International Journal of Project Management 42 (2024) 102564

Contents lists available at ScienceDirect

International Journal of Project Management

journal homepage: www.elsevier.com/locate/ijproman

Pursuing openness in the digital age: Insights from client–contractor knowledge collaboration at the project front end

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ARTICLE INFO

Keywords:
Client–contractor knowledge collaboration
Digitalization
Ambient awareness networks
Institutional logics
Project front end

ABSTRACT

Digitalization, with its potential to enhance the openness of client–contractor knowledge collaboration (KC) at the front end of complex engineering projects, is gaining traction among project scholars and practitioners. Despite this growing interest, project actors still struggle to bring client and contractor experts into an open, digitally enabled collaborative space where they can freely access and cocreate project-related knowledge. In this context, our case study explores client–contractor KC in the front-end phase of oil and gas projects in Norway to understand why project actors struggle to achieve KC openness in the digital age. Based on our qualitative analysis, we developed a model that displays two intertwined aspects giving rise to tensions between knowledge sharing and protection. First, we show that these tensions stem from fragmented awareness of the expertise in the collaborating project organization. Second, we highlight how intrainstitutional complexity, instantiated in coexisting conflicting logics of digital and collaborative action, underlies divergent beliefs and behavior toward client–contractor KC and its digitalization. We offer novel insights into the project management literature by showcasing how organizational heterogeneity, in terms of expertise and institutions, challenges project organizations' pursuit of open, digitally enabled client–contractor KC during the front-end project phase.

1. Introduction

In the realm of complex engineering projects, significant attention has been directed toward client–contractor knowledge collaboration (KC) during the front-end project phase, encompassing the development of the business case with input from the major stakeholders and collaborating project parties (Alimadadi, 2022; Larsen et al., 2021; Liu et al., 2019; Toukola et al., 2023; Williams et al., 2019; Zerjav et al., 2021). In this strategic project phase (Morris & Geraldi, 2011; Zwikael & Meredith, 2019), KC, involving knowledge sharing, transfer, and cocreation, requires careful consideration of what knowledge is to be protected or shared among collaborating parties (Faraj et al., 2011; Jarvenpaa & Majchrzak, 2008). Many studies advocate open client–contractor front-end KC, a concept that has gained momentum with the advent of digital technologies such as Building Information Modeling and digital twins (Korotkova et al., 2023; Papadonikolaki et al., 2022). In traditional high-risk sectors like oil and gas (Hussein, 2020; Walker et al., 2017), these technologies hold the potential to enhance the openness of front-end collaboration, presuming transparent, seamless, and trustful KC between collaborating project actors (Hinings et al., 2018; Murray et al., 2021; Stock et al., 2021).

In theory, digital technologies can facilitate open KC by bringing together loosely coupled client and contractor experts in an open collaborative space, where they can freely access project-related knowledge for codesigning complex engineering solutions (Alin et al., 2013; Forsythe et al., 2015; Papadonikolaki et al., 2022). However, the reality often falls short of these expectations, as digitalization can encounter socio-cognitive tensions, contaminating the front-end KC processes (Forsythe et al., 2015; Zhang & Min, 2019). Diverse expertise, conflicting interests, and differing frames of reference among project collaborators can give rise to tensions that hinder the seamless flow of knowledge and ideas (Hetemi et al., 2022). Yet, a research gap persists in understanding the microfoundations that underlie the difficulties in achieving KC openness at the front end of complex engineering projects in the digital age (Oraee et al., 2019; Papadonikolaki et al., 2022). Addressing this gap would provide insights into the challenges faced by

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https://doi.org/10.1016/j.ijproman.2024.102564
Received 16 November 2022; Received in revised form 15 December 2023; Accepted 25 January 2024
Available online 26 January 2024

heterogeneous project actors collaborating in the digital age (Slavinski et al., 2023), thereby aiding them in effectively managing these challenges and enhancing overall project success.

In this paper, we aim to address this gap by exploring two critical aspects of organizational heterogeneity—expertise and institutional heterogeneity—that impact the micro-level dynamics shaping client–contractor KC and its digitalization. Central to this understanding are awareness networks, which encompass individuals' knowledge about "who knows what" and "who knows whom" within and outside project organizations (Austin, 2022), thereby leveraging the value of heterogeneous expertise. To further grasp KC tensions at the project front end, we draw on the institutional logics and complexity perspective, elucidating the institutional heterogeneity within collaborating project organizations (Thornton & Ocasio, 1999). While this perspective traditionally explores conflicts between institutions, such as market and profession (Fortin & Söderlund, 2023; Hetemi et al., 2021), our study also focuses on intrainstitutional complexity (Meyer & Höllerer, 2016). This arises from conflicting "logics of action" that imply conflicting prescriptions on how to act in the context of client–contractor KC in the digital age. By bringing together these two perspectives, we aim to elaborate upon existing project studies in the evolving landscape of project organizing in the digital age (Slavinski et al., 2023).

To address these issues, we pose the following research question: *Why do client and contractor actors participating at the front end of projects struggle to achieve openness in the digital age*? To answer this question, we conducted a qualitative case study focusing on client–contractor KC in the front-end phase of oil and gas projects on the Norwegian continental shelf. Our analysis centered on individuals whose awareness networks and logics of action influenced their daily collaborative efforts, providing a nuanced micro-level perspective to complement broader structural viewpoints in project studies (Söderlund & Sydow, 2019).

This study contributes to project studies by offering an in-depth understanding of the microfoundations of front-end KC in the digital age. We propose a model of client–contractor KC, highlighting how fragmented ambient awareness networks and coexisting conflicting digital and collaborative logics of action contribute to the sharing–protection tensions. In essence, our findings show that fragmented awareness of expertise scattered in the collaborating organization and contradictions within and between institutions make it challenging for project actors to fully harness the promised benefits of digital technologies in pursuing openness.

This paper is structured as follows: First, we provide a concise overview of our theoretical framework. Second, we introduce our research case and methodology. Third and fourth, we present and analyze our research findings. Finally, we reflect on our study's theoretical and practical implications, acknowledge its limitations, and suggest avenues for future research.

2. Conceptual background

To shed light upon the complexity and the microfoundations of collaborative efforts in projects in the digital age, we review the literature on client–contractor KC at the project front end. We follow this by reviewing the literature on awareness networks and institutional logics that provide insights into individuals' ability and motivation to engage in KC.

2.1. Client–contractor front-end knowledge collaboration

Our work is anchored within the broad research stream of client–contractor knowledge collaboration at the front end of complex engineering projects (Alimadadi, 2022; Larsen et al., 2021; Liu et al., 2019; Solli-Sæther et al., 2015; Zerjav et al., 2021). In this paper, we view KC as a dynamic and multifaceted process encompassing the transfer of knowledge from sender to receiver, sharing of knowledge between senders and receivers, and cocreation of knowledge (Faraj et al., 2011). This concept is particularly relevant in understanding ambivalent client–contractor collaboration, where collaborating actors, driven by conflicting motives, often face a dilemma. Sharing and cocreating knowledge can foster collective problem-solving, but improperly shared knowledge may expose their parent organizations to competitive disadvantage, reputational damage, and theft of intellectual property (Jarvenpaa & Majchrzak, 2008). Effective KC thus requires actors to share and cocreate knowledge while simultaneously protecting it (Ahlfänger et al., 2022).

When considering the temporal dimension of client–contractor KC, there is a growing interest in client–contractor KC and its digitalization in the project front-end phase. Here, client and contractor experts collaborate to diagnose problems and design complex engineering solutions (Larsen et al., 2021; Stock et al., 2021; Takahashi et al., 2018). This increasing scholarly attention is rooted in the broader paradigm shift towards value cocreation (Eriksson et al., 2017; Walker et al., 2017) and digitalization of project work (Whyte, 2019). For instance, a growing stream of studies asserts that digital technologies act as catalysts for the creation of "open" collaborative environments, where counterproductive behaviors, such as knowledge protection, are less likely to occur (Forsythe et al., 2015; Zhang & Min, 2019).

However, earlier studies have consistently shown that establishing and maintaining effective client–contractor front-end KC is challenging, even in digitally enabled environments (Bosch-Sijtsema & Henriksson, 2014; Oraee et al., 2019). In the front-end project phase, KC can face tensions rooted in the embedded, tacit, and sticky nature of project knowledge, differences in organizational culture (Solli-Sæther et al., 2015; Xu et al., 2021), and the paradoxical pressure to "rush" through this project phase despite the low cost of making amendments and the high utility of adding knowledge early in the project lifecycle (Samset & Volden, 2016). Moreover, digital capabilities for mitigating KC asymmetries in complex industries have not yet reached a mature stage (Forsythe et al., 2015).

Nonetheless, scholars exploring the projects' front end have underscored that tensions arising from the multiplicity of actors involved remain inadequately understood (Aaltonen et al., 2015; Larsen et al., 2021; Williams et al., 2019). They have particularly emphasized the neglected research area concerning the collaborative individuals who bear the responsibility for daily knowledge sharing and protecting in this complex context (Ahlfänger et al., 2022; Solli-Sæther et al., 2015). Recent reviews by Papadonikolaki et al. (2022) and Slavinski et al. (2023) similarly identify conceptual and empirical voids in the microfoundations of digitalization in projects and its impact on negotiating knowledge across boundaries.

In light of these considerations and gaps, scholars call for empirical studies that adopt a micro-level view to explore how and why collaborating individuals construct and maneuver KC tensions at the projects' front end in the digital age (Brattström & Faems, 2020; Takahashi et al., 2018; Xu et al., 2021). To this end, project scholars advocate moving beyond formal contractual governance mechanisms and exploring the nonrational underpinnings of project management, such as different expertise and beliefs that drive specific collaborating behavior among project actors (Ahlfänger et al., 2022; Alimadadi, 2022; Cheng et al., 2023).

To fill the highlighted empirical and research voids and delve deeper into project actors' challenges in achieving collaborative openness in the digital age, we turn to two promising theoretical lenses—ambient awareness networks and institutional logics—which we present and elaborate on in the next section(s).

2.2. Ambient awareness networks

Along with the growing stream of context-aware project research (Larsen et al., 2021; von Danwitz, 2018), we apply the concept of awareness networks originating from the transactive memory theory (Wegner, 1987). This theory posits that when confronted with problems,

group members draw on their personal *awareness networks*, referring to individuals' knowledge about "who knows what" and "who knows whom" in the group (Cross & Parker, 2004; Mell et al., 2022). In simpler terms, awareness networks depict the awareness of others' heterogeneous expertise, for example, "who can design a valve block" and "who knows experts in seismic geology." Being integral to collaborative tasks (Mohammed et al., 2021), these networks enable individuals to utilize others as external memory aids (Mell et al., 2022) and recognize, encode, and retrieve their subject-specific knowledge (e.g., how to design a wellhead connector) (Austin, 2022). Several empirical studies in the disciplines of team cognition, organization behavior, and information systems have noted that groups with well-developed awareness networks perform better (Mohammed et al., 2021). This sentiment resonates with the work of Hansen et al. (2020), who argue that project groups handle concurrent engineering issues better if group members know each other's responsibilities and expertise.

Scarce project studies on awareness networking (e.g., Hsu et al., 2012; Lin et al., 2015) explore mainly intragroup contexts from the project manager's perspective. In reality, however, the context of front-end engineering design brings together a vast set of interdependent client and contractor experts who need to map and coordinate unique expertise to perform knowledge-intensive work, such as codesign of subsea trees (Hansen et al., 2020). This prompts a need to extend the concept of awareness networks to the interorganizational level, specifically in the digital age, where expertise is more prone to "leak" across boundaries (Austin, 2022; Leonardi, 2018; Mell et al., 2022). Echoing this need, this paper explores *ambient awareness networks,* which we define as individuals' awareness of the expertise and connections of experts beyond the core group-based collective. These networks, providing awareness of expertise scattered in the collaborating project organization, may help collaborating individuals source nonredundant project-related knowledge (Sydow & Braun, 2018), build trust in the competence and benevolence of certain actors, and determine what should or should not be shared with them (Jarvenpaa & Majchrzak, 2008). In this paper, we treat ambient awareness networks as inputs in project work (Hsu et al., 2012) and examine their permeability and impact on client–contractor KC in the digital age.

Along with the focus on heterogeneity of expertise in groups, scholars examining awareness networks have voiced the need to explore organizational heterogeneity in terms of different belief systems that influence project individuals' behavioral choices (Hansen et al., 2020; Lin et al., 2015). This becomes particularly central in the context of client–contractor KC, where collaborating project experts are guided by mixed motives, leading to potential hesitancy in sharing and cocreating knowledge. This aspect of KC is discussed next.

2.3. Institutional complexity and logics of action

Extant literature often views organizations collaborating on projects as homogeneous entities with consistent beliefs and perceptions (Brattström & Faems, 2020; Xu et al., 2021). However, aligning with Wang et al. (2023), we recognize that project organizations are nested in various coalitions of individuals equipped with diverse institutional logics influencing their views on relationships with different actors.

Institutional logics, defined as socially constructed patterns of practices, values, and rules (Thornton & Ocasio, 1999, p. 804), guide actions at both macro (e.g., market, state, corporate, professions) and meso-levels (e.g., oil and gas industry) (Friedland & Alford, 1991; Mountford & Cai, 2023). Each institutional logic or a combination of them implies specific formal and informal prescriptions on how to act, which we term "*logics of action*" (Winter & Berente, 2012, p. 441) in this paper. Logics of action affect behaviors and task accomplishment of project actors (organizations and individuals alike) (Greenwood et al., 2008; Thornton et al., 2012). For instance, the institutional logic of engineering professionalism prescribes a logic of action focused on solving technical problems. Collaborating project actors carry such logics of action to front-end KC to rationalize their action toward collaborating parties and digitalization (Bacharach et al., 1996).

An implied and perhaps core assumption of the institutional logics approach is that no single institutional logic or logic of action guides all collaborating project actors' behaviors. In this view, KC is rather shaped by a nexus of multiple, often conflicting institutional logics, also referred to as institutional complexity (Fan & Zietsma, 2017). Institutional complexity emerges when project actors experience incompatible prescriptions from multiple institutional logics (Greenwood et al., 2011). For instance, Fortin & Söderlund (2023) demonstrated how conflicting or competing demands from government, academic, and industry logics impacted projects in port logistics.

Project scholars increasingly use the concepts of institutional logics and institutional complexity to understand the references that shape actions and behaviors of collaborating actors, such as contractors, labor unions, and clients (Hetemi et al., 2021; Lundin et al., 2015; Winch & Maytorena-Sanchez, 2020). Yet, few project studies have conducted micro-level analyses of logics in front-end project organizing (Söderlund & Sydow, 2019). Furthermore, studies focus largely on conflicts arising from different institutions, each with its own logic. To this end, Meyer and Höllerer (2016) and Alvesson and Blom (2022) highlighted an underexplored area: conflicts within "one" institution, termed "intra-institutional complexity" by Meyer and Höllerer (2016, p. 374). This concept reveals that even within one institution, such as a profession (Couchoux & Malsch, 2022), religion (Yan, 2020), or market (Meyer & Höllerer, 2016), conflicting or competing logics of action can co-exist, leading to varied views and practices among project collaborators. Therefore, we, in this study, consider how both intra- and interinstitutional complexity affect client–contractor KC in the digital age.

There is also a growing interest among project scholars in the potential of digitalization to mitigate the institutional conflicts that challenge front-end KC. Digitalization, with its core principles of openness, such as connectivity, accessibility, and traceability, promises to introduce new collaborative practices and values, give project stakeholders control, and enhance KC openness by reducing vulnerabilities (Hinings et al., 2018; Lumineau et al., 2022). Despite acknowledging the significance of digitalization in projects, there remains a gap in project studies regarding its effect on institutional complexity in interorganizational projects (Oraee et al., 2019; Wang et al., 2023). This gap underscores the need for empirical research to delve into how digitalization interacts with and is influenced by institutional logics and logics of action, particularly in the context of complex engineering projects (Slavinski et al., 2023; Whyte, 2019). To address this need, the following section presents the results of a qualitative study conducted in the Norwegian oil and gas sector to uncover the microfoundations of tensions in collaborative projects.

3. Research design and methods

Digitalization of KC in the project front-end context is a relatively new phenomenon. Thus, to problematize and elaborate theoretical ideas on this topic, we adopted a qualitative case study research design, which is renowned for exploring relational embeddedness in "the real world" of project organizing (Steen et al., 2018). This study design enhanced the robustness and analytical generalizability of our study results through case elaboration while allowing for the exploration of contextual idiosyncrasies and nascent theorizing (cf. Ketokivi & Choi, 2014).

3.1. Research setting and case selection

Our case study examines KC between the main contractor—a large multinational oil and gas system provider Alpha—and the client—a medium-sized oil operator Beta. In contrast to large operators internalizing an array of expertise and technology, Beta's internal resources are constrained, causing them to outsource front-end studies to Alpha. While the companies share areas of expertise in drilling, exploration, and production services, the intricate nature of front-end work requires a high degree of complementary knowledge. This entails coupling Beta's expertise in oil field prospecting and development with Alpha's competencies in design, construction, and installation of subsea structures. Alpha thus provides technology and project management that enable Beta to produce and transport crude oil from reservoirs to the surface.

Having built up a long history of collaboration in multiple projects, the companies signed a strategic alliance in 2018 to strengthen their KC. However, the need for improved client–contractor KC, particularly in the front-end project phase, became more pronounced with the surge of digitalization in 2019. As the industry evolves and the demand for oil and gas keeps fluctuating, the companies have intensified their efforts to digitalize client–contractor relations. Through digitalization, they aim to integrate client and contractor experts early in the value chain while transforming the contractor's role from being a mere supplier to that of a strategic advisor. Consequently, these companies strive to develop and employ efficient digital technologies, such as digital twins, to improve their core products and services.

3.2. Case context

We analyzed client–contractor KC in three collaborative projects on the Norwegian continental shelf: a time-driven Project A and two cost-driven Projects B and C. The last two were executed as one project under the Engineering, Procurement, Construction, and Installation umbrella. For Project A, Alpha was chosen from four qualified contractors as the supplier of Subsea Umbilicals, Raisers, & Flowlines, Subsea Production Systems, and after-sales technical services in an integrated contract. For Projects B and C, Alpha was chosen as the main contractor because the projects were tiebacks to an oil field developed 12 years earlier, to which Alpha had supplied subsea production systems. Alpha was thus chosen to avoid the complexity of having mixed vendors. At the time of the data collection, all three projects were in the execution delivery phase and were later delivered on time.

In agreement with the companies, we focused on their KC in the front-end engineering and design (FEED) phase, incorporating the Feasibility, Concept, Pre-FEED, FEED, Tender, and Contract Award at decision gate 3 (Fig. 1).

We chose this phase because of the highest alleged value of digitalization for collaborative FEED, since in it, Alpha and Beta engineers, managers, and digital experts collaborated to select the most technically and economically feasible design. To design solutions tailored to Beta's specific technical requirements and needs, Alpha's front-end project groups integrated several hundred people from up to 20 geographically spread departments (e.g., 12 departments in Project A). Given the heavily engineering-based nature of Alpha's solutions, Beta needed to possess matching expertise and mirror Alpha's project design to enable effective KC and to determine the solutions' functionality within Beta's overall system.

Our first meeting notes revealed that the increasing emphasis on integrated project delivery and digitalization necessitated front-end commitments, a high level of trust, and openness between Alpha and Beta. Simultaneously, we noticed that the client–contractor relationship was filled with tensions and mutual doubt about the value of KC openness and its digitalization. These observations challenged the monolithic philosophy. Therefore, we inductively explored why contradictory KC discourses emerged and why the tensions persisted despite digitalization.

3.3. Data collection

Our research data came from primary and secondary sources and were collected in two sequential stages from May 2019 to November 2021 (see Fig. 2 for details). In the first data collection stage, we explored KC puzzles. In the second stage, which focused on digital collaborative technologies, we refined the conceptual framework and central propositions.

Interviews served as primary sources of information on firsthand experiences with KC at the front end of projects. They were the most suitable research method due to their ability to capture and argue for extra-group awareness networks, institutional logics, and logics of action. The interviews were supplemented by analysis of documents (e.g., presentations, reports, and websites) on, and by nonparticipant observations of, the patterns of KC and collaborative and digital discourses. We conducted 65 semi-structured interviews—62 individual and 3 group interviews—with 51 Alpha representatives and 14 Beta representatives. The interviews were conducted face to face, over the phone, or on digital platforms (i.e., MS Teams and Zoom) and ranged from 45 minutes to 2.5 h each, with an average duration of 1.5 h. We used purposive sampling to capture diverse "voices," followed by snowball sampling (Lewis-Beck, 2004). As a result, the research sample included 30 engineering specialists, 25 digital leaders and specialists, 8 commercial and management specialists, and two human relations and organization learning experts. Most of the interviewees had experience in both the early and later stages of the value chain.

The first interviews were more open and conversational, while the following semi-structured interviews were guided by a preliminary interview guide tailored to the interviewee's experience and the maturing research objective. The interviews started with open questions about interviewees' experience with client–contractor front-end KC and its digitalization in projects, after which the interviewees were asked to reflect on specific collaborative events, the value of awareness of others' expertise in project work (e.g., "How aware are you of the expertise on the client/contractor side, and how does it impact KC?"), and their perceptions of the counterparts and digitalization in three projects (e.g., "How and why do you (not) engage in digitalization of client—contractor front-end KC?"). Interviews were, however, not limited to the interview guides but of a more conversational nature, allowing for

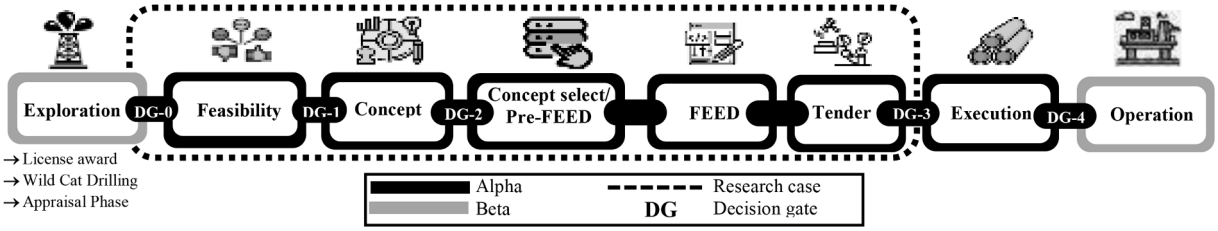

Fig. 1. Oil and gas value chain (Source: interviews)

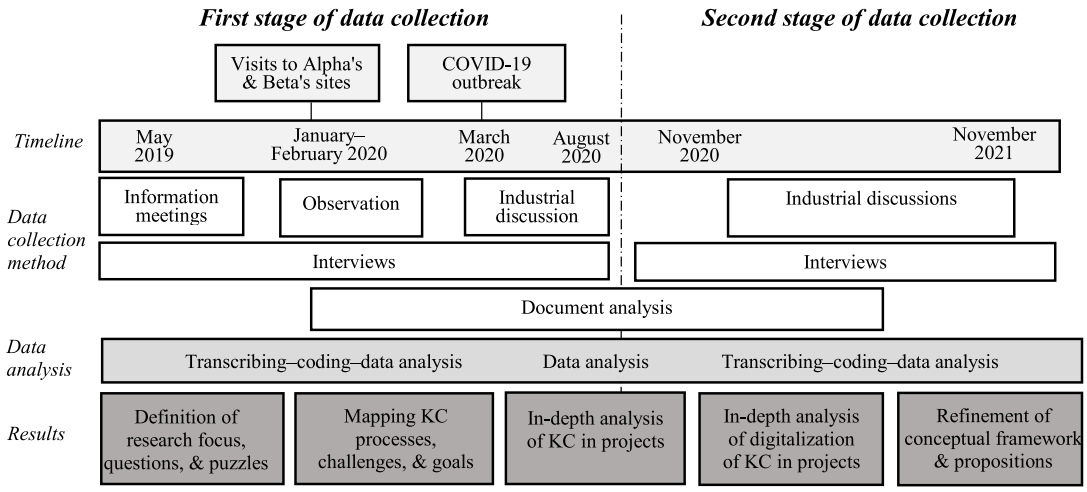

Fig. 2. Data collection overview

new turns in the discussion. Notably, the latter interviews clarified contradictory beliefs, such as (non)inclusive client engagement in development initiatives.

Since we assured the interviewees' confidentiality, we anonymized the company names as "Alpha" and "Beta" and all the quotes. We refer to the interviewees with the following codes: *M* for the management and commercial specialists; *E* for the engineering leaders and engineers; and *D* for the digital leaders and digital specialists, followed by the randomized interview numbers. For example, "Alpha E.1" refers to Engineer Interviewee 1 at Alpha.

3.4. Data analysis

The first author transcribed 88.5 hours of audio recordings to account for specific oil and gas jargon and to perform the initial coding. We further unified the interview transcripts and documentation using the qualitative data analysis software NVivo 20. First, we analyzed and categorized the data thematically, looking for roots of client–contractor KC efforts and deficiencies at the projects' front end. As a result, we abductively identified two intertwined themes: (1) limited awareness of others' expertise and (2) conflicting collaborative and digital action discourses that we termed "logics of action." We then inductively explored these themes.

Fig. 3 shows our data structure, inspired by the Gioia method of data analysis (Gioia et al., 2013). The first-order codes represent the first level of abstraction from the data (those meaningful to the interviewees). Then, we looked at various individuals' beliefs and their central arguments about open client–contractor front-end KC and its digitalization. The codes related to conflicting discourses were further grouped into theoretical subdimensions (Veisdal, 2020) of different institutional logics, which provoked perception heterogeneity. Specifically, we identified two central institutional logics: a) Managerial logic of organizational survival and efficiency, and b) Professional institutional logics related to b1) project management professionalism and b2) front-end engineering design (FEED) creative professionalism.

Given Alvesson and Spicer's (2019) criticism that institutions and logics are "everything and everywhere," we drew broad criteria from organizational studies to ensure the validity and reliability of our findings when arguing about the logics identified in our analysis. We employed the nine criteria from Thornton et al. (2012), suggesting that an institutional logic can be defined using the following categories: (1) root metaphor, (2) sources of legitimacy, (3) sources of authority, (4) sources of identity, (5) basis of norms, (6) basis of attention, (7) basis of strategy, (8) informal control mechanisms, and (9) economic system. Additionally, we drew the organizing principles (guides of activities based on goals and values of institutions), assumptions (specific means-ends relationships), identities, and domains from the seminal work on institutional logics by Thornton and Ocasio (2008). We adopted these criteria to analysis of core institutional logics in our study, which are presented in Table 1.

The first institutional logic that was prominent in our data was managerial logic of organizational survival and efficiency—an instantiation of the corporate institution—encouraged project actors to treat FEED as business and focus on rational and strategic management of FEED activities to ensure business survival, efficiency, and expansion. The second notable logic of project management professionalism guided FEED delivery with minimal risks and within given iron triangle objectives that are habitualized in the project management profession (Berente & Yoo, 2012). Under the third logic of FEED creative design, highly educated FEED professionals narrowly focused on the high-quality, creativity, and innovativeness of FEED regardless of iron triangle or strategic constraints.

Next, we grouped these subthemes and first-order codes related to awareness networks into theoretical dimensions. Through pattern matching, we identified four influential logics of collaborative and digital action that refer to specific prescriptions on how Alpha and Beta project actors should act (see Tables 2–5 for illustrative quotes and thematic coding). First, we defined the *coalescent logic of collaborative action* as a prescription for open KC with a temporary or permanent collaborating organization seen as a trustworthy actor. In contrast, the *guarding logic of collaborative action* prescribes protection of individual and organizational knowledge in the projects' front end if the collaborating organization is seen as an opportunistic actor. Next, we looked for links between the identified institutional logics and perceptions of how to engage in the digitalization of front-end KC. We revealed two conflicting logics of digital action. The *protagonist logic of digital action* refers to a prescription for the organizational actors to engage in digitalization, as it creates valuable openness and is a premise for novel KC in the project setting. The *antagonist logic of digital action*, in contrast, prescribes the mode of opposition or hostility to the digitalization of project relations, as digitalization is suspected as threatening the performance of individuals and front-end project work.

Eventually, through an iterative data structuring process in which we regularly shifted between the data and the literature, we arrived at three aggregate dimensions that explained client–contractor KC tensions at the projects' front end: fragmented ambient awareness networks and conflicting logics of collaborative and digital action.

Fig. 3. Data structure.

Table 1
Core institutional logics guiding conflicting logics of collaborative and digital action.

	Managerial logic of organizational survival and efficiency	Logic of project management professionalism	Logic of FEED creative professionalism
Institution	Corporate	Profession	Profession
Organizing principles	Rational and strategic management of front-end KC for organizational development and protection, focusing on competitive advantage, expertise, and efficiency.	Effective orchestration of resources to deliver FEED within the constraints of the "iron triangle" (time, cost, and quality).	(Co)develop high-quality FEED, prioritizing innovation and creativity.
Assumptions	Strategy, control, and business survival, expansion, and efficiency are central.	Iron triangle and risk minimization are core.	Innovation and high-quality FEED using new technologies and creativity are core.
Identity	FEED as a business operation.	FEED as a structured project management profession.	FEED as a creative engineering profession.
Domain	Management background.	Technical domain of project management.	Technical FEED domain.
Root metaphor	Corporation as a competitive entity.	Projects as structured endeavors.	FEED as an innovative and creative endeavor.
Sources of legitimacy	Business performance metrics, market competition.	Professional standards, project management methodologies.	Professional acclaim, innovative output.
Sources of authority	Corporate hierarchy, strategic decision-making processes.	Project management bodies, certification authorities.	Recognized leaders in FEED innovation.
Basis of norms	Corporate governance, efficiency, and growth-oriented practices.	Professional guidelines, best practices in project management.	Creative excellence, innovative practices.
Basis of attention	Market trends, financial metrics, organizational strategy.	Adherence to project timelines, budgets, and quality standards.	Technological advancements, design innovation.
Basis of strategy	Competitive advantage, market positioning.	Project planning, resource allocation.	Embracing new technologies, creative problem-solving.
Informal control mechanisms	Organizational culture, corporate ethos.	Professional community norms, peer recognition.	Community of practice, peer-driven norms.
Economic system	Capitalist market dynamics.	Efficiency-driven, outcome-oriented project economics.	Innovation-driven value-creation in FEED.

4. Research findings

This section first reflects on the scale and digitalization of client–contractor KC at the project front end, followed by our findings on awareness networks and the coexistence of conflicting logics of action.

The client–contractor front-end KC in all three projects was described as "a giant puzzle" where many decisions had to be made by aligning various expertise, needs, and capabilities. Yet, our general impression from the interviews was that the client–contractor front-end KC was interactive: "Beta comes to us [Alpha] with a blank piece of paper, and hardly do anything by themselves.... They want to engage with us in this feasibility phase" (Alpha E.2). In this early project phase, Alpha and Beta project members shared knowledge digitally and non-digitally through FEED workshops, design reviews, lessons learned sessions, and documentation issues.

The main topic of the interviews was the growing digitalization trend in project organizing: "We are seeing more and more digitalization in everything that we do in projects" (Alpha E.7). This was in reference to the clients' increasing digital requirements in respect to hardware and software, an amplified focus on the utilization of digital tools in collaborative project work (e.g., Microsoft Teams, SharePoint, Interface management systems), and (co)development of digital tools, such as digital twin-based applications for field layout design. Within Alpha, for example, a notable spectrum of 1,700–3,500 digital tools (referring to all information and communication technologies) was available to facilitate inter- and intraorganizational KC.

Despite the vast number of tools available and the increasing focus on digitalization, client–contractor KC in the front-end project phase occurred conventionally via Microsoft Outlook, SharePoint, and Teams: "The way we've been doing [KC with the client], referring to three stages of digitalization [digitization, digitalization, and digital transformation] is very analog. It's typically 250–300 filed documents that we share over a document portal, often email" (Alpha M.25). As a result of limited KC and its digitalization, the engineers sometimes spent several months finding "simple things," such as field characteristics from projects that occurred 6–7 years ago.

The interviewees believed that the limited openness and digitalization constrained Beta's ability to communicate its needs and Alpha's ability to find, codevelop, and share solutions in a timely manner. Hence, we delved into the roots of front-end KC deficiencies, which we present next.

4.1. Fragmented ambient awareness networks

Alpha and Beta interviewees stressed the value of diverse expertise and expertise awareness for collaboration at the project's front end:

When you know what everybody knows—"You're good at that"—then you have already created a level of trust, and you can play each other much better.… That's extremely important … in interactions with the client. So, if you have had a good working relationship with a client for 2, 3, or 4 years, you should also know each other in terms of competency. So, you can contribute in a better way. (Alpha E.20)

Alpha's interviewees remarked that the need for awareness of others' expertise differed between clients—while large operators had the necessary expertise internally, KC with smaller operators like Beta, hinged on expertise networking: "[A large operator] will typically do [feasibility studies] by itself. They have a lot of in-house competence. Smaller operators don't have competences to complete this" (Alpha E.2). Therefore, Beta's experts had to develop a comprehensive awareness of Alpha's scattered expertise in Projects A, B, and C.

The value of awareness of and access to the client's expertise was explicitly evident in project A, wherein Beta contributed expertise that was lacking within the Alpha team, and which proved essential in designing innovative electric trace-heated pipelines. Alpha's engineers also recognized that the design of project-specific solutions relied heavily on their ambient awareness of Beta's expertise, particularly within the realm of geology.

Despite the voiced value of being aware of each other's expertise, we observed fragmented awareness of expertise in the collaborating organization. Although the project and account managers were quite aware of the counterpart's expertise, other interviewees, even the experienced project members, had only "general" expertise awareness anchored on a couple of, if any, contacts: "It's difficult to understand who's got competency. People don't know each other that well" (Beta M.27). This fragmentation was more explicit in the front end than in the execution phase: "Once you get into an EPC contract, [it goes] quite well because

[you seat as a team and] you know your counterparts well. Before we have agreements in place, this [front-end] phase is tricky" (Alpha E.44).

Moreover, despite the companies' broad range of digital tools, digitalization of ambient awareness networks was limited. We observed no digital repository of client–contractor expertise other than the LinkedIn profile of the contractor's engineer: "If I were looking for an expert in an area, I'd probably ask some contacts in the same area where I'd ask who I should speak with to get that" (Alpha E.7).

As a result of fragmented and minimally digitalized client–contractor awareness networks, individuals hesitated sharing and retrieving knowledge due to lack of trust in their counterpart's expertise and benevolence. Hence, front-end KC hinged on a few individuals with well-developed expertise maps, such as account managers, salespeople, and project leaders: "We [engineers] are often dependent on the middleman. That's often the sales department … but that's the challenge—to involve the sales well enough" (Alpha E.44).

4.2. Conflicting logics of collaborative action

In line with fragmented awareness of others' expertise, we observed habitualized conflicting perceptions of client–contractor KC: although many interviewees emphasized the value of open and trustful client–contractor front-end KC, they simultaneously dwelled on why they did not or should not integrate the counterpart in this project phase. This dichotomy was built on the coexistence of conflicting coalescent and guarding logics of collaborative action that unfolded differently among managers and engineers. Our analysis revealed that these logics of actions were guided by three institutional logics, key dimensions of which are depicted in Table 1.

4.2.1. Coalescent logic of collaborative action

The first logic of action prominent in our data was the coalescent logic of collaborative action, prescribing project actors to engage in open and trustful front-end KC between parties: "If we're open with the company, they're open with us. We benefit from that in the end" (Alpha E.16). Our data analysis unveiled several institutional logics underlying these collaborative action beliefs. The interplay between the coalescent logic of collaborative action and the core institutional logics is illustrated in Table 2, showcasing their manifestation in our data.

Our data analysis showed that the managerial logic of organizational survival and efficiency influenced Alpha and Beta managers. Guided by this logic, which emphasized strategy, company size, control, and business efficiency, managers asserted that front-end KC ensured corporate access to competence, technology, and innovations. This was particularly critical in Project A, wherein Alpha designed innovative pipelines. Alpha's managers, seeing FEED as business, repeatedly referred to their strategic beliefs on the "exclusivity" of client–contractor relations, the strategy of "being as early in as possible," and their strategic shift from being systems providers to advisors. Driven by strategic managerial arguments of business efficiency, Alpha and Beta managers noted that the oil price fluctuation in the last 4–5 years compressed the window from the concept selection to the final investment decision from 2 years to 2–6 months. This created the need to align the most suitable solution early to speed up the first oil.

Among the engineers, the project management and FEED creative professional logics were prominent. Guided by project management professionalism with its ingrained focus on risks and iron triangle objectives of project delivery, the engineers noted that client–contractor discussions before "cutting steel," supported: cost, time, and quality objectives, as well as de-risked projects due to the lower costs and risks in the front-end rather than in the execution project phase.

Table 2
Illustration of the coalescent logic of collaborative action.

	Inst. logic		Arguments	Illustrative quotes
Coalescent logic of collaborative action	**Managers**	*Managerial logic of org. survival and efficiency*	Access to expertise & innovations	[At the projects' front end,] there are just a lot of various disciplines, so we need to come together and talk about the main difficulties and how we can handle those. (Beta M.27) In the Pre-Feed/FEED, everyone comes to the supply industry… to understand cutting-edge technology. (Alpha M.4)
			Role transition and exclusivity	[As an] advisor, we can recommend our solutions.… That's the strategy to move to the advisor role. (Alpha M.4) Exclusivity is key because then, you have trust.… With that framework, [Beta] comes when they've made the discovery. (Alpha M.4)
			Acceleration of projects and business	Six months, ideally before the ITT [invitation to tender], we would engage with the client … to de-risk their projects so that they can tender it. (Alpha M.25) We try to use [Alpha's] standard products, which is why you bring them in FEED or earlier. (Beta M.1)
	Engineers	*Project management professionalism*	Iron triangle focus	We want to get to this point where we can agree on a price upfront and then hopefully reduce the time. (Beta E.9) The earlier they [Alpha] are involved…, the more opportunity you have to get most of the equipment for the job, thereby reducing the cost. (Beta E.10)
			De-risking	The risk in a project goes up … [Therefore,] it's important to select the concept and do the engineering before you start to cut steel. So, [the front-end] phase is extremely important. (Alpha E.20)
		FEED creative professionalism	Maneuverability	It's important to discuss solutions because when the FEED is over, you have decided on a system and that system only. (Alpha E.31)
			Innovativeness	[The front-end] is the fun part of the job, where you are creative and challenge the established design. (Alpha E.16)
			Coordinating expertise	[In Project A, Beta] was the client, but they also contributed with expertise. They secured some of the resources we should have had on our side from the start. (Alpha E.33)
			Calibrating needs and solutions	When we receive a document…, it doesn't necessarily tell us what the client really needs … [KC] is kinda calibration of expectations. (Alpha E.20) The whole process is about communicating and defining what we want and Alpha finding a good solution and communicating that to us.… The technical solutions [that] the contractors provide … are so comprehensive that it is very hard to understand them within a very short frame. (Beta E.9)

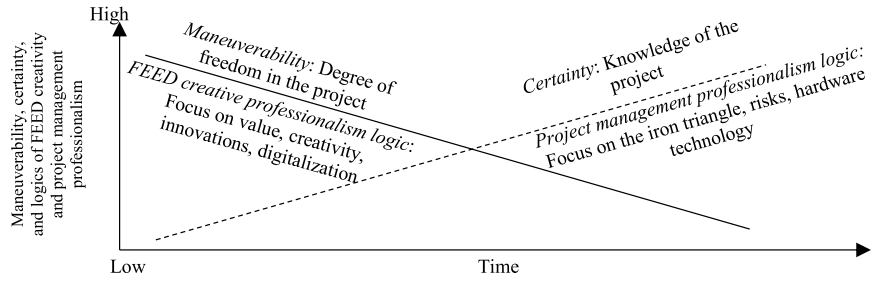

Fig. 4. Institutional logics dynamic in projects.

At the same time, many engineers with master's or Ph.D. degrees in specific engineering fields were driven by the FEED creative logic, which focused on leveraging front-end engineers' expertise to design creative and innovative solutions. In line with this logic, the engineers believed that client–contractor front-end KC was critical due to the front-end maneuverability because there was room for iteration, creativity, and innovation (Fig. 4). Alpha's engineers asserted that project-specific FEED in schedule-driven projects hinged on open KC with Beta in areas where Alpha had limited expertise. These areas included subsurface, reservoirs, and geology: "If we're going to have something project-specific and reservoir-specific, [that's] where we need the client" (Alpha, E.34). Motivated by the calibration argument, Alpha's engineers further stressed the need to "get under the skin of the client": understand their needs and discuss design specifications to produce more value for them. Beta's interviewees, in turn, asserted that KC with Alpha was critical for the FEED of novel technologies. This was due to the complex nature of Alpha's technological solutions, which posed a challenge in terms of comprehending them within a short timeframe.

4.2.2. *Guarding logic of collaborative action*

Along with the coalescent collaborative discourse, we revealed a guarding logic of action prescribing to protect information, knowledge, and data at the projects' front end. Table 3 illustrates how institutional logics and arguments manifested in our data.

Our analysis showed that guarding collaborative action beliefs were rooted in the managerial institutional logic, which was evident among both engineers and managers. Alpha's and Beta's managers stressed that sharing "too much" information and data could jeopardize their organizations' existence. This challenge was amplified after the oil crisis in 2014. A Beta engineer said: "Sharing with [Alpha] makes it possible for them to develop better designs and reduce costs … but we are also competitors by the end of the day. So, there's a limit to what we prepare to share" (Beta E.10). This notion of potential competition between client and contractor was primarily linked to the expertise overlap. This implies that Alpha and Beta could independently develop similar technology, and Beta could also undertake a part of FEED internally. Driven by FEED as business identity, interviewees also noticed that although nothing stopped them from sharing non-critical for business knowledge, achieving openness was tough for people in the "engineering-savvy front-end environment" with limited contractual regulation of KC. However, while the Beta interviewees were more concerned about protecting their stock-sensitive data (e.g., subsurface data), Alpha's engineers noted the tricky challenge of simultaneously sharing data and protecting intellectual property and technical knowledge, which they considered central to business success and existence.

Our data further unveiled that the logic of project management and FEED professionalism shaped not only coalescent, but also guarding collaborative orientation among engineers. Guided by project

Table 3
Illustration of the guarding logic of collaborative action.

	Inst. logic		Arguments	Illustrative quotes
Guarding logic of collaborative action	**Managers/ Engineers**	*Managerial logic of organizational survival and efficiency*	Jeopardizing org. existence	Everyone understands that the more you share, the more value you create. But it comes to a point where you, as a company, jeopardize your strategic agenda or your role to exist. So, here but not any further. (Alpha M.4)
			Protecting sensitive information	What makes Alpha Alpha is the competency…. We need to be very careful [that] we aren't giving away too much of that. (Alpha D.24) I've seen that confidential information … has been shared with other contractors. One client said, "Okay, we bought the equipment, so we own the technology." That's kinda clear evidence that that person has no clue who has the IP…. It was a strong signal to me that … we should be careful with what kind of information we share. (Alpha E.34) We need to look into how we can restrict [Alpha's] access to everything … because the data that we have [are] sensitive. (Beta E.40)
			"Stubborn" oil and gas culture	[Norwegian] culture and the industry haven't fostered very transparent [KC]…. In many discussions, I've said to one of our engineers, "Send that information. What are you afraid of?" (Alpha M.19) It's difficult to imagine that … you send a [draft] to your client.... There might be disappointment on the other side…. So, getting to that point where people feel comfortable enough in cocreating … is challenging. (Alpha E.21)
	Engineers	*PM prof.*	Iron triangle constraints	We, on purpose, sometimes hold back information … to limit spreading of our expertise and also to limit engineering hours. (Alpha E.7) [Schedule] is the driver of how detailed [KC in] the pre-FEED and FEED can be. (Beta E.10)
		FEED creative prof.	Information immaturity & creating more questions	In Project A,… [Beta] thought we held back information, but we didn't have the information.... Providing incomplete information too early just raises too many questions. (Alpha E.33) They [Alpha] want to hold back the information, and that will always be—the more they tell us, the more questions we have.… It's a balancing act. (Beta E.8)

management professionalism, the engineers often felt "time-crunched" and "rushing to the first oil." They emphasized that over the past decade, the maneuverability of FEED has diminished, along with an increased focus on the triangle between cost, time, and quality on which projects and project members were often evaluated. This shift led to reduced time-availability for the client–contractor discussions: "Whenever a new project starts, people need to have time to sort of familiarize [themselves] with [lessons learned] and take action. So, there's something about time" (Beta E.17).

Driven by the FEED creativity institutional logic, Alpha's engineers perceived knowledge protection in the project front-end phase as essential. This was attributed to the scarcity of technical information, particularly concerning new oil and gas fields characterized by specific reservoir geologies that the operator had not previously encountered. Moreover, Alpha's engineers attributed their reluctance to openly collaborate with the client to concerns about unnecessary questions that might compromise the FEED quality and innovation.

Historically, we [Alpha] are used to the client almost knowing more about our work…. Some engineers were beaten up so often that they don't want to disclose more than they have to.… Clients will tie you down for weeks…. The question is … are you asking for more information because you want to increase your importance as the client, or is this something you need to do your job? (Alpha E.34)

4.3. Conflicting logics of digital action

Along with the conflicting collaborative logics of action, our analysis uncovered diverse beliefs about how to act in relation to the digitalization of client–contractor front-end KC.

4.3.1. Protagonist logic of digital action

The protagonist logic of digital action refers to a prescription to support and engage in open, digitally enabled collaboration in the project settings (see Table 4 for details).

Digital protagonist discourse was prominent on the companies' websites and particularly resonated among managers. We observed that the managerial institutional logic strongly influenced Alpha and Beta commercial and digital managers. At information meetings and industrial discussions, they collectively showcased a shared perception of the need to engage in digitalization as a strategic shift because contractors and clients have "reached the end of the line" (Alpha D.18) in how they collaborated on the new economic realities of fluctuating oil prices. Therefore, they alleged that engaging in digitalization enabled business model innovation, entailing close client integration throughout the life cycle of the assets, specifically regarding small clients that were more open to sharing data and using Alpha as an advisor. Managers were propelled by managerial efficiency beliefs, such as breaking down silos by digital means to ensure immediate transparency and access to knowledge across boundaries.

Engineers were driven by project management professionalism, which evoked a hope that digitalization would improve the quality, costs, and speed of front-end project work. Alpha's engineers looked at 5 to 20 field architecture alternatives per project. Therefore, they stressed that engagement with digitalization ensured their ability to review more cases, perform better revision control, and reduce both the time to the first oil and the costs related to running too many alternatives. The engineers, as knowledge workers, also expressed hope when discussing the digitalization of project-related lessons learned that had to become less people-dependent to increase project efficiency: "That'd be a dream. … We produced a lot of presentations—PowerPoints, emails—stuff that haven't been stored very well for a long time. Much of that could have been formalized in technical memos [and] documents and stored for the future" (Alpha E.32).

Digital protagonist beliefs among engineers were also grounded in the institutional logic of FEED creativity, which spurred the belief of engineers and managers that digital tools, such as Alpha's digital twin for field layout design, enable real-time customer-centric codesign: "Digitalization presumes disrupting your ways of working, but that means … discussing problems with the contractor instead of telling the solution" (industrial discussion).

4.3.2. Antagonist logic of digital action

Along with the protagonist digital discourse, there was a dubious narrative on the digitalization of KC—antagonist logic of digital action—prescribing the mode of opposition and hostility to the digitalization of project relations (see Table 5 for details).

Guided by the managerial institutional logic, all the interviewees grounded their digital antagonistic action beliefs in low trust in digital "buzzwords" perilous for business efficiency. Guided by the principle of organizational survival and efficiency, several interviewees believed

Table 4
Illustration of the protagonist logic of digital action.

	Inst. logic		Arguments	Illustrative quotes
Protagonist logic of digital action	**Managers**	*Managerial logic of organizational survival and efficiency*	Business model innovation & role transition	X [a digital twin-based tool] supports very well our strategy of early engagement, a collaborative working model with the client to show our capabilities early, build the relationship … and be the preferred supplier. (Alpha M.4) [CEO] had a vision that we could utilize [those] data and build new business models out of [them]. (Alpha D.48)
			Digital trends	We are seeing digital [as] more present in the requirements we get from our clients.... Digital is generally becoming more of a trend. (Alpha M.25)
			Collaboration efficiency gain	The work we've done with Beta on Project A has allowed us to make those inefficiencies [around KC] very visible.… That's why I think that a digital twin environment will be the necessary way for us to do business. (Alpha M.25)
	Engineers	*Project manag. professionalism*	Iron triangle effectivization	With digital tools, if we could compress a concept study from 3 months down to 3 weeks and spend the rest of that time bouncing ball with the client,… then I think we could produce more value [for our] clients; we can go deeper, we can go further, we can go faster. (Alpha E.34)
			De-risk by making KC less people-dependent	It's a good idea [to digitalize experience] because … it's very people-dependent. We drilled a reservoir; we had a lot of important experiences.… Luckily, the people are here now, so we avoid making the same mistakes. But if it were a completely new team, we'd make the same mistakes. (Beta E.6)
		FEED creative professionalism	Enabling cocreation	From a digitalization point of view, small companies are much more of interest to us—we can (co)develop good solutions, both in this [front-end] phase and the operation phase. (Alpha E.8) It [sharing by cloud] also brings very different working practices because … you shift from individual contribution to … parallelization of input. (Alpha D.21)

Table 5
Illustration of the antagonist logic of digital action.

	Inst. logic		Arguments	Illustrative quotes
Antagonist logic of digital action	**Manag./ Engineers**	*Managerial logic*	Low trust in digital buzzwords	I'm not sure that people will truly trust digitizing or 100 %, you know, because of the consequences. (Alpha M.19) Digital [has become] a buzzword. (Alpha D.48)
			Oil and gas non-disruptive culture	This is an extremely conservative business. It takes a long time to bring [digital] things to the market. (Alpha E.22) Benefits [of digitalization] are so far into the future … so for a small company, it's not the right thing to do.… The low-hanging fruit is more attractive for us. (Beta E.3)
	Engineers	*Project management professionalism*	Project complexity	I think, in theory, yes [digitalization may accelerate projects], but there are so many other things that slow that process down.... Having a digital tool or not would not change that. (Alpha M.19)
			Iron triangle rigidity	I think our company doesn't really know how to attack [the front-end] phase.... Traditional project managers who want to de-risk the project … are not incentivized to try something new [digitalization]. (Alpha D.37)
			Limited control and individual risk assessment	[KC in Clouds] was more destructive because you had a moving target.… In the FEED, I have 400 new documents every week. And the engineers were going nuts. … "Did you use the revision we had on Tuesday or the one we received on Wednesday?".... It ended up just being noise. (Alpha E.34) In FEED now, we're using Teams, SharePoint, everything, but I find it uncontrollable. (Alpha E.39) Risk is an individual perception.… We don't have Monte Carlo simulations for everything we do. (Alpha E.34)
		FEED creative professionalism	Design requires human creativity	What is the most sensible way to design the subsea manifold? … That is a design issue that demands human creativity and is extremely hard to program. (Alpha E.34)
			Contextuality	I still miss seeing somewhere where we've digitally managed to transfer experience in an efficient way.… In a big project, the problems are going to be in the details. The devil is in the details. (Beta E.27)

that engaging in the digitalization of KC would result in added costs and a risk of IP rights violation: "[Digitalization] is helping us to be more open, but we still need to protect [our] IP…. It's easier for others to copy as well" (Alpha D.24). The industrial precautions, non-disruptive orientation also triggered digital antagonism among the interviewees. In the oil and gas industry, low-hanging fruits (i.e., incremental changes with immediate results) were seen specifically by Beta's managers as "the right way to go," in contrast to disruptive shifts, such as digitalization. Beta, as a small operator, was more careful with digitalization since it did not have the competency and resources to evaluate risks related to digitalization.

Project management professionalism spurred antagonistic digital beliefs among engineers. This was specifically evident in their arguments on the project complexity, the iron triangle objectives, and the "rush" in the front-end phase: "The FEED phase is very rush and reactive in a way, not very digital…. It's like, 'I need this. How can I get it?' So, very last minute" (Alpha D.42). A specific point of skepticism in the engineering environment was the parallelization of inputs in Cloud platforms, as it could hamper project workflow by creating a "moving target." Many engineers experienced the use of digital collaborative tools as "dangerous" for projects due to limited control: "Two thousand years ago, people carved stories on stone, and the stories are still there. … [but if] something collapses now, everything is gone for us" (Alpha E.39).

Eventually, the FEED creative professionalism logics also drove antagonistic digital actions among both companies' engineers. This institutional logic was grounded in the argument of the value of human design and human-to-human interaction in FEED processes. An experienced Alpha engineer stressed that digital tools could supersede humans in engineering, such as defining a pipeline cross-section, but not in design which requires human creativity. The emotion of doubt was further linked to the uniqueness of each project, presuming that highly context-specific knowledge was challenging to formalize: "Project A can be totally different from Project B even though it's in the same field … [and for] the same client" (Alpha E.47).

5. Discussion

Heeding the recent calls for more empirical studies on microfoundations of collaborative efforts at the project front end in the digital age (Matinheikki et al., 2016; Slavinski et al., 2023; Williams et al., 2019), this study explored tensions that hinder the openness of client–contractor front-end KC and its digitalization. To summarize our contribution, we developed a double-shaping model of client–contractor KC at the project front end (see Fig. 5). This model displays how fragmented ambient awareness networks and the coexisting conflicting logics of collaborative and digital action result in dual collaborative framing of actions toward the collaborating project organization. The core elements of the model are discussed next.

5.1. Fragmented awareness at the projects' front end

Studies have claimed that awareness networks are prerequisites to KC (Hansen et al., 2020; Jarvenpaa & Majchrzak, 2008). Our results show that ambient awareness networking is specifically valuable in the front-end phase of innovative engineering projects. In this context, awareness of nonredundant client–contractor expertise facilitates open and trustful cocreative and collaborative interaction. Open knowledge sharing and cocreation, in turn, enable the development of trustful expertise networks.

Despite the asserted importance of expertise awareness in interorganizational front-end settings (Hsu et al., 2012; Lin et al., 2015), our findings demonstrate that individuals' awareness of knowledge ownership (e.g., IP rights) and "who knows what and whom" in the collaborating organization is fragmented in this strategic project phase. One explanation of this fragmentation is the issue of time (its diverse perception by the collaborative parties) (Ligthart et al., 2016). The front-end context attributes regarding time, structure, and collective goals hinder individuals' abilities and motivation to invest in awareness network development. Another explanation is partial technology-enabled expertise networking, which we address below.

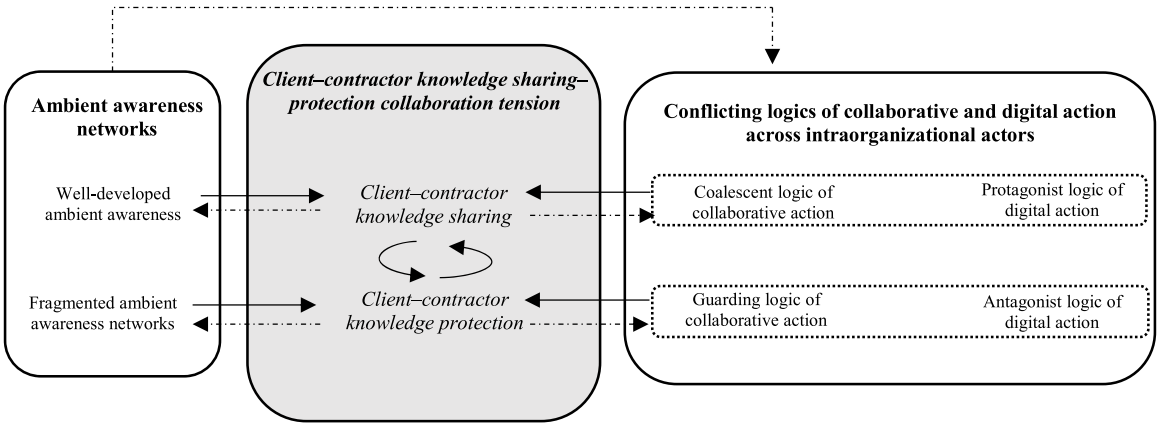

Fig. 5. Model of client–contractor front-end knowledge collaboration in the digital age.

Collaborating individuals with fragmented ambient awareness networks struggle to trust their counterparts' competence and benevolence (Xu et al., 2021) and to make in-the-moment decisions regarding what knowledge to protect or share. This fragmentation thus spurs individuals' propensity to protect knowledge at the projects' front end, which, in turn, hinders extra-group expertise awareness. Hence, our model depicts how (fragmentation of) ambient awareness networks results in dual collaborative framing of actions toward the collaborating organization. Our empirical insights also show that the identified fragmentation nurtures conflicting logics of action by diminishing trust in the collaborating counterpart, which is vital for client–contractor KC in the digital age.

5.2. Conflicting logics of action

Extant literature claims that institutional logics, inhabiting project individuals and their organizations, recursively shape interorganizational collaborative processes (Fu et al., 2022; Hetemi et al., 2021; Winch and Maytorena-Sanchez, 2020). Our study adds nuances to these findings, showing that individuals and coalitions of individuals (i.e., managers and engineers) involved in project front-end engineering design act upon coexisting, conflicting prescriptions on how to interact with collaborating organizations (i.e., logics of collaborative action) and how to engage in digitalization of KC (i.e., logics of digital action). Consistent with Berente and Yoo's (2012) remark that technology is inserted into an ecology of multiple logics, we find that logics of digital action reinforce the contradictions between logics of collaborative action in client–contractor front-end KC.

Regarding the constitutive factors that prompt different logics of action, our results point to the roles and the underlying institutional logics in the collaborating organizations. Our findings uncover that managers' actions and beliefs are driven by the managerial institutional logic of organizational survival and efficiency—an instantiation of the corporate institution—emphasizing strategy, company size, control, and business efficiency. In contrast, engineers' logics of action are primarily driven by institutional logics of project management and FEED creative professionalism—instantiations of the professional institution. These institutional logics respectively underpin iron triangle objectives of cost, quality, and time and risks in projects, and creativity, innovation, flexibility, and quality of FEED.

These institutional logics of corporate and profession embrace coexisting, conflicting logics of action. On the one hand, they embody *coalescent* and *protagonist logics of collaborative and digital action* which imply a prescription to engage in open, digital-driven client–contractor KC, wherein the collaborating counterparts are seen as trustworthy actors and digitally enabled transparency as a catalyst for innovations. On the other hand, they evoke the *guarding* and *antagonist logics of collaborative and digital action,* prescribing project actors to protect organizational knowledge and resist digital efforts because digitally enabled openness increases the risks of the collaborating organization's opportunistic behavior. This highlights the contradictions within single institutions by showcasing how, for example, the habitualized project management professionalism with strong "iron triangle" and "de-risking" thinking provides conflicting prescriptions on how to collaborate and digitalize KC at the front-end project work. These results imply that along with the relational and contractual complexities of the project procurement setting, the coexistence of conflicting logics of action (Fu et al., 2022; Winch & Maytorena-Sanchez, 2020) affects the propensity of project actors to share or protect knowledge. This directly influences the openness of client–contractor front-end KC in the digital age.

Although the sharing–protection collaboration tension appears to be an outcome of coexisting conflicting logics of action and fragmented ambient awareness networks, the premise of our model is that KC tensions continue as a process. The interpretation of others' behavior thwarts competence-based trust (Zhang & Min, 2019) and reinforces existing preconceptions (Vlaar et al., 2007). Thus, the sharing–protection tensions cause a vicious cycle of fragmentation of ambient awareness networks and inhibit the gradual convergence of logics of collaborative and digital action. While these findings are distinctive to the front-end project phase, attributed to the specificity of identified institutional logics and expertise fragmentation during this pre-contractual phase, similar dynamics may occur in other project phases, where the heterogeneity of expertise and institutions also plays a critical role.

5.3. Digitalization of client–contractor knowledge collaboration

Recent studies suggest that digitalization, rooted in the principles of openness—such as connectivity, accessibility, and traceability—will change how collaborating project parties engage in KC (Braun & Sydow, 2019; Whyte, 2019). Specifically, it is argued that digital technologies will leverage open, seamless, and trustworthy knowledge sharing and cocreation at the project front end by enabling easy access to other parties' crucial knowledge (Hinings et al., 2018; Murray et al., 2021). This coerces the pursuit of digital-driven openness among collaborating project parties. However, our study paints a less optimistic picture, revealing persistent vulnerabilities and emergent challenges related to KC in the digital age.

Our findings show that digitally enabled openness does not remove individual vulnerabilities in the pre-contractual front-end KC between the client and the main contractor. Instead, the digital age introduces new hurdles for collaborating project actors, particularly in terms of limited control and increased risks of intellectual property in the open collaborative digital environment. Our study uncovers explicitly that digital-driven ambient awareness networking (Leonardi, 2018)—essential for open KC—faces constraints not only due to its limited

integration into front-end routines (Faraj et al., 2011) but also due to granularity concerns. The latter refers to the limitation of digital tools in representing expertise at the level of detail required for effective front-end KC (at least at their current state).

Furthermore, our results suggest that the principles of "digital openness" spur conflicting logics of digital action that reinforce contradictory collaborative beliefs and behaviors in the front-end project context. However, in response to the recent call to explore conditions under which organizational institutional heterogeneity is desired (Brattström & Faems, 2020), our results suggest that the coexisting logics of collaborative and digital action may play a stabilizing strategic role in client–contractor front-end KC in the digital age. The rising institutional demands for digitalization and economic efficiency are increasingly coercing project organizations to pursue the open, digitally enabled client–contractor KC (Hinings et al., 2018; Korotkova et al., 2023). Yet, this KC openness can harm projects, as the principles of connectivity, accessibility, and traceability conflict with the assumptions of the corporate and professional institutional logics. Hence, coexisting logics of collaborative and digital action—where managerial "openness" talk cohabits with local guarding talk and actions concerning the digitalization of KC—may serve as a constructive response to the "insoluble" organizational problem of "pursuing openness" in interorganizational projects.

Our observations thus support Forsythe et al.'s (2015) caution against seeing digitalization as a panacea for project collaboration issues. Our findings question whether digital technologies can really leverage collaborative openness, as there seems to be a substantial reluctance, or even inability, to share knowledge openly at the start of the project. Our research thus advocates a more balanced approach to shaping KC in both front-end and other project phases in the digital age. This approach recognizes the potential of digital technologies but also considers the heterogeneity of collaborating actors' expertise, backgrounds, and viewpoints in today's digital environment.

6. Conclusion

By exploring and explaining the complexities and tensions in client–contractor front-end KC in the digital age, our study makes valuable contributions for both researchers and practitioners.

6.1. Theoretical contributions

We draw on awareness networks and institutional logics theoretical perspectives to explore the microfoundations of client–contractor KC tensions at the project front end in the digital age, a relatively underexplored area within project management literature. In doing so, we provide a threefold contribution to the existing literature. First, our study contributes to the literature on project front end by offering empirical and theoretical insights into the existing research gaps regarding the microfoundations of front-end KC in the digital age (Oraee et al., 2019; Papadonikolaki et al., 2022; Solli-Sæther et al., 2015). We enrich the current limited understanding of challenges hindering digitalization in projects while also shedding light on KC tensions prompted by this transformative shift in interorganizational project settings (Slavinski et al., 2023). Our research explores the covariance among multiple dimensions: the front-end project lifecycle stage, the level of fragmentation, and the focus on the micro versus macro-level of analysis, as called for by Glynn and D'Aunno (2023). We emphasize the value of considering the contextual, project, and individual realms in exploring beliefs and behaviors influencing the digitalization of client–contractor front-end KC in projects. By bringing together the literature on awareness networks and institutional logics, our model sheds light on how often overlooked yet vital interplay between expertise heterogeneity (fragmented ambient awareness networks) and institutional heterogeneity (coexisting conflicting logics of action) underlies the sharing–protection tensions in client–contractor front-end KC in the digital age.

Second, we contribute to the growing body of literature on institutional logics in projects and respond to the call for more project studies on the heterogeneity of collaborating project parties (Wang et al., 2023). Project studies employing the institutional logics perspective traditionally focus on conflicts between different institutions (e.g., Farid & Waldorff, 2022; Hetemi et al., 2021; Winch & Maytorena-Sanchez, 2020). We advance the project literature by challenging this somewhat simplistic approach (Alvesson & Blom, 2022; Meyer & Höllerer, 2016) by empirically showing that contradictions may occur not only between institutions but also within 'one' institution, in our case, corporation and profession. We thus contribute to research on intra-institutional complexity (Meyer & Höllerer, 2016)—a relatively underexplored research area in project studies—by empirically demonstrating that institutional logics of profession and corporation are inhabited by contradicting prescriptions on how to act professionally—logics of collaborative and digital action—among collaborating project actors. Hence, we show how a constellation of corporate and professional institutional logics and the four instantiated logics of collaborative and digital action can affect client–contractor front-end KC in the digital age. This perspective opens an avenue for moving beyond a simplistic delineation of contradictions between varying institutions to appreciate the rich, complex, and sometimes conflicting dynamics within institutional logics.

Lastly, we contribute to the literature on awareness networks and expertise boundaries in projects (Leonardi, 2018; Mohammed et al., 2021) by extending the awareness networks perspective to client–contractor KC. We particularly address a void in the project management literature regarding ambient awareness. Despite its recognized significance in nurturing interorganizational relationships and enhancing overall project performance (e.g., Hansen et al., 2020; Hsu et al., 2012), this area has remained relatively unexplored in empirical research. While prior studies have partially examined ambient awareness in the context of permanent organizations (Austin, 2022; Jarvenpaa & Majchrzak, 2008), our research is among the first aiming to empirically investigate the role of ambient awareness networks in the dynamic project front-end context, specifically in complex interorganizational projects settings. Our study showcases the permeability of project group expertise boundaries (Mell et al., 2022) and the value of extra-group awareness networks in relationally governed front-end client–contractor KC. We also provide empirical insights into the contextual, technological, and normative factors that lead to fragmentation and limited digitalization of ambient awareness networks at the projects' front end.

6.2. Practical implications

This study also offers implications for practitioners pursuing the rising trend of open, digital-driven KC in the strategic front-end project phase. We recommend project practitioners be aware of the intricate dynamics and tensions introduced by digitalization. While augmenting connectivity and accessibility in project work, digitalization can simultaneously challenge the established project management norms and influence actors' logics of action at the projects' front end. In this context, fostering open front-end KC and its digitalization requires addressing not only technical but also (inter)organizational and institutional aspects to ensure that all actors are motivated and able to balance the sharing–protection tensions. Digital technologies must thus be carefully selected at the projects' front end and adapted to support not only data sharing but also transparent, continuous, and dynamic client–contractor KC while upholding necessary privacy measures. This careful balance plays a pivotal role in building and maintaining trust between clients and contractors (Lumineau et al., 2022; Xu et al., 2021). The ongoing KC and its digitalization is, thus, vital for ensuring that the project remains on par with changing goals and stakeholder needs, as highlighted by Zwikael and Meredith (2019).

Additionally, our study suggests that project managers must address the fragmentation of awareness networks by routinizing ambient awareness networking in project work. This can be achieved by encouraging project members to proactively move beyond project group expertise boundaries (Austin, 2022) and fertilizing digital opportunities for learning and utilizing expertise in the client–contractor context. By doing so, practitioners can enable efficient orchestration of expertise scattered across collaborating organizations, which is critical to strengthening cognitive-based trust and achieving a negotiated order in the increasingly complex front-end engineering context. Our findings also highlight the need for project practitioners to manage the heterogeneity of collaborative project actors adeptly. This involves navigating the complexities of institutional binding processes, which often produce divergent and contradictory collaborative and digital beliefs. Recognizing and understanding these multifaceted institutional dynamics enables project actors to be more conscious of their own and their counterparts' pressures and choices, enhancing overall project KC and success.

6.3. Limitations and future studies

Our study has some limitations. First, it was grounded mainly on interview data, which are appropriate for developing knowledge on a context-specific phenomenon (i.e., front-end KC in oil and gas projects) but can only be cautiously used to generalize to large populations. We believe, however, that our results can be valuable to other project phases and project-based organizations, considering the ongoing societal trend of projectification and digitalization of business and work life (Lundin et al., 2015). Moreover, the strategic partnership showcased in this paper could impact our findings on the coexistence of conflicting institutional logics and logics of action. Considering the potential impact of strategic partnership on collaborative openness in the long run (Eriksson et al., 2017), future studies could build on our results to examine whether and how strategic alliances impact the dynamics of awareness networking and logics of action and, eventually, the emergence of sharing–protection tensions throughout the project life cycle.

Another limitation of this study is its focus on capturing socio-cognitive microfoundations of front-end KC tensions. Future studies may explore the interplay between the unveiled microfoundations and the contractual arrangements governing client–contractor front-end KC (Zhang et al., 2018). Researchers may also draw on institutional logics and self-regulatory (Jarvenpaa & Majchrzak, 2008) theories to pragmatically examine how individuals navigate the identified intrainstitutional complexity in the temporary context. Additionally, our findings on the perpetual sharing–protection tensions and the coexistence of conflicting logics of action partly contradict previous studies on trust in the project life cycle (Xu et al., 2021). This sets the stage for further empirical and conceptual investigation of whether trust and technology-enabled openness fit into project management.

Declaration of competing interest

There are no conflicts of interest to declare.

Acknowledgment

This research is sponsored by BRU21 – NTNU Research and Innovation Program on Digital and Automation Solutions for the Oil and Gas Industry (www.ntnu.edu/bru21). The authors acknowledge the valuable and constructive feedback received during the 38th EGOS Colloquium 2022 and the EURAM Annual Conference 2023, where preliminary drafts of this paper were presented. Further, we thank the editor and the anonymous reviewers for invaluable guidance. The authors also thank David Cameron and Magdalena Villegas Lilliesköld for proofreading the manuscript.

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