. Activity links are the connections between the firm's activities, such as coordinated production, logistics or development work that become aligned overtime. Resource ties describe how the firms' resources are connected or adapted to each other, for example, through technical adaptations, shared systems and investments. Actor bonds refer to the social and organizational connections between individuals and organizations, built on trust, commitment and shared experience.

Together these layers give each relationship a specific profile that both constraints and enables what firms can jointly do.

The network layer: activity patterns, resource constellations and web of actors
The ARA model captures how individual relationships are embedded in a wider constellation of interconnected ties, thus, forming a network. An activity pattern denotes the largest system of connected activity links across multiple relationships, forming interdependent chains and network of production, distribution and development. Resource constellation refers to how resources are distributed and connected across the network, including how different actors combine adapt and develop through multiple relationships. The web of actors describes the network of interdependent firms and subunits linked by multiple relationships, where each actor´s position depends on its portfolio of ties and bonds.

As a conceptual framework of the process and outcomes of interaction, the ARA-model has been used for studying various phenomenon in relation to many different industries, for example, organizing industrial activities across different manufacturing industries and business-to-business settings (Dubois 2006), collaborative innovation and openness in the multi-industry scenario with five case studies spanning across several industries (Laage-Hellman *et al.* 2021), and digital and non-digital resources in the automotive industry (Ferreira *et al.* 2025). In specific, within INA research in the construction industry, the ARA model has been used in various studies, for example, the effects of client requirements for renewal of construction projects (Havenvid *et al.* 2016), organization of construction logistics (Sundquist et al., 2018), and the use of BIM (Building Information Modelling) (Davies *et al.* 2015).

2.4.3 Interaction in construction innovation

The construction innovation landscape evolves cumulatively and unevenly, reflecting both collaboration and fragmentation. This makes the Industrial Network Approach particularly suitable for explaining why innovation in construction often appears slow and path-dependent, alternatively it can also produce rapid shifts when interaction patterns change across multiple scenarios or relationships (Håkansson *et al*., 2009).

In construction, INA has been employed to analyze how interaction and relationship patterns condition innovation processes, showing that new solutions often emerge from adaptations and joint problem solving between interdependent actors, rather than from single firm acting alone (Bygballe and Ingemansson 2011, Bygballe and Ingemansson 2014, Bygballe *et al.* 2015, Havenvid *et al.* 2019, Linné 2019). Interaction plays a central role in shaping how innovation emerges and develops in construction, a project-based industry characterised as a loosely coupled systems where temporary projects coexist alongside enduring permanent networks (Dubois and Gadde 2002a). The construction industry features a wide spectrum of interdependent actors such as clients, contractors, suppliers, and project teams. The interdependencies and relationships within this network of actors shape the project outcomes, particularly in decision making processes, which are often situated within the context of temporary organizations (Winch 2003). Within individual projects, these actors engage in intense short-term interactions to coordinate design production and execution, mobilising resources like knowledge and technology to co-create solutions (Håkansson *et al*., 2009). Single or rare interactions, however hinder innovation development, as outcomes from one episode become inputs for the next, interpreted differently by each actor (Bygballe *et al* 2015). This intensity of interaction fosters rapid problem solving but is constrained by the temporary nature of projects, where learning risks being lost between project-to-project engagements. Central actors such as main contractors or consultants acting as facilitators for knowledge transfer across projects, enhancing access to diverse resources and driving change, while their isolated positions limit innovation potential (Bygballe and Ingemansson 2014, Happalad *et al.* 2026).

Conversely, the permanent network surrounding projects enables long-term interactions that build trust and shared understanding with repeated partners, easing innovation management and sustaining innovation practises (Håkansson *et al*., 2009). Construction innovation thus emerges cumulatively from these interconnected interaction episodes, which follow path dependent patterns yet remain capable of rapid shifts when interaction intensities and network positions evolve. This dynamic interplay of temporary and enduring interactions underscores the need for a systematic analytical approach that examines how activities, resources and actors connect across levels. Thus, innovation in construction can be understood as embedded in networks where changes in one relationship can have consequences for others, highlighting the importance of network structure.

2.4.4 A conceptual framework for cross-industry innovation networks in construction

A cross-industry innovation (CII) network involves actors from distinct industries. An industry is defined as groups of companies engaged in specific business types, for example, construction for building structures and infrastructure, chemicals for transforming raw materials into products, automotive for vehicle manufacturing and ICT for developing digital technologies. In relation to that, each industry is characterised by its own technological base, production logic and organization routines. From an INA perspective, CII networks "stretch" across industry boundaries through evolving interaction processes forming connections between activities, resources and actors. These interactions create interdependencies that shape how innovation emerges and evolves in a dynamic network structure.

The activity layer in construction remains highly inter-organizational, distributed across projects and firms. This is because the "specialist knowledge in these project networks is often practice based, situational, sticky and locally embedded which makes it more difficult to collaborate across structural, cultural and spatial boundaries"(Bosch-Sijtsema et al. 2014, p. 2 Bosch-Sijtsema and Postma 2009, 2010). Winch (2003) argues that most innovative activities in construction, such as advanced design, engineering, and technical consultancy, are carried out by specialist suppliers whose work falls under service categories distinct from core construction tasks, like manufacturing materials, distribution, or building maintenance. These suppliers' contributions, particularly in digital innovation, are essential in the inter-organizational collaboration within projects, even though their activities are classified separately as core construction tasks. Additionally, incorporating actors from non-project-based industries (such as ICT or manufacturing) into these activity structures enables new ways of coordinating processes for example, through digitalization, modularization or automation. However, connecting the project to the broader organization, referred to as boundary spanning activity, is also identified as a challenge of the project organization in capturing what has been developed and learned in individual projects conveying this knowledge to senior management of the respective organizations (Hartmann and Dorée 2015, Havenvid *et al*. 2016). In construction, activities form a pattern of tight couplings within each project but loose couplings over time across projects, reflecting the industries project-based, loosely coupled system, which tends to favour short-term productivity but hampers the diffusion of innovative activities at the permanent network level (Dubois and Gadde 2002a, Gadde and Dubois 2010). Non-project industries, in contrast, organise many activities in more repetitive and continuous processes with stronger integration across organizational boundaries overtime through long-term production planning, stable supply chains and joint developments routine, as enabled and characterised by high-involvement relationships (Gadde and Dubois 2010).

At the resource layer in cross-industry innovation, the focus lies on how tangible and intangible resources are combined and reconfigured within and across industry boundaries. In construction, the temporary project organizations mobilise materials, equipment, digital platforms and organizational capabilities to produce complex product systems. Yet, they face challenges in coordinating and identifying the right resource in use across intra- and interorganizational boundaries (Hobday 2000). From a cross-industry innovation perspective, these limitations can be mitigated through resource interfaces with non-project-based industries that provide standardised technologies, data-driven tools or specialised know-how. Drawing on the 4R model, (Håkansson and Waluszewski 2002a, 2002b), a CII network can thus be conceptualized as a space where physical (products and facilities) and organizational entities (organizational units and organizational relationships), from different industries are combined into new resource constellations. These combinations enable collective learning, innovation capacity and the co-creation of innovative resources that transcend traditional industry boundaries. In particular, combining digital resources generates value by enhancing data accessibility and knowledge creation, improving efficiency, and stimulating innovation across the entire lifespan of products (Ferreira *et al.* 2025). In construction, many resource adaptations are concentrated in the project, where technical and logistical adjustments between firms´ equipment, materials and routines must be handled on site under tight constraints. While, in the permanent network, firms often strive for organizational independence and standardised exchanges, which reduces the extent of long term, mutual adaptations of resources across recurring relationships (Gadde and Dubois 2010). By contrast, high-involvement relationships in non-project-based industries support systematic, long-term adaptations of resources between specific buyer-suppliers, such as co-developed components, integrated production systems or shared IT logistics platforms which are designed and refined over time.

In construction, innovation networks are typically structured around temporary project organizations with fragmented responsibilities and time bound collaborations as described in the previous section. Within this environment, the actor layer is shaped by organizational roles and construction project-specific interdependencies, requiring relationship and adaptation between construction industry firms: contractors, consultants, clients and suppliers. Håkansson *et al*. (2009) argue that it is easier to manage an interactive view of activities and resources than an interactive view of business actors. This is because each actor is unique when a given point in the network´s space and time. The introduction of new actors is relatively rare; when it occurs, it is often the product of prior interactions, whether through ongoing connections or through specific combinations of resources and activities. The introduction of new actors from another industry (for example, technology providers from another industry) challenges the established coordination patterns within construction (due to the new actor´s new processes) and often depends on previous relationship history and shared learning processes (Håkansson *et al.* 2009). In construction, actors interact very intensively within the temporary project organization, where numerous specialised firms must coordinate under strong time pressure and technical interdependence, while interaction across projects in more permanent network remains weak and fragmented, so continuity and learning between projects are limited (Gadde and Dubois 2010). In contrast, high involvement relationships in non-project-based industries like manufacturing feature longevity, mutual adaptations, frequent interactions, strong interdependence among limited set of actors, enabling stable roles and ongoing collaboration across multiple product development cycles (Gadde and Dubois 2010).

The ARA model provides a basis in terms of a conceptual framework that can be applied to analyze cross-industry innovation networks. The illustration in Figure 2 presents the conceptual framework of this thesis in regard to the research phenomenon: interaction within cross-industry innovation networks in the construction industry. The conceptual framework captures interaction in the innovation process between actors from different industry contexts: actor A from the construction industry named ‘a’ and actor B from another industry, named ‘b’. The collaboration between these two actors unfolds simultaneously across the three analytical layers of ARA: the activity layer, where serial, dyadic and joint interdependencies among activities exists within and across industry boundaries. The resource layer, where tangible and intangible resources (technologies, knowledge, digital tools etc.) are mobilised and combined; The actor layer where each actor’s perceptions, behaviours and expected results evolves vis-a-vis each other; and These layers operate at multiple levels: within single firms/ organizations, across dyadic relationships (between organizations) and throughout the broader network. Accordingly, a key aspect in the conceptual framework is that the structure and function of what take place in interaction between actor A and actor B is contingent on other, direct and indirect, interaction with other parties. Thus, the interaction between A and B in their cross-industry business relationship is dependent on other relationships, situated within and across industries.

Consequently, the conceptual framework (see Figure 2) forms the basis of the exploration of the two research questions in this thesis: "How does interaction unfold in cross-industry innovation networks within and across project, organizational, and industry levels?" (research question 1) and "How is the role of the construction contractor characterized in innovation processes within cross-industry innovation networks?" (research question 2). The first research question involves the "mapping" of interaction in time and space in the cross-industry innovation process regarding settings on project, organizational and industry levels. Research question 2 entails a more specific focus on the function of the construction contractor (Actor A in Figure 2) in the cross-industry innovation process, with the important notion that this role arises, emerges and is adapted in relation to the roles of other actors (Actor B in Figure 2 and other actors) owing to interaction. Accordingly, research question two examines a specific aspect in terms of how interaction unfolds in cross-industry innovation networks (research question one).

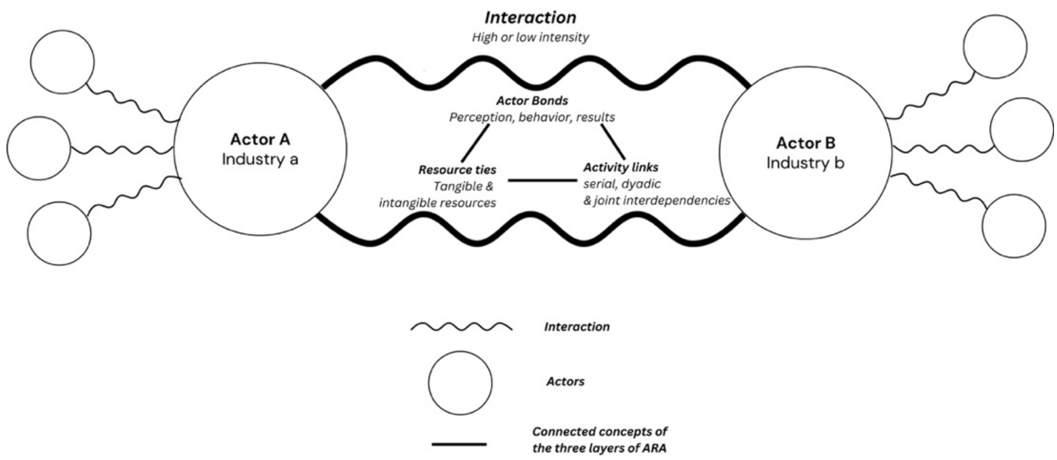

Figure 2- Conceptual framework for analysing CII
(developed in Paper one)

3. Methodology

This chapter outlines the methodology used in this study. In the first section, the research context is presented. In the second section the research approach, case-based research, is explained. In the third section the data collection is presented. In the fourth section, the detailed research process is explained along with research timeline and the research analysis method, i.e., systematic combining. In the last section the chapter concludes with reflections on research quality aspects in this thesis work.

3.1 The research context

Digitalization has been identified as an important means of enabling a more sustainable construction industry. This thesis work stems from a previous study "Digitalisation of information flows for more efficient infrastructure projects" (SBUF project 14000, 2022) conducted by my supervisors. The results showed that digital solutions create benefits through the integration of information flows, which in turn contributes to more efficient processes and value creation. These solutions are developed through collaboration between several parties, as it allows knowledge and experiences from different actors to be combined. One important conclusion was that digitalisation of information flows often requires development and innovation, as to take into consideration specific needs of the use context. Based on the conclusions of the preliminary study, there was a need to research innovation processes, including working methods, roles, and conditions further in relation to digital solutions. These insights guided the focus of the PhD project, which aimed to study innovation processes with a particular interest in how contractors engage in inter-organizational collaboration in the development of digital solutions.

Accordingly, this thesis work is designed as a doctoral project to enable a more in depth and comprehensive study, with the title "Innovation processes for digital services and solutions" (SBUF project 14180, 2023). The doctoral project aimed to study how inter-organizational innovation processes related to digitalization emerge and develop within the construction industry. It takes the contractor's role as a starting point and explores how the contractor collaborates with other actors in joint innovation efforts, taken into account the relationships between actors in the innovation network. Accordingly, the Industrial Network Approach (see e.g. Håkansson *et al*., 2009) provides the theoretical framework of this thesis work. The construction industry is characterized as project-based and fragmented, in which innovation often takes place as a problem-solving activity within individual projects.

The previous study identified an interesting example of how a construction contractor got involved in an innovation process with actors from the automotive industry to develop a digital solution. This example addresses the problem of truckloads of excavated material being either overloaded or underloaded, which is a challenge in large infrastructure projects. This example later became the basis for one of the sub-studies in the current research, called "Efficient Load Out" (ELO) (see Section 3.3 for data collection and Section 3.4 for details). Accordingly, when my research began, the construction industry and its ongoing efforts in digitalisation were already defined as the empirical starting point. But the first study covered an inter-organizational innovation process with firms from the construction industry and the automotive industry.

The research project involved a reference group consisting of two representatives from the main construction contractor (Head of Research and Innovation and Infrastructure Manager for Design), two other construction contractors' company representatives, a researcher from KTH university, a representative from a public client organization and one representative from another client organisation. During one of the reference group meetings, it was suggested that another relevant study of inter-organizational innovation involving the construction contractor could be studied. As a result, the sub-study "Smart Vests for Road Construction" (Smart Vests) was included in this research (see Section 3.3 for data collection and Section 3.4 for details).

Accordingly, this research focus covers two empirical sub-studies. The first, ELO, concerns collaboration between a construction contractor and an automotive industry conglomerate. The second sub-study, Smart Vests, examines collaboration between a contractor and a technology development startup developing wearable safety devices. Both sub-studies focus on inter-organizational innovation processes where the construction contractor work with actors from other industries in innovation processes to develop and implement digital solutions in the construction industry. Due to the nature of these empirical sub-studies, the focus of the research project evolved from studying inter-organizational innovation processes to studying cross-industry innovation processes in the construction industry.

3.2 The research approach: case-based research

This thesis deals with the involvement of construction contractors in cross-industry innovation networks focussed at developing digital solutions. Adopting an Industrial Network Approach, this research takes 'relationships' as the unit of analysis, following Håkansson *et al*. (2009). It focuses on how relationships and interactions between actors influence the innovation processes and its outcomes. under the conditions of high coordination demands, documentation needs, and sustainability. As (Håkansson *et al.* 2009, p. 185) note: "the relationship provides the particular context within which specific episodes of interaction between the companies and individuals take place". To understand business relationships as entities for innovation in construction, it was essential to follow the innovation process in the empirical setting through a case study approach. Case research is widely regarded as an appropriate method for describing and understanding business relationships within networks (Andersen *et al.* 2018).

This research aims to explore to explore cross-industry innovation networks in the construction industry, using the Industrial Network Approach (Håkansson and Snehota 1995, Håkansson *et al*., 2009) as the theoretical framework. Thus, in this thesis, the research phenomenon in focus is, 'interaction within cross-industry innovation networks in the construction industry'. This phenomenon is researched by using a qualitative research methodology, because "qualitative research often brings the reader closer to the phenomena that's being studied" (Bansal and

Corley 2011, p. 235). Qualitative research aims to offer deep understanding of complex issues, uncover key problems, and propose potential explanations (Flick 2014).

Given the explorative nature of the thesis work, this thesis adopts a qualitative explorative case study design and research methodology (Easton 2010). Case-based research offers an opportunity to obtain detailed, in-depth contextual knowledge of a specific and contemporary phenomenon (Dubois and Gadde, 2002). Moreover, a case study approach is particularly suitable for addressing "how" and "why" questions as it enables the tracing of the process links over time (Yin 2009). A main reason to adopt case studies for industrial networks is "the unit of analysis of the study, which are organizations and relationships that are difficult to access and complex in structure, as a result a case method can provide a great deal of large qualitative data which can be illustrated as a "case" offering insights into the nature of the phenomenon" (Easton 2010, p. 118).

Case-based research can involve a single case or multiple cases. This research is based on one case, which entails two sub-studies. The selected single case study approach in this thesis work is detailed and focuses on the research phenomenon of interaction in cross-industry innovation networks within the construction industry. It includes the process of direction and redirection in which the theoretical framework co-evolves and is adapted in iteration with the case as it unfolds (Dubois and Gadde 2002b). The case study examines innovation between cross-industry actors for developing digital solutions, intended for use in construction project setting. The case study draws on two empirical sub-studies involving a large Swedish construction contractor. The first sub-study, Efficient Load Out (ELO), covers a cross-industry innovation process with the automotive industry to develop an app that optimizes the loading of materials in construction projects. The second sub-study, Smart Vests, examines a cross-industry innovation process involving the technology development industry, aimed at developing smart vests to enhance safety in road construction. As Andersen *et al*., (2018, p. 5) emphasize, "Single-case research concerns a holistic rather than an atomistic approach to a phenomenon, as it tries to frame and set the boundaries around aspects relevant to the case and focus on both actors and the contexts they inhabit"

The case method itself represents an iterative process of "casing", the act of "making something into a case", as described by (Ragin 1992). This process connects theoretical ideas with empirical data by determining which aspects of the empirical material are relevant to the phenomena being explored. Casing is continuous and iterative throughout this research, the question of "what the case is a case of" has been revisited multiple times and from different perspectives. This ongoing reassessment ensures that the empirical evidence is systematically evaluated for its capacity to clarify the phenomenon of interaction within cross-industry innovation networks in construction. The case emerges from the dynamic interplay between theory, the case, the empirical world and the framework (systematic combining approach, see section 3.4.2).

Figure 3 (Adapted from Dubois and Gibbert, 2010), shows how the theory, empirical phenomenon and case method of this research interrelate. All three dimensions of research converge to provide insights situating construction contractors in cross-industry innovation networks from an interactive perspective. The theoretical frame of reference, and more specifically, the theoretical framework in the form of the Industrial Network Approach, provides a structured lens to analyze the case and empirical material. Thus, the empirical phenomenon of this research is, construction contractor´s involvement in cross-industry innovation processes for digital solutions (that is something that happens, based on real observations and data). The research phenomenon, which represents the focus of this research and what I as a researcher wants to understand, is interaction within cross-industry innovation networks in the construction industry. This phenomenon bridges case observations and theoretical understanding by demonstrating how actors from construction, automotive and technology development industries are involved in evolving interaction to develop and implement digital innovations. By examining cross-industry innovation networks, the research reveals how contractors interact with actors from industries with different organizational logics (the automotive industry and technology development industry) and how these interactions shape innovation processes and outcomes. The empirical material thus anchors the analysis in network dynamics and relational processes.

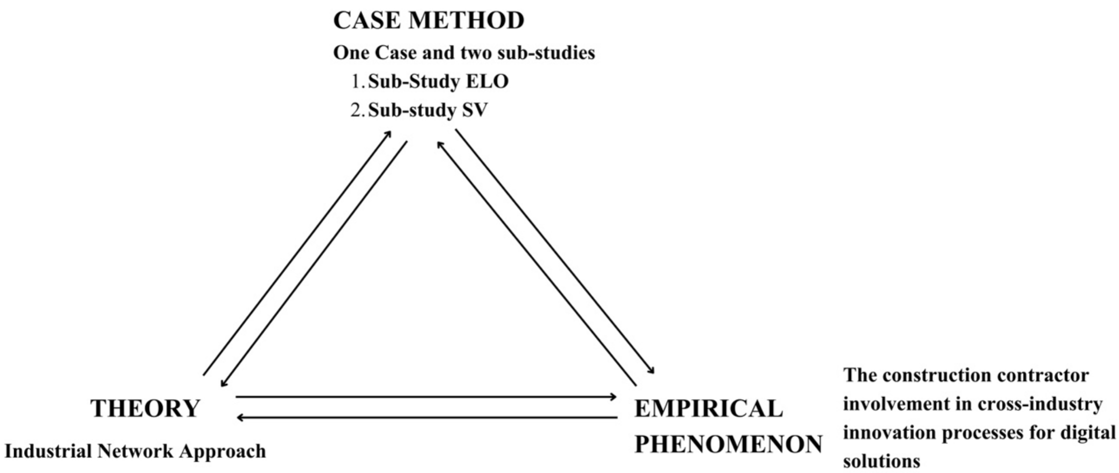

Figure 3- The three dimensions of research
(Adapted from: Dubois and Gibbert 2010)

3.3 Data collection

In the data collection, as a researcher, I engaged with individuals (interviewees) involved in the innovation processes to interpret the meanings and situations they created in interaction. These individuals are thus representatives for their firms, but foremost, they provide the actor perspective for their role in the cross-industry innovation network. The reason for conducting semi structured interviews was that the interviewees can express their thoughts and show their subject-matter expertise with open-ended questions (Bell *et al*, 2022). Semi-structured interviews were chosen as the primary data collection method, focusing on interaction and relationships in the cross-industry innovation network, innovation process outcomes for different organizations, and the contractor's role in the innovation process. The data collection procedure was rooted in understanding how participants construct meanings in their organizational environments via discourse and interaction. The interviewees were selected using snowball sampling in both studies, starting with contacts provided by the contractor firm and a key initial contact person who referred additional suitable participants based on their direct or indirect involvement in the innovation process. Regarding the time period of data collection in Table 1 and Table 2, for sub-study ELO and sub-study Smart Vests respectively, all the interview from 2023 onwards were conducted by me, and all the interviews before 2023 were conducted by my main and co-supervisors (who are responsible for the administration and funding acquisition of the doctoral project). For both sub-studies, an interview guide was developed with the following themes: features of the innovation, the innovation process, characteristics of the collaboration and the relationship of actors involved, how the innovation is used as of today (at the time of interview), value and usefulness of the innovation and, challenges in relation to the innovation process and its outcomes. Before commencing the data collection of this thesis work, the preliminary data gathered by my supervisors during the previous study was analysed to prepare the interview guidelines. As suggested by Walsh *et al*. (2015), the data gathered should constantly be compared to previously collected data for identification of similarities and differences. New empirical incidents were analyzed and compared with previous data to see if data continues to support the emerging theoretical patterns. The Industrial Network Approach with the ARA model served as the conceptual framework to capture interaction, and the research analysis followed the systematic combining approach grounded in an objective logic (Dubois and Gadde 2002b), see the details in the section 3.4.2.)

Data collection: sub-study Efficient Load Out (ELO)

The empirical data was collected through sixteen semi-structured interviews. See Table 1 that summarizes the list of interviewees, their roles in the organization, duration of each interview, and the time period of data collection. All the interviews were recorded and subsequently transcribed. Participants were purposively selected for their direct involvement that included representatives of the main construction contractor (CC), the truck group conglomerate (TGC) with its separate companies the truck manufacturer (TM), the truck construction equipment company (TCE) and the truck technology developer company (TT) as actors from the automotive industry, and two subcontractors: transport & logistics subcontractor (SC1) and transport & logistics service provider (SC2). This sub-study gave opportunities to collect data over time, as well as to capture the changes that took place in the innovation process in its different phases. The data collection retrospectively identified and covered four phases of the innovation process: initiation (year 2020), development (year 2020), pilot (year 2022), and scale-up (year 2023) (the phases are identified based on the results from paper one). Interview data for the initiation and development phases were collected retrospectively in 2021, whereas follow-up interviews relating to the pilot and scale-up phases were conducted in 2023. In addition, data was collected by observing a meeting (in 2021) when the involved parties discussed how the Efficient Load Out application could be developed further.

Table 1- Interview list, Sub-study ELO

	Firms	**Title**	**Duration**	**Time period of data collection**
1	CC- Construction contractor	Project development manager	1h 30 m	2021
2	TCE - Truck construction equipment company	-Road Business Development Manager	1h 10m	2021
3	TCE - Truck construction equipment company	Program Leader Service Solutions Emerging	1h 20m	2021
4	TGC-Truck group conglomerate	Services Strategy manager	1h	2021
5	TGC-Truck group conglomerate	Portfolio Director	1h	2021
6	CC- Construction contractor	Nordic Business Development Engineer	1h	2021
7	SC1-Sub contractor- Transport & logistics sub-contractor	CEO	1h	2021
8	TT-Truck technology developer company	Service innovation manager	1h	2021
9	TGC-Truck group conglomerate	Business development in new services	1h	2021
10	CC- Construction contractor	Production manager	1h	2021
11	CC- Construction contractor	Block Manager Excavation and Foundation	1h	2021
12	SC2 - Sub contractor - Transport & logistics service provider	Transport Supervisor	1h	2021
13	SC1-Sub contractor- Transport & logistics sub-contractor	Manager - Future development transport	1h	2021
14	CC- Construction contractor	Infrastructure manager – Design	2h	2023
15	CC- Construction contractor	Head of research and innovation	1h	2023
16	TCE - Truck construction equipment company	Product manager	1h 10m	2023

Data collection: sub-study Smart Vests

The empirical data was collected through eleven semi-structured interviews, see Table 2 that summarizes the list of interviewees, roles in the organization, duration of each interview on the time period of data collection. All the interviews were recorded and subsequently transcribed. The interviews included many participants from the various departments of the main construction contractor organization, i.e., research and innovation team, health and safety coordinators at infrastructure department, project site administrators as well as safety coordinators who were directly or indirectly involved in the innovation project. Also, the main technology developer who was the main actor for the initiating and co-developing the product and owns the Smart Vests. Additionally, the interviewees included academic researchers from research institutes and university were involved in advising for safety development in relation to road works. In addition, data was collected by a site observation that was conducted by me during 2025, to observe and understand the functionality of the Smart Vests that are being used in an ongoing infrastructure project.

Table 2- Interview list, Sub-study Smart Vests

	Fims	**Title**	**Duration**	**Time period of data collection**
1	Construction contractor	Digital innovation manager (R&I)	1h	2024
2	Construction contractor	Digital innovation manager (R&I)	45min	2025
3	Construction contractor (Infrastructure)	Health and safety officer	1h	2025
4	Construction contractor	Health and safety representative on site	1h	2025
5	Construction contractor (Projects)	Health and safety representative on site	1h	2025
6	Construction contractor (Projects)	Site administrator	1h	2025
7	Construction contractor (Projects)	Water treatment plant manager	45min	2025
8	Construction contractor	Work environment manager	1h	2025
9	Technology development company	Owner	1h	2024
10	University	Researcher and Professor	1h	2025
11	Research Institute	Researcher	30 min	2024

3.4 Research process

This section outlines the research process in detail by presenting the research timeline and thereafter, presenting the systematic combining approach which was used for data analysis and through which the "case" has emerged.

3.4.1 Research timeline

Figure 4 illustrates my research process from start of this PhD work till finalizing this licentiate thesis and the licentiate seminar, which will take place in February 2026. The illustration highlights the 'milestone' for the major events that took place to shape this PhD education from August 2023 till February 2026. The 'phase' is the time period for the data collection, academic courses and writing for this thesis(kappa). The red circles indicate the three reference group meetings held during the two and half years.

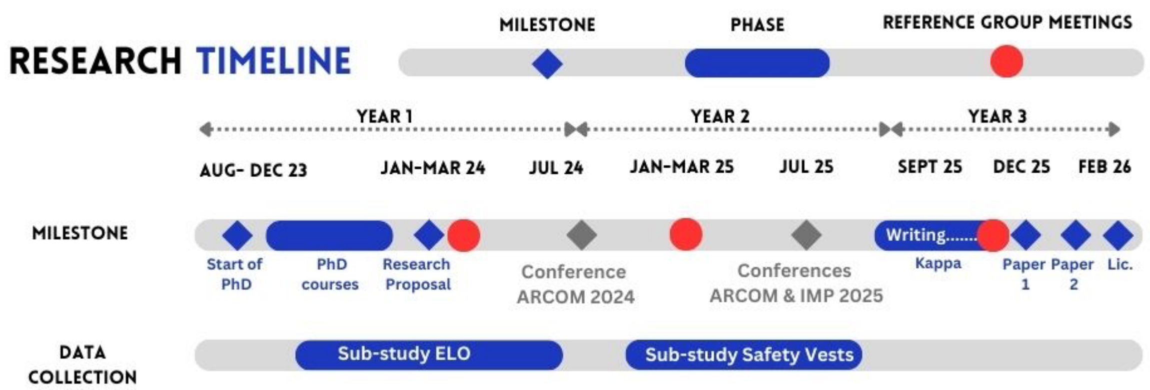

Figure 4- Research Timeline

The research commenced with clear research context and brief from my supervisors (detailed in section 3.1), grounded in exploring inter-organizational innovation processes for digital solutions in infrastructure construction. Rather than focusing narrowly on individual companies or actors, the research adopted the Industrial Network Approach (INA) perspective, recognising that business relationships and their characteristics are shaped by specific interactive patterns resulting from the interplay of, activities, resources and actors.

During the first six months (August 2023-January 2024) of my PhD journey, I was reading and synthesising literature on construction innovation and the Industrial Network Approach, collecting data in the sub-study ELO, and started to address research methodology. I also took some advanced PhD courses such as qualitative research methods, organization theory course that helped me to compile some of the course work into a research proposal report which was presented in a formal seminar in February 2024. In the seminar, a senior professor, Lars-Erik Gadde was the discussant.

Furthermore, I did the data collection for sub-study ELO, are presented in 3.3 section. Based on the findings from ELO, I wrote a conference paper for ARCOM, that was peer reviewed and submitted. The conference paper formed the basis for paper one that focuses on cross-industry innovation (CII) to explore the dynamics of an innovation network in construction. Paper one has now been published in "Construction Management and Economics" as of January 2026. Simultaneously to writing Paper one, I began data collection for the sub-study Smart Vests, see the details of data collection outlined in 3.3 section. During the analysis of Smart Vests, the idea for paper two emerged, integrating both sub-studies ELO and Smart Vests as complementary studies to show the contractor´s role for collaborative innovation with cross-industry actors. Further, I wrote another conference paper, that focused on the contractor´s role in taking the interactive perspective in initiating innovation networks. Paper two was peer reviewed and presented at 2 conferences, where one conference had the construction focus (ARCOM conference) and the other conference had the industrial network perspective (IMP conference). Two conferences with different foci offered valuable feedback that helped me to strengthen the analysis and contributions. Paper two has now been further developed into a full paper intended to be submitting to journal. Paper one and Paper two are the appended papers in this thesis, based on which I have developed and wrote the kappa for this licentiate thesis. The detailed analysis for this thesis is explained in section 3.4.2. Accordingly, the aim of this thesis focussed to explore cross-industry innovation networks in the construction industry. The study pays particular attention to how the role of the construction contractor is shaped through interaction.This research is guided by two research questions: (1) How does interaction unfold in cross-industry innovation networks within and across project, organizational, and industry levels? and (2) How is the role of the construction contractor characterized in innovation processes within cross-industry innovation networks?

Additionally, Figure 4 illustrates the three reference group meetings held (indicated by red circle shape) involving representatives from various construction companies and academic institutions in Sweden as explained in section 3.1. These meetings served to present the ongoing progress of my research, obtain expert feedback, and iteratively improve both analysis and contributions of this research. In line with Bluhm et al. (2011), the use of reference groups function as part of a broader set of qualitative approaches, with strong potential to advance research beyond traditional designs. This transparent and iterative engagement with practitioners and academics reinforced the credibility and practical relevance of the study.

Through this multi-stage iterative process, involving conference presentations, peer review, reference group feedback, and after refinement for journal publication, the study maintained a consistent trajectory of research quality and trustworthiness. The research questions evolved from an initial focus on inter-organizational innovation processes to explicitly centre on the interaction within cross-industry innovation network as a central phenomenon. This transparent methodology demonstrates how the research has maintained methodological rigor and consistency, thereby enhancing trust and confidence in the findings presented.

3.4.2 Systematic combining approach

This research employed a systematic combining approach, forming an abductive methodology that integrates iterative engagement with theory and empirical material (Dubois and Gadde, 2002b). This approach was particularly suited to exploring the emerging phenomenon of interaction in cross-industry innovation networks in the construction industry, as it allowed the research focus to shift and develop as and when new empirical insights emerged and theoretical understanding deepened. This methodological approach is particularly suited to research context requiring explanation of contact specific dynamics and the systematic process of direction and redirection, (Dubois and Gadde 2002b, Siggelkow 2007), allowing the researcher, me, in my case, to tell the story of interaction in cross-industry innovation networks in the construction industry, with a particular focus on the construction contractor role.

The research initially focused on inter-organizational innovation processes within construction projects. However, through iterative analysis between the four aspects, (empirical world, framework, theory and the case) (see Figure 5), the focus evolved to center on interaction within cross-industry innovation networks. Empirically, the two sub-studies covered interaction across industries. In literature, I discovered research on so called cross-industry innovation (CII) (Carmado-Lavado *et al*. 2023). Throughout this process, theoretical literature on inter-organizational innovation, construction innovation, and the Industrial Network Approach (INA) was continuously matched with the two empirical sub-studies. Drawing on INA as the primary theoretical lens, additionally incorporating concepts of time and space within INA, a conceptual framework of interaction in cross-industry innovation (CII) was developed (see Figure 2), to explicate how interaction unfolds across project, organizational, and industry levels.

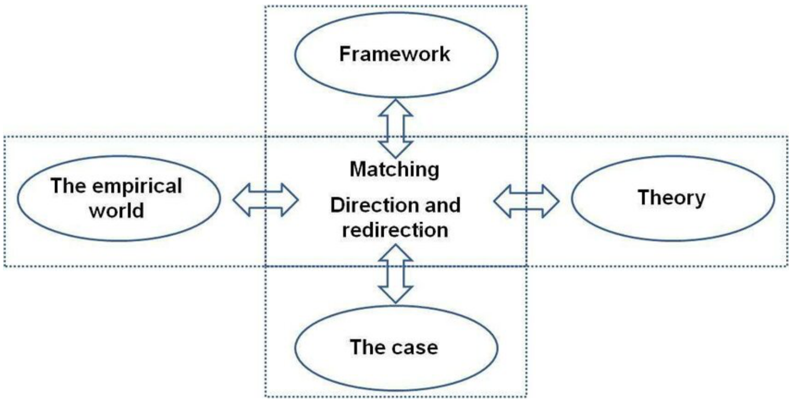

Figure 5- Systematic combining
(Adapted from: Dubois and Gadde 2002b)

Sub-study ELO concerns the innovation process between a construction contractor and an automotive industry partner (truck manufacturer) focused on developing a digital application for managing excavated material logistics. The innovation emerged from a need to address sustainability and efficiency challenges on a large infrastructure construction project involving underground railway and station construction. The construction contractor and truck manufacturer, drawing on their prior relationship, initiated an innovation process to tackle problems related to the transportation of excavated masses—specifically, optimizing truck loads to reduce environmental impact and improve operational efficiency. The analysis of ELO revealed four distinct phases of innovation: initiation (identifying the problem and establishing the collaborative partnership), development (designing and building the digital solution), testing (implementing and refining the application in the project context), and scaling (extending the solution beyond the initial project). Throughout these phases, the study identified critical interactions, interdependencies, roles, challenges, and enablers within the network that shaped the innovation process.

Sub-study Smart Vests concerns the innovation process between the construction contractor's research and innovation team and a technology startup developing wearable safety devices for construction and road work environments. The innovation addressed critical safety challenges in high-risk work environments, leveraging machine learning technology integrated into smart vests to detect falls and automatically alert emergency responders. This sub-study was analyzed through the lens of the contractor's coordinating role across multiple levels: project level (how the technology was tested and integrated into specific work environments), organizational level (how the contractor's innovation team championed and facilitated the collaboration), and industry level (how the partnership emerged due to encounters at industry level forums, establishing new capabilities and knowledge exchange between construction and technology development industries)

Both sub-studies share common characteristics that became important for the case analysis. Both studies involve the same construction contractor as the focal actor (although different teams for both studies), in terms of where the data collection began. Both sub-studies illustrate co-development of digital solutions with external partners from other industries, and the innovations emerged in relation to project settings and construction production as infrastructure construction sites and provided great value to the external industry actors through access to the project site and real-world testing environments. These common characteristics served as a foundation for analyzing the two sub-studies together as a unified case. However, the detailed systematic combining analysis for sub-study ELO was first conducted separately in paper 1, aiming at exploring the question, how a cross-industry collaborative innovation network evolves in a construction setting? Followed by detailed analysis of sub-study in paper 2, aiming at exploring the question, how does construction contractors as innovation champions (R&I teams) facilitate innovation by engaging in inter-organizational activities in interaction with actors within and across industries? The results are presented in the appended papers (see Papers 1 and 2 for stepwise explanation of the analysis). For this thesis text, the kappa text, the combined analysis of both sub-studies provides integrated insights into cross-industry innovation networks in the construction industry.

First, taken together, the results from the two sub-studies includes the spatial and temporal dimensions of interaction in cross-industry innovation networks, specifically addressing RQ1. Second, taken together, the results from the two sub-studies on how the contractor coordinates activities, demonstrates championing characteristics, engages in boundary spanning activities, and facilitates knowledge exchange, along with different roles in different phases of innovation, demonstrating that the contractor role is contingent on the roles of others, formed the results for RQ2. The analysis also highlighted challenges of intra-organizational connection and diffusion of innovation. Through this combined analysis, the case is a case of "construction contractor involvement in cross-industry innovation networks for digital solutions" emerged as the outcome of systematic combining. The two sub-studies together illuminate how interaction unfolds in cross-industry innovation networks in construction, providing a comprehensive understanding of the research phenomenon.

3.5 Reflections on the quality of the study

It is important to transparently show that the conducted research is of good quality and that the researcher is aware of the choices made and their consequences. To that extent, all sections of chapter 3 have an important role in the form of being "evidence". Accordingly, how convincing the presented interplay between method, case, and theory has been for the reader is therefore important for evaluating the quality of the study in case-based research (Dubois and Gibbert, 2010). To that extent, what has been presented in Chapter 3 prior to this section 3.5, are most important in terms of quality of the study

Trustworthiness in qualitative research ensures the credibility, transferability, dependability, and confirmability of findings (Lincoln and Guba 1985). This chapter addresses these four aspects as part of this thesis work's design and execution. The iterative refinement process following systematic combining enhanced trustworthiness through multiple stages (see 3.4.2). Credibility concerns the authenticity and accuracy of the findings—ensuring that the research reflects participants' experiences and the empirical reality being studied. This PhD project was structured from its inception in August 2023 to ensure credibility through iterative refinement at multiple stages. The systematic combining approach contributed to credibility by allowing continuous matching between empirical observations and theoretical concepts, grounding interpretations in both data and theory rather than researcher assumptions. Credibility was strengthened through triangulation, employing multiple data collection methods including interviews, observations at construction sites and project meetings. This methodological triangulation allowed different sources of evidence to corroborate findings. Statements from interviews were sometimes cross-checked to clarify and confirm the intended meaning. Prolonged engagement with the case organization and discussions with the reference group provided feedback that supported interpretation and trust in the results

Transferability assesses the extent to which findings apply to other contexts. This study provides extensive contextual detail about the two sub-studies (ELO and Smart Vests), the construction contractor, external actors, and the specific projects where innovations were tested, allowing readers to assess the relevance of findings to other settings. The analytical framework examining interaction in cross-industry innovation networks using Industrial Network Approach (INA) theory can be applied to other contexts than the construction industry that involves cross-industry innovation process studies. However, the systematic combining methodology itself is highly case-dependent and iterative. The continuous direction and redirection based on emerging findings is specific to each research context and cannot be transferred directly without significant adaptation. Researchers seeking to apply the analytical framework to other contexts would need to develop their own systematic combining processes tailored to their specific phenomena. That in turn, would generate new insights.

Dependability demonstrates that the research process is consistent and built on sound methodological procedures. A research proposal report documented the research objectives, theoretical foundation, and planned methodology before additional data collection began. The research process, as described in this thesis, outlines the structure and procedures followed: qualitative research method, case-based research and the systematic combining approach. Supervisors' involvement in terms of reading and discussing throughout the research process provided oversight that contributed to rigor and consistency. Documentation of data collection methods provides transparency about the basis for findings.

Confirmability ensures that findings emerge from data and empirical observations rather than researcher bias. The systematic combining approach incorporates reflexivity by requiring continuous engagement with both theory and empirical material. Iterative matching of theory and reality forces the researcher to confront contradictions and revise interpretations when data do not align with theoretical expectations. Peer debriefing with supervisors and reference group members provided external validation of interpretations and analytical decisions. The reference group's involvement was valuable, as experienced practitioners could assess whether findings aligned with their understanding of the phenomena. Transparent coding practices were employed in both sub-studies. For Smart Vests, the three-level framework (project, organizational, and industry levels) provided a documented structure for categorizing data. For ELO, thematic analysis was employed based on theory and INA concepts for categorizing data (see details in Paper 1). These approaches reduce the possibility that findings reflect arbitrary or biased categorization.

Ethical consideration

The research was conducted with the highest standards of integrity, transparency, and fairness. Informed consent was obtained from all participants after they were fully briefed on the project's purpose and how their statements and recordings would be used. Participant privacy was safeguarded by ensuring anonymity in all citations and quotations. No deliberate deception occurred at any stage of the research process. The storage and management of data were handled with strict confidentiality in accordance with research ethics guidelines.

Transparency

The research process is designed to assure readers of the trustworthiness and usefulness of the findings. Detailed descriptions of the research context, evolution of the research focus, theoretical framework, case structure, and systematic combining approach contribute to transparency. This allows readers to evaluate the study's quality and assess the relevance of findings to their own contexts. In the interest of full transparency, this thesis acknowledges that ChatGPT-4 was employed solely for language improvement and refinement. Prompts explicitly requested grammar and sentence structure enhancement while preserving the original meaning, maintaining technical accuracy, and preserving all relevant references. This use of AI was limited to linguistic enhancement and did not influence the substance, analysis, or findings of the research. Through the combination of credibility, transferability, dependability, confirmability, ethical integrity, and transparency, this study meets the standards of trustworthiness expected in qualitative research. These measures ensure that the findings are rigorous, meaningful, and useful to the construction industry, researchers, and other stakeholders interested in understanding cross-industry innovation networks.

4. Summaries of the Appended Papers

This section summarizes the two appended papers, highlighting their aims, methodologies, key findings, and main contributions. Table 3 provides an overview of how each paper relates to the two research questions.

4.1 Summary of paper one

Paper 1: Cross-industry innovation: Exploring the Dynamics of an Innovation Network in Construction.

Aim: The paper explores how a cross-industry collaborative innovation network evolves within a construction context. Specifically, the study conceptualizes collaborative innovation between actors from the automotive and construction industries engaged in a co-development initiative of a digital application known known as "Efficient Load Out". The theoretical grounding is based on two main themes: collaborative innovation in construction, and actor roles in cross-industry innovation.

Method: A qualitative, case-based research approach was used, following systematic combining with an iterative, cross-feeding process of theory and empirical reality. Data were gathered through 16 semi-structured interviews with representatives of the main construction contractor (CC), the truck group conglomerate (TGC) with its separate companies the truck manufacturer (TM), the truck construction equipment organization (TCE) and the truck technology developer organization (TT), and two subcontractors: transport & logistics subcontractor (SC1) and transport & logistics service provider (SC2). A conceptual framework "interaction in cross-industry innovation" (Figure 2 in this thesis) was developed in this paper and served as as the analytical foundation. Drawing on the Industrial Network Approach (INA), the study examines how interdependencies and interactions shape the dynamics of innovation within a cross-industry context.

Findings: The results are organized across four phases of the innovation process: initiation, development, pilot, and scale-up, and capture the interaction, and evolving roles of the two actors that forms the focal relationship. Three primary dynamics were identified:

1.**Interaction Dynamics:** This study contributes by showing insights into the dynamic features of 'context dependency' emphasizing network interdependencies among heterogeneous resources, activities, and actors in across industry innovation network. In terms of key features of the interaction, there was a shift of dynamics from a strong focus on exploring actor bonds (initiation phase), strong resource ties (development phase) and activity links (pilot phase), to weak actor bonds resource ties and activity links due to low interaction intensity(scale up phase). Interaction intensity shifted from high to low across phases.

2.**Organizational interfaces:** Changing interaction patterns and degrees of actor involvement resulted in distinct interface types—interactive, translation, specified, and standardized. These interfaces explain how joint development occurs across different stages of innovation, offering a rich understanding of innovation network evolution.

3.**Shifting actor roles:** Roles evolved alongside changing interactions and interfaces. Construction actors faced particular challenges in sustaining benefits from innovations because of the project-based nature of implementation, making scalability difficult. Role shifts were driven by variations in knowledge, resource access, and industry specificity.

Contributions:
The study extends construction innovation literature by exploring the dynamics of interaction and interdependencies in innovation processes from initiation to scale-up. It contributes to understanding how interaction, organizational interfaces, and actor roles constitute the context of innovation and how that in turn, affects the development and implementation of an innovation, that is the implications of relative boundedness and context dependency of innovation processes. This research offers practical insights for construction contractors' dynamic roles in cross-industry innovation by revealing how network interdependencies and relationship features influence collaborative outcomes and clarify the associated competences required to advance an innovation process.

4.2 Summary of paper two

Paper 2: An interactive perspective on the activities of construction contractors' innovation champions: Boundary spanning in cross-industry innovation networks

Aim: This study aims to explore the activities of the construction contractor as an innovation champion involved in cross-industry innovation. Grounded in the innovation champion literature, the study focuses on the innovation activities of an innovation champion teams in construction acting in the settings of projects, organizations and industries in cross-industry innovation networks.

Method: The study draws on the Industrial Network Approach (INA) to conceptualize innovation as an interaction process. A qualitative case-based research design is used based on two sub-studies, which identifies the Swedish construction contractor's research and innovation (R&I) teams as innovation champions. The first sub-study, Efficient Load Out (ELO), concerns the development of a digital application in collaboration with the automotive industry. The second sub-study, Smart Vests, concerns the development of a digital safety solution in collaboration with the technology development industry.

Findings: The findings show that innovation championing in construction is not limited to promoting ideas or overcoming internal resistance, but is enacted through activity linking across project, organizational, and industry levels, forming complex activity patterns of which innovation activities become embedded. Accordingly, the innovation champion sustains network building, by interactive activities maintained and developed over time. Consequently, boundary spanning activities to facilitate the innovation process may challenge established activity patterns, or be restrained by existing activity patterns, hence, the resistance, or difficulty of scaling innovation in the construction industry

Contributions:
Applying INA, the study contributes to the interplay of interactive activities between internal and external innovation networks across project, organization and industry levels where research has been limited. This study provides valuable insights into the role of construction contractors as innovation champions, emphasizing their active involvement in driving innovation through a diverse set of activities that vary between the initial and later stages of the innovation process. This multi-level boundary spanning activities by innovation champion teams address the inherent fragmentation of project-based organizations demonstrating that innovation is not confined to project settings but is intricately connected to the home organization, collaborating organizations, and the broader innovation network.

4.3 Overview of how the papers are related

For RQ1, which explores how interaction unfolds across project, organizational and industry levels in cross-industry innovation networks, paper one provides the primary contribution showing insights into the dynamic nature of interaction during innovation network formation throughout the phases of the innovation process. Paper two provides the secondary contribution to RQ1 by analysing activity links that are contingent on the interactive activities undertaken by the construction contractor at project, organization and industry levels.

Regarding RQ2, the role of the construction contractor characterized in innovation processes within cross-industry innovation networks, paper two provides the primary contribution by examining activity interdependencies in-depth in terms of the construction contractors' innovation champions. Paper one provides secondary contribution highlighting the shifting actors' roles throughout network evolution, including identifying the innovation champion role of the construction contractor, but not analysing it further.

Table 3- Overview of how each paper relates to the two research questions

	Paper 1 **Cross-industry Innovation : Exploring the Dynamics of an Innovation Network in Construction.**	**Paper 2** **An interactive perspective on the activities of construction contractors' innovation champions: Boundary spanning in cross-industry innovation networks**
RQ1 **How does interaction unfold in cross- industry innovation networks within and across project, organisational and industry levels?**	● Emphasises the dynamic nature of interaction, cross-industry innovation network formation, and phased evolution of the innovation process that is highly context depedent and varying in time and space	◐ Contributes with insights on the interactive activities undertaken by the construction contractor at project, organization and industry levels.
RQ2 **How is the role of the construction contractor characterized in innovation processes within cross-industry innovation networks?**	◐ Highlights shifting actor roles in cross-industry innovation network evolution, including the contractor characterised as an innovation champion.	● Provides an interplay of interactive activities by champion teams in the innovation network, contingent on other roles and complexity of multi level coordination.

● Primary contribution ◐ Secondary contribution

Table 3 illustrate the relation of how the two papers are related to the research questions. Together, the two papers present a cohesive and complementary understanding of interaction in cross-industry innovation in the construction industry. Whereas interaction is inherently embedded in space and time, the papers differ in terms of how this is reflected in their findings. Accordingly, paper one presents its findings in accordance to the identified innovation phases in regard to the cross-industry innovation network, thus, 'a logic of following the cross-industry innovation process'. Paper two presents its findings in relation to 'a logic of following the cross-industry network structure', explaining how boundary spanning activities undertaken by the construction contractor's innovation champions relate to project, organization and industry levels. The combined insights capture both the structural and functional dimensions of interaction and role transformation within cross-industry innovation networks, providing a holistic understanding of innovation dynamics in the construction context.

5. Results and discussion

This chapter discusses the key findings from the two sub-studies in this thesis in relation to the two research questions. The discussion is drawing on the theoretical background (literature) in the fields of, i.e., inter-organizational innovation in construction, cross-industry innovation in construction, actor roles in construction innovation and the theoretical framework (the INA). The first section (5.1) presents results and discussion on interaction unfolding across time and space, thus, addressing research question 1. This section is in turn structured in three sub-sections covering the project level, the organization level and the industry level. The second section (5.2) covers the results and discussion regarding the role of the construction contractor, hence, addressing research question 2. The subsections of this part cover the different roles in different phases of innovation, how the contractor role is contingent on the roles of other actors, and concludes this by addressing the challenges of diffusion of innovation. The third section (5.3) presents the theoretical and practical contributions.

5.1 Interaction unfolding across spatial and temporal dimensions

At a specific point in time the interaction in a cross-industry innovation network will be dealing with particular issues. Furthermore, interaction does not only take place at a certain point in time, but also in a specific space, characterised by one, or more, relationships. The research phenomenon of this thesis explores these characteristics in cross-industry innovation networks. Project, organizational and industry levels represent various 'spaces' in which interaction takes place, that is, spatial settings, defined by various characteristics, abilities and logics, that affect the innovation process. Those 'spaces' are also characterized by certain temporal features, which affect the innovation process. Consequently, interaction in cross-industry innovation networks unfolds differently at the project, organizational and industry levels but remains tightly interconnected through evolving activity links, resource interfaces and actor roles, as conceptualized in the INA framework. Across both empirical sub-studies, these multi-level interactions shape how digital solutions are developed, tested and scaled, revealing construction projects as critical arenas for cross-industry innovation. This research thereby responds to the call by Havenvid *et al*. (2019), Bygballe and Ingemansson (2014) and Reichstein *et al.* (2005) for studies of inter-organizational interaction patterns and innovation processes in the construction industry, extending this inquiry into cross-industry contexts, involving the automotive and technology development industries. The discussion below focuses on how interaction unfolds across space and time dimensions in the two empirical sub studies, ELO and Smart Vests, to illuminate the temporal and spatial complexity of cross-industry innovation in construction.

5.1.1 Interaction unfolding at the construction project level

The construction project functions as an important interaction space as a resource constellation crucial for developing and testing the innovation in a real time day-to-day construction production setting. The construction site is also the resource constellation where the innovations ultimately are going to be used and implemented, making it essential to adapt the digital solution in terms of how the production activities are carried out when the digital solutions are deployed as to assure the right features of the solution. The project level is where heterogeneous resources are combined and actor bonds are formed and strengthened, making the project a vital learning arena but fundamentally challenging for cross-industry innovation, as the temporary and fragmented project logic makes it difficult to secure long-term innovation outcomes and scaling (Bygballe and Ingemansson 2014).

At the construction project level, interaction in cross-industry innovation is problem-driven within the temporary, loosely coupled project logic (Dubois and Gadde, 2002). In both sub-studies ELO and Smart Vests the innovation process responded to immediate project needs. Araujo et al. (1999) identify that interactive interfaces based on open-ended dialogue and joint problem-solving create strong conditions for learning and exploratory innovation. However, when construction actors engage in cross-industry innovation, these organizational interfaces become spatially grounded in the construction site and temporally bounded by project schedules, characterising construction innovations as emerging within temporary alliances of organizations (Slaughter 1998). Yet, for the automotive and technology development counterparts, the project serves as a controlled testing environment with connections extending beyond the project time-frame to more lon-term service development, business opportunities and market positioning. This divergence between construction's project-bound urgency and other industries extended temporal horizons creates an asymmetry in how actors interpret and leverage project-level activities. This pose challenge for long-term scaling for construction contractors, in line with inter-organizational innovation challenges identified in construction literature (Håkansson & Ingemansson, 2013; Harty, 2008). Hence, in construction, as each project is fragmented and to some extent independent, resource development for innovation at the project level must align to organizational level structures to enabling scaling of the innovation, highlighting the need to link project interaction spaces with more permanent organizational networks.

In temporal terms, interaction episodes at the project level are interconnected over time, forming cumulative evolution rather than isolated events (Håkansson *et al*., 2009). Yet in cross-industry innovation settings, these episodes involve distinct logics stemming from the construction industry in relation to other industries, reflecting their network interdependencies – making the analytical challenge not simply showing that one episode follows another in time, but tracing how interpretations, priorities and decisions of actors from one episode shape what becomes possible or difficult in the next. The time invested in linking these episodes across project duration is generative: time enables actors to revisit past interactions, gradually co-create shared understandings and renegotiate expectations essential for cross-industry innovation.

5.1.2 Interaction unfolding at the organizational level

At the organizational level, relating to the ELO study, the truck group conglomerate's internal organizations (TM, TCE and TT) translated "project space insights" into more stable resource combinations, formal roles and development processes in their own organization environments.

Hence, innovation depends on how firms embed learning in their permanent networks (Bygballe & Ingemansson 2014, Havenvid *et al*. 2019).

In ELO, a striking contrast emerges in terms of organizational structures and how those relate to the construction project level. For the automotive industry actors, the organizational structures for scaling innovation were already in place. They possessed internal R&D processes, service deployment models and multi-project coordination capabilities. For the construction contractor, translating project learning into organizational routines was more challenging. This relates to the concept of "openness" as described by Laage-Hellman *et al.* (2021), and specially on the degree of openness that varies with context. In ELO study, the degree of openness was lower despite a long-term past relationship between the construction contractor and the automotive actors that formed the basis for initiating the innovation project and to implement the innovation solution. The degree of openness featured lower due to the contractor's limited technological understanding that created barriers to understand the importance of the use of 'data' in the digital innovation, while automotive actors had sufficient knowledge and aim to use the capabilities to expand their business. This asymmetry meant construction actors had to construct entirely new knowledge bases whilst simultaneously engaging externally in the cross-industry innovation network.

In contrast, in the sub-study Smart Vests, the construction contractor was involved in the new relationship with the technology development actor, yet the relationship between the actors demonstrated higher degree of openness in the CII network, engaging actively with technology developers around fully understanding the technical concepts and joint R&D activities focused on safety and digitalization. However, this external openness with the new, potential actor did not help to translate the insights internally with the purchasing department at the contractor organization. Hence, operations and workflow mechanisms across the construction contractor's spatial organizational structure remained unaligned, preventing systematic embedding of innovation implementation across projects despite demonstrated potential. What this empirical studies reveal is that the degree of openness is contextual, i.e., determined not simply by relationship history but by whether constraints are knowledge-based in ELO study: i.e., established relationships, external knowledge barriers requiring extended temporal learning. Or on the other hand, coordination-based in Smart Vests study: new relationships, internal spatial-organizational embedding barriers, and whether firms possess the organizational infrastructure to translate external CII collaboration into permanent routines across space and time.

Cross-industry innovation literature concludes that adapting external ideas can lead to efficiency and competitiveness gains (Enkel and Mezger 2013). This research reveals the complexity in terms of this 'adapting', as adapting is context-dependent in terms of that an innovation, has to be embedded as to provide value in its use context. I.e., a smooth joint development at the project level does not automatically generate organizational conditions for embedding or scaling, and "the efficiency and competitive gains" thus play out differently in regard to various spatial and temporal settings. Rather, sustained innovation requires separate, intentional organizational redesign must align spatial structures (company environments, workflows, coordination mechanisms) and temporal episodes (decision-making cycles, investment timelines, capability development). The research demonstrates two distinct pathways to organizational-level constraint i.e., knowledge asymmetry (where actors lack conceptual capacity to internalize innovation, requiring extended temporal investment) and coordination limitation (where knowledge exists but spatial-organizational mechanisms for cross-project diffusion are absent). This advances cross-industry innovation research by addressing context dependency not as a matter of industry conditions, but cross-industry innovation as featured by interaction dependency. The construction industry's structural fragmentation between project and organizational levels means temporal dimensions at these levels diverge fundamentally whilst spatial configurations remain disconnected. This does not necessarily has to be 'bad' thing, while the project urgency does not create organizational capability for long-term renewal, at the same time, it provides an arena for inventing new solutions and is not restricted by more long term, mature organizational level conditions.

5.1.3 Interaction unfolding at industry level

At the industry level, interaction is oriented towards scaling by aligning the innovation with broader institutional structures. In ELO, in terms of "the broader scaling context" this would represent the continuous use of the innovation by construction industry actors who choose to use it in construction projects. This would not require any fundamental changes in terms of practices, processes or routines, with little collective negotiation of standards, business models and cross-industry applicability. Across both empirical sub-studies, project-level episodes feed into organizational decisions, which in turn condition industry-level positioning, whilst industry structures and expectations loop back into how future projects and organizational strategies are designed (Bygballe and Ingemansson 2014). This feedback and feed-forward dynamic loop illustrate how the three levels are interconnected as spaces through which innovation potentially diffuses.

Yet the spatial configuration of the industry level differs fundamentally from project and organizational spaces. Rather than concentrated sites or bounded company environments, industry-level spaces scatter across hubs, forums and industry bodies, whose boundaries are permeable and not rigid. The connections through which innovation reaches this dispersed space depend significantly on R&D actors whose role bridges organizational innovation and industry positioning. In Smart Vests, attempts to position the smart vest innovation as an industry solution for construction safety depended on establishing channels and credibility within construction networks. Yet construction's fragmented company and network structure made this connectivity difficult compared to more coordinated industries (Larsson *et al.* 2022)

In temporal terms, industry-level episodes accumulate differently than project or organizational episodes: they are less frequent, involve more dispersed actors, and temporal linking becomes analytically challenging. Moreover, the temporal dimension at industry level span years with extended periods between key interactions and its realization becomes far slower. The temporal frequency and spacing of industry-level episodes differs from the dense, frequent interactions at project level. In both sub-studies in this research, cross-industry actors must invest substantial time in relationship-building, standards negotiation and industry positioning activities extending far beyond project completion and requiring sustained commitment that construction's project-based logic does not naturally support. However, the three levels are interconnected as spaces, yet due to the time dimension, interaction does not unfold as expected. Project-level learning does not automatically translate to organizational embedding, and organizational innovations do not necessarily diffuse to industry level. This temporal misalignment extends beyond project-organizational boundaries: project-level innovation intensity does not predict industry-level adoption because temporal dimensions, actor compositions and network logics differ fundamentally at each level.

CII outcomes require translation at multiple levels, from adapting technical features to construction contexts (project level), embedding learning in permanent organizational structures (organizational level), and positioning solutions within business networks and practices (industry level). Construction's fragmented company and network structure makes this multi-level translation particularly challenging, distinct from more coordinated industries where industrial mechanisms for diffusion exist. This advances construction innovation understanding by explicitly centring temporal and spatial dimensions of inter-organizational processes (Bygballe and Ingemansson 2014, Havenvid *et al.* 2019). Construction innovation research has often been framed around the implementation of innovations and their realized outcomes at the level of individual projects (Slaughter 2000, Winch 2003), with less attention to longer-term, industry or firm-level learning dynamics with limited attention to how innovations unfold across time and levels. From an INA perspective, innovation advancement depends on managing temporal and spatial coordination across project, organizational and industry levels – a capability that construction's project-centric governance does not inherently provide.

5.2 Role of the construction contractor in cross-industry innovation networks

The roles of actors in cross-industry innovation are not fixed and cannot be understood solely as generic roles, for example, “a construction contractor” or “a client”. Roles are dynamic and evolves in interaction as a result of changes in interaction patterns in space and time and shifting interfaces. The discussion here focuses particularly on the evolving role of the construction contractor, and this role vis-à-vis others.

5.2.1 Different roles in different phases of innovation

In the ELO, representatives from the construction contractor organization initiated the innovation and provided the project site as a testbed. Sub-study ELO in paper two reinforces this by showing how the construction contractor innovation champion teams actively identify opportunities for innovation and articulate needs across project sites. This resonates with work recognizing contractors as possible innovation sources (Slaughter, 1993; Keung & Shen, 2017), but, this research shows that even more important than identifying opportunities, are the roles played throughout the innovation process. This complements research highlighting the role of construction contractors in fostering innovation within construction projects (Eriksson 2013, Eriksson *et al.* 2017).

The actor roles are closely tied to network interdependencies and organizational interfaces. The findings from the ELO sub-study identify that the roles of the construction contractor and the truck group conglomerate shift across the four phases of innovation. Where, on the one hand, the construction contractor role shifts from being an innovation initiator to being champions and further as a contributor of feedback then, shifting to finally becoming as a user of the digital solution. On the other hand, the automotive actor's role shifts from being initiators to becoming main developers, further shifting to as a pilot lead to finally becoming service providers, while subcontractors oscillate between supporting implementers and feedback providers (see paper one for a detailed explanation). These shifts reflect cross-industry innovation characteristics where, inbound knowledge transfer (construction problems informing automotive solutions) evolves into coupled CII (joint development and testing of digital solution) and outbound CII (scaling and standardised services) (Carmona-Lavado *et al* 2023; Gassmann *et al* 2011) , with changing interfaces from interactive and translation in early phases to specified and standardised interfaces in later phases, enables adaptations across industries . This also echoes INA research on how actor role configurations relate to changing resource constellations and activity patterns (Bygballe *et al*., 2015; Havenvid *et al* 2016). Sub-study ELO in paper two highlights that construction contractors, through their multi-level activities, sometimes act as champion teams facilitating innovation ideation activities, and for bringing together construction and technology developing industry boundaries and facilitating cross -industry innovation activities. They sometimes act as boundary spanners between the project setting and innovation network for innovation co-development and testing activities. This is in line with earlier studies (Slaughter 1993, Drechsler *et al.* 2021) on activities and influences of innovation champion roles. These actor roles change, depending on activities that stabilise changing interfaces across project, organizational and industry levels. However, the project-based nature of construction makes these shifts particularly challenging, as construction actors often cannot fully capture long-term benefits from innovations implemented in time-limited projects, reinforcing findings on the relative boundedness and path-dependence of construction innovation (Dubois and Gadde 2002a, Harty 2008). The thesis findings highlight the shifting roles of the construction contractor, and additionally highlight the challenges associated for scaling-up the innovation and using it across projects.

5.2.2 The contractor role is contingent on the roles of others

The findings show that the construction contractor's role in cross-industry innovation is relationally contingent, emerging from and depending on the roles and activities of other actors in the network. In the cross-industry setting relating to ELO, the construction contractor's innovation activities were shaped by how automotive and technology partners structured their development processes. The construction contractor could only act as a coordinator and co-developer to the extent that these partners were willing to engage in joint problem solving and sharing of knowledge, emphasising openness as a pattern of R&D-related interaction across established collaborative relationships (Laage-Hellman *et al.* 2021). The construction contractor's ability to coordinate, translate, and stabilize innovation depended on how other actors positioned themselves as, technology specialists, automotive digital solution resource providers, or project delivery partners and how far they were prepared to engage in open, co-development interactions across organizational boundaries (Laage-Hellman *et al.*, 2021). In paper two, the contingent nature of the construction contractor's role is further illustrated by the contrast between the two empirical studies. In Smart Vests, the technology developer was an emerging start-up that was highly open and willing to co-develop, actively seeking a contractor champion who could provide opportunities to test and refine their innovative product and thereby build their business. This differs from sub-study ELO, where the large truck group conglomerate was also open to collaboration but did so from a more strategically oriented position, using cross-industry innovation primarily as a means to expand its business in the construction industry in line with overall strategic goals of being a service provider . The construction contractor's role is therefore not simply to "receive" external innovations but to embed them within construction practices, in continual interaction with partners whose roles define what forms of adaptation and integration are possible.

These results support the Industrial Network Approach view that roles are not fixed attributes but are continuously negotiated through interaction, and that they are defined by the pattern of activities, resources and relationships in which actors are embedded (Håkansson *et al*. 2009). They also connect to work on openness in collaborative innovation, which highlights that effective innovation outcomes often require extensive, long-term interaction in established relationships where activities, resources, and actor bonds can be repeatedly aligned and realigned. In this sense, the construction contractor's role emerges as a relational achievement, shaped by what others do, how open they are, and how strongly their R&D and project functions are connected across organizational boundaries.

5.2.3 Challenges of intra-organizational connection and diffusion of innovation

The findings also underscore that it is particularly challenging for the construction contractor to secure intra-organizational connections and thereby diffuse innovations beyond the specific network in which they have been developed, this aligns with the study by Eriksson *et al.* (2017) in terms of that co-creation practices are often confined to individual projects rather than being transferred across projects. While the construction contractor is able to act as a main actor in coordinating in cross-industry innovation projects, the embedding of resulting innovative solutions into the construction contractor's wider organizational routines and future projects is far from straightforward. This difficulty of construction contractors mirrors broader observations in construction innovation research that inter-organizational collaboration can generate novel ideas and solutions, yet fragmentation and weak intra-organizational linkages often hinder their diffusion across projects (Eriksson *et al.* 2017, Satheesh *et al.* 2024).

In the studied construction contractor organization, the R&I teams act as champions within the innovation network but had limited authority and weak structural ties to the core functions of its organization, such as purchasing. This lack of strong intra-organizational interfaces constrained their ability to scaling the innovation (Håkansson and Ingemansson 2013). Without robust connections between the R&I function and other organizational units/teams, innovations risked staying "trapped" at the periphery of the firm, associated with specific projects or pilots rather than being taken up as standard innovative solutions or procurement requirements in future work.

This challenge aligns with Laage-Hellman *et al*. (2021), who argue that successful renewal through collaborative innovation requires not only knowledge and resource exchange across organizational boundaries, but also joint R&D activities carried out by actors with established collaborative relationships. In the construction context, such openness is still relatively underexplored and under-institutionalised compared with other industries (Slaughter, 2000; Bygballe & Ingemansson, 2014). The two studies suggest that, in the absence of explicit coordinating roles linking R&I, purchasing, and project functions, as well as linking the construction contractor's internal organization to its external partners, the potential for lasting renewal is significantly reduced.

Overall, these results highlight an intricate situating in terms of the multiple roles of the construction contractor´s organization: they must simultaneously maintain multiple external roles in innovation networks (coordinator, champion, co-developer, boundary spanner) and multiple internal roles that connect innovation units to core business functions if project-generated innovations are to be embedded and reused in future projects. Addressing this dual challenge is central to overcoming the organizational structural fragmentation identified as a key barrier to renewal in construction networks (Håkansson & Ingemansson, 2013).

5.3 Theoretical and practical contributions

This thesis advances understanding of cross-industry innovation in construction by applying the Industrial Network Approach (INA) perspective, revealing how innovation unfolds as a multi-level, temporally and spatially evolving network process.

5.3.1 Theoretical contributions

Multi-level network conceptualization and relative boundedness
The thesis conceptualises cross-industry innovation in construction as a multi-level, evolving network process where activity links, resource ties, and actor bonds connect interactions across project, organizational and industry levels (Håkansson and Snehota 1995, Håkansson et al. 2009, Bygballe and Ingemansson 2014). Rather than viewing innovation as a project outcome or technology transfer, the research reveals that cross-industry innovation in construction is fundamentally context-dependent: scaling occurs when interdependencies across levels are actively managed, yet the outcomes and implications of scaling differ for each industry actor involved. Harty (2008) identifies this through the concept of "relative boundedness" that the same innovation generates different outcomes for different actors depending on their context, resources and organizational characteristics. The research advances this understanding by demonstrating empirically how the project-organizational-industry levels in construction

creates asymmetric temporal and spatial interdependencies, in relation to other industries' logics of temporal and spatial conditions.

Temporal and spatial unfolding of interaction episodes

The thesis details how interaction episodes co-evolve across innovation phases, shaped by network interdependencies. Drawing on Håkansson *et al*. (2009) the research shows that interaction episodes in cross-industry innovation are interconnected, forming cumulative evolution rather than isolated events, where outcomes from earlier phases (initiation, development, pilot, scale-up) serve as inputs for subsequent ones in the innovation process, but also how historical interaction episodes and expectations on future interaction episodes affect the innovation process. However, in cross-industry settings, these episodes involve distinct logics stemming from the construction industry in relation to automotive and technology development industry, making the analytical aspect challenge one for tracing how interpretations, priorities and decisions from one episode shape what becomes possible or difficult in the next. The novelty of this research highlights the explicit integration of both temporal and spatial dimensions: interaction unfolds through episodes, distributed across project sites, company environments and dispersed industry spaces, with temporal interdependencies at each level diverging fundamentally. This research advances construction innovation literature (Slaughter 2000, Winch 2003), which has traditionally emphasised end-result outcomes with limited attention to how innovations unfold temporally and spatially across interconnected network levels, additionally extending the understanding of the three levels (Bygballe and Ingemansson 2014) in terms of cross-industry innovation, of which studies of the construction industry are scant.

Construction contractor roles in cross-industry innovation networks

The thesis enriches understanding of actor roles in cross-industry innovation by providing an activity-based perspective (Harrison *et al.* 2023) on how contractors evolve across innovation phases. Rather than viewing contractors as static executors, the research shows they perform multiple functions – ideation, collaborative development, testing, and translation activities – across project, organizational and industry levels. Slaughter (1993) identifies various roles for construction actors in innovation processes, including champions in commitment phases; the thesis extends this by showing that contractor champion teams perform bridging and coordination activities across all phases and levels, and contingent on the roles and interdependencies of other actors. Satheesh *et al*. (2024) recognise boundary-spanning roles in inter-organizational collaboration; This research acknowledges the important boundary spanning role that construction contractors can undertake, specifically in cross-industry contexts, connecting construction-specific knowledge and resources with automotive and technology development industries. The thesis contributes by showing that the construction contractor roles are not fixed but shift with interaction patterns and ARA interdependencies. This positions contractors as central actors in construction cross-industry innovation networks rather than merely operational executors, with their network position and provision of construction project sites constituting key resource constellations for innovation.

5.3.2 Practical contributions

The thesis demonstrates that construction managers must acknowledge temporal and spatial interdependencies as vital for navigating cross-industry collaboration effectively. The research shows that innovation unfolds differently depending on where interaction occurs – within company environments, at project sites, or across dispersed industry forums – and that aligning these spaces enhances continuity and diffusion potential. Contractors need to develop strategic network management capabilities to coordinate innovation across levels and industries, treating their network positions and access to project sites not as purely operational responsibilities but as deliberate innovation assets. This requires recognising that project sites function as critical gateways for testing, validating and translating digital solutions into context-specific applications (Slaughter 2000, Dubois and Gadde 2002a).

Managers should view construction projects nor as starting points, neither as endpoints, but as bridging platforms linking temporary project networks with permanent organizational, enabling iterative learning and scaling. To address this, managers in all involved industries – construction, automotive, technology development – must actively design and manage organizational interfaces and interdependencies. Connecting interaction episodes and synchronising timing and interests across project, organizational and industry levels, can support the scaling of the innovation. In particular, by strengthening intra-organizational connections and knowledge transfer mechanisms network-generated innovations can be embedded in permanent routines rather than remaining episodic project outcomes (Håkansson and Ingemansson 2013).

6. Conclusion

The aim of this thesis is to explore cross-industry innovation networks in the construction industry. Empirically, this exploration takes its starting point in construction contractor involvement in cross-industry innovation processes for digital solutions, examining co-development with partners from the automotive and technology development industries. By applying an interactive perspective in the form of the Industrial Network Approach (INA) and its Activity-Resource-Actor (ARA) model, the study traces dynamic interdependencies among actors, resources and activities across project, organizational and industry levels. Two research questions guided the investigation.

RQ1 How does interaction unfold in cross-industry innovation networks within and across project, organizational, and industry levels?

Interaction unfolding across multiple spatial and temporal levels

In conclusion, cross-industry innovation networks in the construction industry unfolds in dynamic interaction in relation to three distinct, but related, spatial and temporal settings: project, organizational and industry. The research revealed that innovation evolve from initial idea generation through organizational learning to industry-level scaling, with each level characterized by different spatial configurations (construction project sites, company environments, dispersed industry forums) and following temporal interdependencies.

A critical finding is that the three levels—project, organizational and industry—are interconnected through activities, resources and actors, forming activity links, resource ties and actor bonds. At the same time, they represent distinct spatial and temporal settings with different characteristics, abilities and conditions. Project-level interaction is characterized by high intensity within a temporary setting, organizational interaction depends on more enduring structures and routines that develop over longer time horizons, and industry-level interaction is shaped by dispersed arenas and slowly changing practices and standards. This spatial and temporal misalignment means that project-level innovation success does not automatically translate into organizational embedding or industry-level diffusion. For construction firms engaging in cross-industry innovation, innovation must be reconceptualised from episodic project activities toward continuous, multi-space, temporally managed network engagement, requiring deliberate mechanisms to bridge the temporal and spatial divides that the industry's structural characteristics otherwise perpetuate.

Divergent industry logics shape actor interpretations across levels: construction prioritizes efficiency and project delivery, while automotive/technology partners emphasize scalability and service development. Rather than treating "industry context" as a simple explanatory factor, the cases show that what matters is how activities are linked and resources are combined within and across industries, and how these patterns play out differently for the actors involved. Relative boundedness emerges in CII: the same process generates different outcomes due to actors' specific network connections and activity/resource patterns across levels.

RQ2 How is the role of the construction contractor characterized in innovation processes within cross-industry innovation networks?

Dynamic roles of the contractor

In conclusion, the construction contractor's role in cross-industry innovation networks is neither fixed nor limited to project execution. It is indeed very dynamic, which adds to the complexity of its function. Rather, contractors evolve through multiple, interconnected roles across innovation phases and levels: from co-developers and problem-definers at the project level, to organizational champions coordinating and aligning to organizational goals, to boundary spanners supporting and establishing CII networks and facilitating a step towards industry-level scaling.

A key aspect in terms of how construction contractor champions perform these roles is the collectively, using their access to project sites as critical assets for testing, translating and contextualising innovations. However, the research revealed a critical constraint: whilst contractors can perform these diverse roles externally (engaging with partners across industries), their capacity to embed innovations internally, translating project learning into permanent organizational routines, is often limited due to organizational structures designed for project independence rather than cross-project knowledge diffusion.

The construction contractor's role is fundamentally contingent on the roles of other actors and on interaction patterns within and across project, organizational and industry levels, each level considered to be unique in spatial and temporal settings with different characteristics and logics. The construction contractor needs to manage their dynamic roles differently across these settings: acting as a problem-solving collaborator to the construction context at project level, as an internal translator and organizer of innovation-related structures and routines at organizational level, and as a boundary-spanning actor that selectively positions solutions and relationships in relevant industry arenas.

6.1 Future research directions

The findings open several avenues for future research. First, this study highlights the challenge contractors face in project-based organizations within the construction industry when the ambition is scaling up innovation from individual temporary projects to more permanent organizational networks. How temporary project networks are linked to more permanent organizational networks, and prerequisites and challenges in this "linking" is an intricate issue since this bridging is a precondition for innovations to move from project specific solutions to enduring practises, as to provide renewal in the industry (Håkansson *et al.*, 2009; Bygballe & Ingemansson, 2014). Accordingly, in terms of the construction contractor role, one avenue for future research is to explore how the internal structure of the construction contractor, including intra-organizational interaction, interrelate to external partners, in ambitions of scaling innovation. Specifically, such bridging often requires standardisation of digital processes and data structures because, without shared formats, procedures and interfaces, innovations remain highly context bound and difficult to integrate into the everyday routines, systems and contracts that characterise permanent networks. This includes examining how standardisation reshapes interaction patterns and interdependencies in supply networks, and how it affects the contractor's internal department's, supplier companies and client organizations, as well as business relationships among these parties in innovation processes as part of digital transformation. In this regard, internal digital innovation in a contractor organization can be further studied that reconfigures interaction both at the temporary project level and at the more permanent network level.

Second, data emerges as a critical resource in this thesis, and future research is needed in terms of how data as a resource is combined with other resources, including the associated technical knowledge and competences. Resource combinations involving digital resources are essential for creating value in the form of increased data accessibility, interoperability, and efficiency, and how data is shaped and shapes resource combinations (Ferreira *et al.* 2025). There is scope for case studies that examine what digitalization in construction supply networks entails from a network perspective, even when collaborations are not explicitly cross-industry. This responds to calls for more research on the impact of digitalization on business relationships (Ritter and Pedersen 2020). Such studies could address how interaction evolves in terms of how data is treated as a resource and how data becomes embedded (or not) in contexts of projects and more permanent business structures in the construction industry. This should be seen in relation to reusing project learnings at firm and network levels, particularly within the broader contexts of innovation, sustainability and digitalization in construction.

Third, although this thesis illuminated a contractor's role in terms of innovation champion behaviour, it did not examine how champions from different organizations interact within cross-industry networks. Future research could examine innovation champion dynamics from an interactive perspective, given that innovation champions would be considered individual, teams, departments or firms, in other words, actors, with the explicit role of facilitating innovation development and diffusion. How the position, behaviour and identity of those innovation champions evolves vis a vis each other in interaction is thus interesting to explore further, in particular, how such dynamics influence the direction and scalability of innovation is considered interesting both from a theoretical and practical perspective. This could advance the understanding of collaboration, leadership an orchestration in innovation networks, and in regard to the construction industry, how multiple champions coordinate across temporary and permanent networks do achieve sustained and scalable innovation. In this respect, my future PhD work could address these phenomena concerning intra- and inter-organizational innovation related to digitalization and digital transformation in the construction industry.

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