Structural holes and brokering in triadic supply networks in industrial digital service innovations

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Abstract

Purpose – This study explores how industrial firms structure their relationships with technology providers and customers in digital service innovations (DSIs) – the use of digital technologies to create new value-added services. DSIs challenge supply network structures by reshaping roles and creating new dependencies. Therefore, understanding these changes is critical as they affect innovation outcomes, control over customer access, technology integration, and strategic positioning. Drawing on structural holes and brokerage, the study examines how industrial firms manage disconnections in these settings.

Design/methodology/approach – The study employs a qualitative multiple-case study approach across four DSIs. While each case has a triadic analytical setting, the empirical material is collected through 21 interviews with Finnish industrial firms and technology providers.

Findings – The study identifies that structural holes in DSIs are multidimensional, extending beyond relational gaps to include knowledge, cognitive, technical, and temporal gaps. Industrial firms structure triadic relationships through brokerage practices, including streamlining workflows, balancing priorities, controlling the flow of information and access, and mediating customer knowledge across firm boundaries. These practices allow industrial firms to selectively preserve, reshape, and connect relationships across gap dimensions and project phases.

Originality/value – The study extends research on structural holes, brokerage, and digital service innovation. The findings move the discussion beyond the binary of connected vs. disconnected by showing that actors may become connected in one dimension while other gaps remain. The study further shows that industrial firms sustain brokerage in DSIs through a synthesis capability: they filter, translate, sequence, and align customer, technical, and business knowledge without necessarily owning all digital capabilities. Finally, the continued acceptance of brokerage depends on whether other actors perceive the industrial firm's intermediation as adding value through coordination, customer understanding, and technology integration.

Keywords Digital service innovations, Supply network, Triad, Structural holes, Brokerage, Technology suppliers, Digital servitization

Paper type Research article

1. Introduction

In industrial markets, service innovation is increasingly connected to digital technologies, as manufacturers broaden their offerings from products to include data-driven services (Kindström and Kowalkowski, 2014; Kowalkowski *et al.*, 2013). Digital service innovations (DSIs) are a specific form of service innovation in which digital technologies like the Internet of Things (IoT), cloud computing, and predictive analytics are integral to the creation and delivery of new value-added services (Opazo Basáez *et al.*, 2024). DSIs enable firms to extend their offerings beyond product delivery through, e.g. remote monitoring,

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predictive maintenance, and performance analytics (Kowalkowski *et al.*, 2024; Raddats *et al.*, 2022). While these innovations are promising, they also challenge the supply network structures by reshaping roles and introducing new interdependencies among industrial firms, customers, and technology providers (e.g. developers, platform providers, and IT consulting firms) who possess the resources and capabilities industrial firms require (Chen *et al.*, 2021; Dalenogare *et al.*, 2023).

Although previous research has widely studied the impacts of digitalization on supply networks, it has primarily focused on topics such as operational efficiency, resilience, and the adoption of specific technologies (Auramo *et al.*, 2005; Perano *et al.*, 2023; Zouari *et al.*, 2021). A few previous studies focusing on supply chains have highlighted the transformative impacts of digital servitization, such as shifts in power dynamics, enhanced end-user connectivity, and the reconfiguration of supply chain relationships to foster innovation (Mosch *et al.*, 2021; Pizzichini *et al.*, 2023; Vendrell-Herrero *et al.*, 2023). DSI literature has increased understanding of the technologies underpinning DSIs, the required capabilities, and the challenges and opportunities raised by DSIs (Burton *et al.*, 2024; Coreynen *et al.*, 2024; Raddats *et al.*, 2022). DSIs often require firms to reconfigure resources and relationships. The reconfiguration may involve strengthening ties with some actors, such as customers, introducing new actors, such as technology providers, and weakening ties with others, such as external service providers, as digital technologies allow industrial firms to get closer to customers (Sklyar *et al.*, 2019). Prior research has also highlighted the increasing need for collaboration between industrial firms, technology providers, and customers (Dalenogare *et al.*, 2023; Narvaiza *et al.*, 2024), showing that successful DSIs often depend on shared knowledge, coordinated development efforts, and mutual adaptation (Huikkola *et al.*, 2022; Schymanietz *et al.*, 2022; Sjödin *et al.*, 2020). The literature underscores the relational and interactive nature, as well as the challenges and tensions between actors involved in DSIs (Burton *et al.*, 2024; Smania *et al.*, 2024). However, much less is known about how industrial firms structure their networks to co-create value with customers and technology providers in DSIs.

This study adopts a triadic approach rather than the broader supply network in DSIs. In this study, the triad refers to the relationship between an industrial firm, a technology provider (such as an IT or software provider), and a customer organization. While supply networks can be studied at multiple levels (i.e. dyadic, triadic, or the whole network), studying triads in DSIs enables a more focused analysis of how industrial firms navigate the complexities of digital development with external technology partners and customers. Many of these complexities can be addressed by shifting from a dyadic to a triadic perspective, and they are not significantly changed by adding four or more actors (Wuyts *et al.*, 2004). This configuration is common in DSIs, where industrial firms rely on external digital expertise to develop DSIs while maintaining responsibility for customer relationships and service outcomes.

We draw on the concepts of structural holes and brokerage (Burt, 2005). While these concepts originate from classic network theory, they remain useful in digital contexts as they highlight disconnections and relational positioning that persist even in highly connected systems (Brändle *et al.*, 2025). Digital technologies increase connectivity, but they may also introduce new forms of fragmentation across knowledge silos, organizational boundaries, or technical architectures. In this sense, structural holes help identify disconnections between technology providers and customers in DSIs, while brokerage and brokering help explain how industrial firms navigate those disconnections (Halevy *et al.*, 2019).

Building on these perspectives, two key gaps still exist in our understanding of DSIs. First, although existing research highlights the significance of collaboration, coordination, and joint development (Dalenogare *et al.*, 2023; Narvaiza *et al.*, 2024), it still provides a limited understanding of the different kinds of disconnections between actors in DSIs. In particular, there is limited understanding of how structural holes in DSIs extend beyond relational separation and influence the transfer of knowledge, resources, and value across organizational boundaries. Second, there is still a limited understanding of how industrial firms structure these relationships in DSI networks. Specifically, service triad research highlights a focal firm's role in coordinating interactions between a supplier and a customer (Suurmond *et al.*, 2022) but pays less attention to the ways in which industrial firms position themselves, shape inter-firm connections, and widen or narrow access to knowledge and capabilities within the supply network (i.e. brokering) (Halevy *et al.*, 2019; Quintane and Carnabuci, 2016). This question is particularly important in DSIs, where industrial firms often depend on external digital expertise while still maintaining customer access, coordinating service development, and remaining responsible for service outcomes. Against this backdrop, this study aims to investigate: *How do industrial firms structure their triadic relationships with technology providers and customers in digital service innovations?*

The study adopts a qualitative multiple-case approach across four DSIs. Across the cases, 21 interviews were conducted with Finnish industrial firms in the capital goods and machinery sectors and their technology providers. While each case has a triadic analytical setting, the empirical material is based on interviews with Finnish industrial firms and technology providers. Industrial firms offer a highly relevant context for studying DSIs because they face strong pressures to adopt digital technologies within their long-standing product and service offerings (Raddats *et al.*, 2022). Such innovations often need external digital expertise, making collaboration between firms both essential and complicated (Dalenogare *et al.*, 2023).

This study contributes in three ways. First, the findings extend structural hole and service triad research (Finne and Holmström, 2013; Tahi *et al.*, 2022) by showing that structural holes in DSI triads are multidimensional, spanning relational, knowledge, cognitive, technical, and temporal dimensions, thereby moving the discussion beyond the binary of connected vs. disconnected by specifying that while actors may become connected in one dimension, other gaps can remain. Second, the study refines research on brokerage and brokering (Halevy *et al.*, 2019; Quintane and Carnabuci, 2016) by showing how industrial firms maintain central intermediary roles in DSI triads despite depending on external technology providers for digital expertise. The findings show that brokering in DSIs is dimension-sensitive and phase-sensitive: industrial firms may preserve intermediation around customer access, data sensitivity, and intellectual property while modifying coordination routines, knowledge interpretation, and development priorities, and may shift between separation and connection across project phases. Third, the study contributes to research on intermediation in service and innovation networks by showing that the continued acceptance of brokerage depends on whether other actors perceive the industrial firm's intermediation as adding value through coordination, customer understanding, and technology integration (Cross and Cummings, 2004; Seclen-Luna *et al.*, 2024).

2. Literature review

Earlier service innovation literature has addressed how service innovation in industrial firms evolves through new value propositions, changes in service business orientations, and information and communication technologies (Kindström and Kowalkowski, 2014; Kowalkowski *et al.*, 2013; Witell *et al.*, 2016). Building on this stream, DSIs have recently emerged at the intersection of digitalization and servitization as a distinct form of innovation that combines technological and service logics (Coreynen *et al.*, 2024; Opazo Basáez *et al.*, 2024; Opazo-Basáez *et al.*, 2022). DSIs are about the development of new value-creating services enabled by digital technologies such as IoT, cloud computing, and artificial intelligence, which reconfigure provider-customer relationships and transform business models (Kowalkowski *et al.*, 2024; Rabetino *et al.*, 2024). DSIs have been associated with digital servitization, where manufacturers shift from product-centric to digitally enabled, service-based offerings (Marić *et al.*, 2024; Vendrell-Herrero *et al.*, 2023). From a service-dominant logic perspective, DSIs are not only technological but also institutional, as they reshape value propositions, roles, and norms within service ecosystems, making value co-creation a systemic and multi-actor process (Vargo *et al.*, 2024; Vargo and Lusch, 2016). In this way, DSIs extend beyond internal firm boundaries to reconfigure inter-organizational relationships.

To better understand these relationships and reconfigurations, this section first examines triads; triads serve as a useful meso-level unit of analysis for capturing these dynamics while acknowledging their embeddedness in broader networks. To further explore how firms navigate such configurations, concepts like structural holes, brokerage and brokering emphasize how disconnections across networks create both challenges and opportunities, and how firms can strategically organize and manage relationships across organizational boundaries.

2.1 Supply network in DSIs: triadic approach

Service innovation depends on resource integration and the coordination of diverse roles across organizational boundaries (Gustafsson *et al.*, 2012; Kindström *et al.*, 2013; Koskela-Huotari *et al.*, 2016). This multi-actor view is especially relevant for DSIs, which are rarely developed in isolation; they emerge in multi-actor settings involving networks of actors with different roles and knowledge (Narvaiza *et al.*, 2024; Smania *et al.*, 2024). Implementing DSIs often requires collaboration beyond industrial firms' boundaries, especially when firms lack in-house digital expertise (Momeni *et al.*, 2023a). Therefore, industrial firms frequently rely on technology providers to co-develop or deliver parts of the service (Chen *et al.*, 2021; Dalenogare *et al.*, 2023), while also engaging customers, when services are tailored to their operations (Sjödin *et al.*, 2020). These interdependencies underscore that DSIs are embedded in supply networks rather than isolated firm-level processes, making the supply network central to DSI execution.

These supply-network relationships also exhibit the kind of interdependence characteristics of the service triad, where value is shaped not only by contracting but also by interaction among the industrial firm, the technology provider, and the customer in use and feedback processes (Siltaloppi and Vargo, 2017). Triads are common structures in industrial service supply networks (e.g. industrial firm–supplier–customer) and have been well-recognized as building blocks of extended supply networks (Ayala *et al.*, 2019; Choi and Wu, 2009). A triadic setting introduces complexity not present in dyadic relationships (industrial firm–customer or industrial firm–supplier). At the same time, triads do not capture the full scope of network complexity but rather serve as meso-level building blocks situated between dyads and whole networks. However, they provide a manageable and analytically robust structure for studying inter-organizational relationships (Ayala *et al.*, 2019; Choi and Wu, 2009; Wichmann and Kaufmann, 2016).

Service triads differ from more generic manufacturing or supply-chain triads because service provision involves more direct, processual interaction with the end user (Siltaloppi and Vargo, 2017). This structural interdependence requires an ongoing coordination role by the buyer (i.e. focal firm), which is critical for value co-creation, operational feedback, and service improvement (Suurmond *et al.*, 2022). Previous research has studied triads to understand relationship management, outsourcing decisions, and performance outcomes (Sengupta *et al.*, 2018; Wynstra *et al.*, 2015) and helped uncover power asymmetries, interconnectedness, and coordination mechanisms (Andersson *et al.*, 2019; Hartmann and Herb, 2014; Kovalevskaya *et al.*, 2021; Momeni *et al.*, 2023b). In DSIs, a typical triad consists of an industrial firm, a technology provider (e.g. a software/IT firm), and a customer, as DSIs require coordination of complementary knowledge: operational usage (customer), digital capability (supplier), and domain-specific expertise (industrial firm). This triadic setting becomes especially evident when external firms provide digital capabilities (e.g. analytics, cloud integration) (Narvaiza *et al.*, 2024). In this sense, DSI triads overlap with service triads where the buyer or focal firm — in this paper, an industrial firm — often plays a central coordinating role, but this position is not necessarily stable as direct interactions between other actors may change over time (Li and Choi, 2009).

Relationships within DSIs often involve a combination of formal contracts and more informal, trust-based coordination with technology providers and customers. Prior research highlights that supply network governance typically involves a mix of contractual and relational mechanisms (Kohtamäki and Partanen, 2016; Poppo and Zenger, 2002) and the focal firm's role goes beyond contracting and governance to include ongoing operational coordination and feedback management, even when parts of service delivery are delegated to suppliers (Suurmond *et al.*, 2022). Developing digital services, in particular, requires striking a balance between formal agreements and informal collaboration (Sklyar *et al.*, 2019). The challenge lies not only in managing flows or relationships but also in enabling digital value creation through multiple disconnected roles (Burton *et al.*, 2024). Such interdependencies are difficult to capture in dyadic studies but become visible in triadic analysis (Choi and Wu, 2009; Wuyts *et al.*, 2004). At the same time, these configurations often contain gaps and disconnections between actors, such as mismatched expectations or knowledge asymmetries (Finne and Holmström, 2013; Zhou *et al.*, 2020). While service-triad research has emphasized the focal firm's coordinating role and the significance of triadic exchanges, less attention has been given to how various forms of structural disconnection develop and are actively managed in DSIs.

2.2 Structural holes and brokerage practices

Industrial firms often encounter mismatches between their own capabilities and the technological expertise of providers, or between provider solutions and customer needs (Narvaiza *et al.*, 2024; Sjödin *et al.*, 2020). These tensions can hinder collaboration (Smania *et al.*, 2024), but they can also create opportunities for firms that can mediate across boundaries. In addressing these issues, this subsection clarifies key aspects of disconnections in the supply network and how industrial firms navigate those disconnections: structural holes, the contingencies and dynamics of structural holes, brokerage and brokering, and strategic forms of brokerage (Table 1).

First, to conceptualize these conditions, the study draws on Burt's (2004) concept of structural holes. Structural holes are described as gaps in a network where there are no direct connections between certain nodes (or entities) in the network. An actor positioned between disconnected others can serve as a broker, gaining access to diverse information or influence and benefiting from information advantages, control benefits, and opportunity structures. Figure 1 provides an illustrative example of one possible triadic DSI setting in which the industrial firm occupies an intermediary position between technology providers and a customer. From this perspective, limited or mediated direct interaction between technology providers and customers in DSIs can indicate a structural hole that positions the industrial firm as a potential intermediary.

Second, structural holes, rooted in social capital research, view disconnections in supply networks as both strategic opportunities and coordination challenges and emphasize the contingent nature of structural holes (Hahl *et al.*, 2016). Early work suggests that while cohesive networks offer reliability and trust, they can limit flexibility, whereas networks rich in structural holes enhance adaptability but risk weaker cooperation (Gargiulo and Benassi, 2000). Structural holes are indeed strategic spaces, and their significance depends on whether and how actors choose to exploit or ignore the disconnection (Choi and Wu, 2009). Structural holes can positively and negatively affect innovation, depending on the type of benefits pursued; on the one hand, structural holes can increase access to non-redundant knowledge and information spillovers, and on the other hand, they may reduce resource-sharing effectiveness due to lower trust and coordination across disconnected partners (Ahuja, 2000).

Servitization literature has also acknowledged these contingencies, where structural holes are often implied in service delivery networks rather than directly studied. For example, Tahi *et al.* (2022) show how central actors control and filter knowledge flows among disconnected stakeholders, especially in the presence of institutional boundaries or

Table 1. A summary of previous research on structural holes and brokerage, and their implications for this study

Concept	Author(s)	Main findings	Implication for this study
Structural holes	Burt (2004), Ahuja (2000)	Structural holes are network gaps that create brokerage opportunities for actors positioned between disconnected others. They enhance access to non-redundant knowledge, but may weaken trust, coordination, and resource sharing	Provides the core lens for identifying intermediary positions of industrial firms between technology providers and customers in DSIs
Contingencies and dynamics of structural holes	Choi and Wu (2009), Finne and Holmström (2013), Gargiulo and Benassi (2000), Hahl *et al.* (2016), Li and Choi (2009), Zhou *et al.* (2020)	The effects of structural holes are contingent on context, network structure, and actors' responses to disconnection Structural holes may restrict access, reduce efficiency, and change over time as direct ties between actors emerge	Suggests that gaps in DSI triads should be examined as contingent conditions rather than fixed advantages or disadvantages
Brokerage and brokering	Balachandran and Hernandez (2018), Burt (2005), Halevy *et al.* (2019), Hargadon and Sutton (1997), Llopis and D'Este (2022), Obstfeld (2005)	Brokerage enables actors to connect disconnected others, influence exchanges, and create value through intermediation Brokering refers to the relational practices through which actors shape others' interactions The value of brokerage depends on both access to diverse knowledge and the costs of integrating it	Helps explain how industrial firms leverage intermediary positions in DSI triads
Strategic forms of brokerage	Quintane and Carnabuci (2016)	Brokers may either preserve separation between actors or facilitate direct connection between them	Provides a basis for analyzing whether industrial firms in DSIs maintain or reduce disconnection between providers and customers

Source(s): Authors' own work

strategic concerns. This perspective highlights that structural holes serve not only as structural conditions but also as tactical tools that can be leveraged to manage risk, influence development, or safeguard competitive advantage. Chen *et al.* (2019) argue that structural holes can be strategically managed through ecosystem orchestration, utilizing digital platforms and network capabilities, such as coordination, learning, and integration, to transform disconnected positions into improved service performance. By contrast, Finne and Holmström (2013) explore how subsystem suppliers face restricted access to end users because of their upstream network positions. Zhou *et al.* (2020) further argue that structural holes adversely affect financial performance in industrial service supply networks, as lack of connections between service suppliers leads to inefficiencies. Previous studies on service triads suggest that structural holes are not static; a focal firm's central role can diminish or

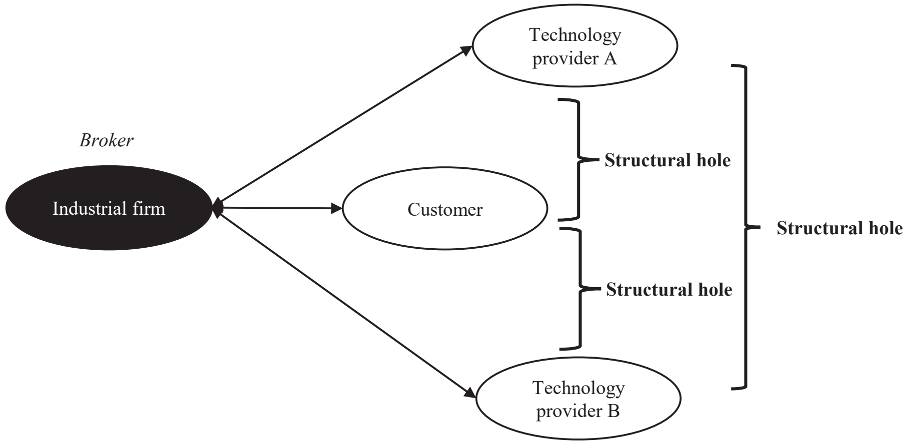

Figure 1. Illustrative example of structural holes in a DSI triad. Source: Authors' own work

change over time as direct interactions between suppliers and customers evolve, resulting in bridge decay or transfer (Li and Choi, 2009).

Third, while these studies highlight the contingent nature of structural holes, they also underscore the importance of understanding how firms actively manage such gaps. Structural holes represent potential spaces for brokerage. Brokerage emerges as a central mechanism through which brokers navigate structural holes (Obstfeld, 2005). Brokers are often positioned between otherwise disconnected actors and can facilitate the flow of information, control access to resources, influence the decision-making process, and create new opportunities (Burt, 2005; Hargadon and Sutton, 1997). Recent studies distinguish brokerage, seen as a structural role of holding a bridge position between disconnected others, from brokering, seen as the behavioral processes through which actors influence others' relationships and determine whether they stay separate, become connected, or interact differently over time (Halevy *et al.*, 2019). Within this view, brokering can involve intermediation, where the broker remains between otherwise disconnected actors and manages their indirect exchange, or modification, where the broker reshapes an existing relationship by changing how actors interact, coordinate, or relate to one another (Halevy *et al.*, 2019).

In knowledge-intensive contexts, such as DSIs, brokering is particularly important because the knowledge exchanged across boundaries is often complex and specialized. Here, the broker's ability to interpret and translate knowledge between different domains becomes critical (Cross and Cummings, 2004). However, brokers, as an innovation intermediary, are not only defined by structural position, but they also need capabilities that create value for the other actors, such as specific know-how or orchestration skills (Seclen-Luna *et al.*, 2024). Innovation benefits depend on factors such as the broker's reputation and, thus, other actors' willingness to be brokered (Hahl *et al.*, 2016). Brokers must be able to build trust, communicate effectively, and negotiate across diverse groups (Cross and Cummings, 2004).

Fourth, previous research further suggests that brokering can take on different strategic forms. Brokers may adopt a more separating approach by keeping disconnected actors apart and acting as an intermediary (Tertius Gaudens), or a more joining approach by promoting direct interaction and collaboration between them (Tertius Iungens) (Quintane and Carnabuci, 2016). Recent innovation research also suggests that the value of open triads depends not only on access to non-redundant knowledge, but also on the costs of integrating that knowledge, implying that some brokerage configurations are more effective than others for innovation (Balachandran and Hernandez, 2018; Llopis and D'Este, 2022). This distinction is important in triadic DSI settings because holding an intermediary position alone does not explain how focal firms influence relationships among technology providers and customers. Instead, it requires focusing on brokering as a set of practices.

Table 1 summarizes previous research on structural holes and brokerage and their implications for this study. Structural holes provide an analytical lens for identifying disconnections across actor interfaces, while brokerage and brokering help explain how focal firms navigate these disconnections. Together, these perspectives provide a "guiding frame" (Gioia *et al.*, 2013) that shapes the data interpretation.

3. Research methodology

3.1 Research design

This study adopts a qualitative multiple-case approach to explore how industrial firms structure relationships with technology providers and customers in DSIs (Figure 2). This approach is particularly suitable for studying DSIs as they are complex, context-dependent, and not yet fully understood, which requires an in-depth analysis of processes (Edmondson and Mcmanus, 2007; Eisenhardt and Graebner, 2007). A multiple-case approach also enables comparison across different DSI settings, making it possible to identify recurring patterns and differences in how industrial firms configure their roles, broker structural gaps, and structure supplier-customer relationships. In this way, the design supports comparison across cases and the development of analytically generalizable insights, aiming to extend and refine the theoretical understanding of how industrial firms structure and broker relationships in DSIs (Yin, 2018). Following Yin's (2018) distinction, the study uses an embedded case design because the phenomenon of interest—relationship structuring—develops through interactions among these sub-units rather than at the level of the firm or technology alone.

Clearly defining this unit of analysis is crucial for ensuring validity and interpretive accuracy in qualitative case research (Jack and Raturi, 2006). In this study, each case is defined as a DSI involving a focal industrial firm, its technology providers, and external customers. The unit of analysis is the industrial firm's triadic relationship structure, involving the industrial firm, its technology providers, and customers in DSIs (Figure 1). While each case has a triadic analytical setting, the empirical material is based on interviews with industrial firms and technology providers; the third actor's perspective, i.e. customers, is captured indirectly through how customers and customer-related interactions are described by the industrial firms and technology providers, following Jraisat *et al.* (2023) and Patrucco *et al.* (2022). Therefore, the study does not aim to compare fully symmetrical three-sided perspectives. Instead, it explores how the interviewed actors perceive, interpret, and manage triadic relationships involving industrial firms, technology providers, and customers in DSI settings.

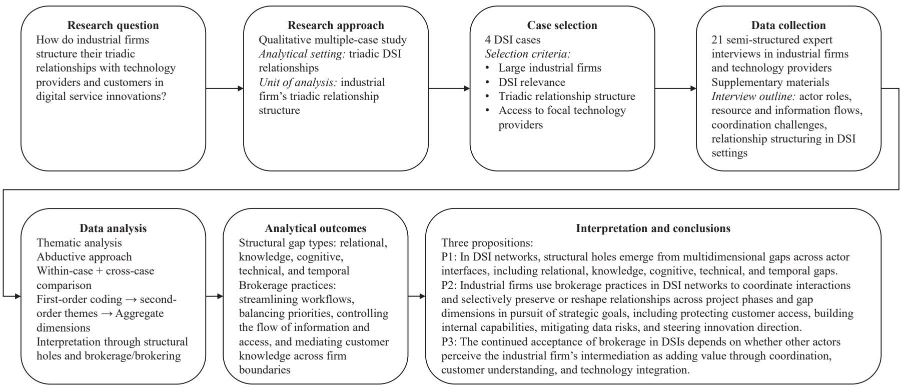

Figure 2. Overview of the research process. Source: Authors' own work

Four key criteria guided the case selection. First, all selected industrial firms are large, well-established companies in their respective industrial sectors. Industrial firms manufacture industrial machinery and systems and offer various services to their installed base and customers. Their scale and position in industrial supply networks provide a meaningful context for examining interfirm collaborations. Second, each case focuses on a DSI, in which the focal firm integrated digital technologies like IoT, cloud solutions, and predictive analytics into its offerings. Third, the DSIs involved triadic relationship structures connecting industrial firms, technology providers, and external customers, allowing us to analyze how firms structure relationships in these settings. Fourth, we ensured that industrial firms could provide access to their corresponding technology providers, and the technology providers were willing to participate and share insights into their collaboration in DSIs.

The final sample includes four DSI cases. These cases span different industrial sectors (automation, load handling, and forestry machinery). This selection logic allowed comparison of cases that shared similar triadic DSI structures but differed in industrial context, thereby enabling analytical generalization through replication logic (Langley and Royer, 2006). Technology providers offer digital transformation and technology consulting, software, and digital service design services. Across the cases, the customer refers to external organizational customers, who occupy the third-actor position in the DSI setting. While C1 and C2 occur in one industrial firm, the cases were treated as analytically distinct because they concern different focal DSI, service solutions, technology providers, interaction patterns, and brokerage challenges. Table 2 provides an overview of the cases.

3.2 Data collection

Within each case, data were collected through semi-structured expert interviews with key informants from industrial firms and technology providers. The interview outline was initially developed from existing research on DSIs, supply networks, and interfirm collaboration. After the first interviews with key contacts in each focal firm, the questions were refined to address case-specific details. Two similar interview guides were used, one for industrial firms and another for technology providers, which shared the same overall structure but were tailored to reflect their distinct roles within DSIs. This design facilitated consistent data collection across different actor groups while respecting their unique responsibilities, dependencies, and interaction patterns within the focal DSI. The interview outline did not explicitly address structural holes. Rather, the interview questions focused on the interviewees' backgrounds, the specific DSIs, the roles of the industrial firm and other actors, resource and information flows, coordination responsibilities, perceived challenges, and the structure of interactions among industrial firms, technology providers, and customers in DSIs, without presuming the existence or non-existence of structural holes. The synthesis of prior research presented in Table 1 was later used in the data analysis as a guiding frame (Gioia *et al.*, 2013) for interpreting the responses and to support the analysis of structural hole and brokerage practices in relation to the research question. Within each case, the interviews focused on a focal DSI setting known to the involved actors, which supported within-case comparison across respondents. The interview outlines are provided in Table A1 in Appendix 1.

We followed an expert interview approach to gain in-depth insight into the relationships between actors. To identify the most relevant informants, we consulted a contact person within each industrial firm who had an overview of the DSI project. We selected a limited number of experts from each firm who were directly engaged in the focal DSI setting and had a deep understanding of the supply network (Bogner and Menz, 2009). These informants were well positioned to describe how the DSI was coordinated across organizational boundaries and how responsibilities and interactions were distributed among the involved actors. A total of 21 interviews were conducted. All interviews were conducted online with participants based in Finland. Each interview lasted approximately 48–82 min and was audio-recorded with the participant's consent. Table 2 summarizes the four cases, the focal firms and their technology

Table 2. Case overview and interview data

Case	Focal DSI	Company pseudonym	Company information	Interviewees
C1	Developing digital tools that support and service the installed base, enabling real-time, 24/7 information on devices' activities and statuses for its users	AutomationCo (industrial firm) TechPro1 (technology provider)	Manufacturing automation solutions, revenues €100 M, employees 500 Digital transformation and technology consulting, revenue €70 M, employees 600	Product Manager Digital Services; Head of Service Business Software Consultants (2)
C2	Developing a production monitoring and optimization platform that allows customers to monitor and optimize production processes in real-time, providing insights for operational improvements	AutomationCo (industrial firm) TechPro2 (technology provider)	Manufacturing automation solutions, revenues €100 M, employees 500 Software development, IT Architectures, and Agile Methodologies, revenue €5 M, employees 40	Head of Product Management; Product Manager CEO (involved directly in DSI development)
C3	Developing analytics and preventative maintenance tools that use data to predict and prevent potential issues, optimization system for cargo load handling, and e-commerce for spare parts	MarineCo (industrial firm) TechPro3 (technology provider)	Cargo and load-handling solutions, revenues €1,800 M, employees 700 Technology, data, and design services, revenues €200 M, 1,600	Enterprise Architect; Digital Solutions Lead; Platform Management Lead Software Architect; Project Manager; Operations Manager
C4	Developing digital solutions to track and manage fleets of vehicles in real-time	ForestCo (industrial firm) TechPro3 (technology provider)	Forestry machinery, revenues €750 M, employees 2,000 Technology, data, and design services, revenues €200 M, 1,600	Director of Global Service; Digital Services Product Manager; System Specialist; Digital Services Sales Manager Service Designers (2); Industry Segment Manager; Account Manager

Source(s): Authors' own work

providers, and the interviewees' roles. A complete list of interviewees by role and case is provided in Appendix 2. The number of interviews differed between cases. This variation reflects differences in project scope, the number of organizational functions in industrial firms involved in the DSI, and the size of the technology provider, and thus the number of relevant experts involved in the focal DSI setting. Following Langley and Royer (2006), this kind of variation aligns with multiple-case study research, where strength comes from comparing both similarities and differences across the sample as a whole. Company reports and publicly available data were also reviewed to contextualize the cases and verify background information.

3.3 Data analysis

Data were analyzed using a thematic analysis approach (Braun and Clarke, 2006). The goal of the analysis was to identify patterns related to how industrial firms structure and broker relationships with technology providers and customers in DSIs, thus directly addressing the research question. The concepts of structural holes and brokerage were not built into the interview outline; they were applied after data collection during coding and interpretation. The analysis followed an abductive approach (Dubois and Gadde, 2002), iteratively connecting empirical patterns with theoretical concepts such as structural holes and brokerage, as introduced in the guiding frame. All interviews were transcribed verbatim and coded using NVivo 15, supporting systematic data management and transparency.

The analysis involved multiple steps, following the Gioia methodology (Gioia *et al.*, 2013). Initially, open coding was used to identify initial codes. In this step, we identified sections describing actor roles, interaction patterns, dependencies, information and knowledge flows, coordination challenges, capability mismatches, and concrete actions taken. Particular attention was paid to how interviewees described disconnections between actors, asymmetries in access to information or capabilities, and practices used to connect, filter, sequence, or control interactions across organizational boundaries. This allowed us to capture both perceived gaps and the practices through which such gaps were managed in the focal DSI.

The second-order themes were developed through repeated comparison of first-order codes within and across cases. We first identified the main types of gaps and relationship structuring in each case, then compared these patterns across cases to refine the higher-order categories. Through this process, we consolidated recurring forms of gaps into specific gap types, including relational, knowledge, cognitive, technical, and temporal gaps. A gap was identified when actors were not fully able, allowed, or positioned to coordinate directly, access relevant knowledge or resources, develop shared interpretations, use shared technical infrastructures, or remain continuously involved. Each coded excerpt was assigned to the gap type that best captured the main form of separation it described. When excerpts reflected more than one gap type, we coded the dominant type and compared overlaps within and across cases to refine the categories. The practices identified in the data were also grouped into streamlining workflows, balancing priorities, controlling the flow of information and access, and mediating customer knowledge across firm boundaries. During this process, we also analyzed which actor relationships or lack of relationships the coded excerpts referenced, such as industrial firm-technology provider, technology provider-customer, or between two technology providers, which allowed us to present the findings with attention to role-specific interpretations.

During the later stages of coding and cross-case comparison, the main categories became stable. Additional interviews and case comparisons mainly elaborated the identified gap types and brokerage practices rather than producing new categories. The four cases and 21 interviews were therefore considered analytically sufficient for the purpose of this study, as they provided repeated evidence across different DSI settings, industrial firms, technology providers, and actor interfaces. This supported the refinement of the five gap types and four brokerage practices reported in the findings.

As shown in the data structure (Figure 3), the second-order themes were aggregated in two dimensions: structural holes and brokerage practices. In the analysis, a structural hole was interpreted as a recurring gap between actor groups that constrained direct coordination, mutual understanding, resource access, or knowledge transfer in the focal DSI setting. Brokerage practices were identified as actions through which industrial firms managed, mediated or selectively bridged these disconnections. Excerpts from the interviews are used in the Findings section to illustrate the identified themes and preserve the interviewees' viewpoints. Representative quotes about second-order themes are presented in Table A2 in Appendix 3.

4. Case descriptions

This section briefly describes the focal DSIs, the roles of the industrial firms, technology providers, and customers, and the main interaction patterns relevant to the triadic relationship structures examined in the study.

AutomationCo is the focal firm in cases C1 and C2. In both cases, the company collaborated with a technology provider to develop DSIs while retaining the central role in

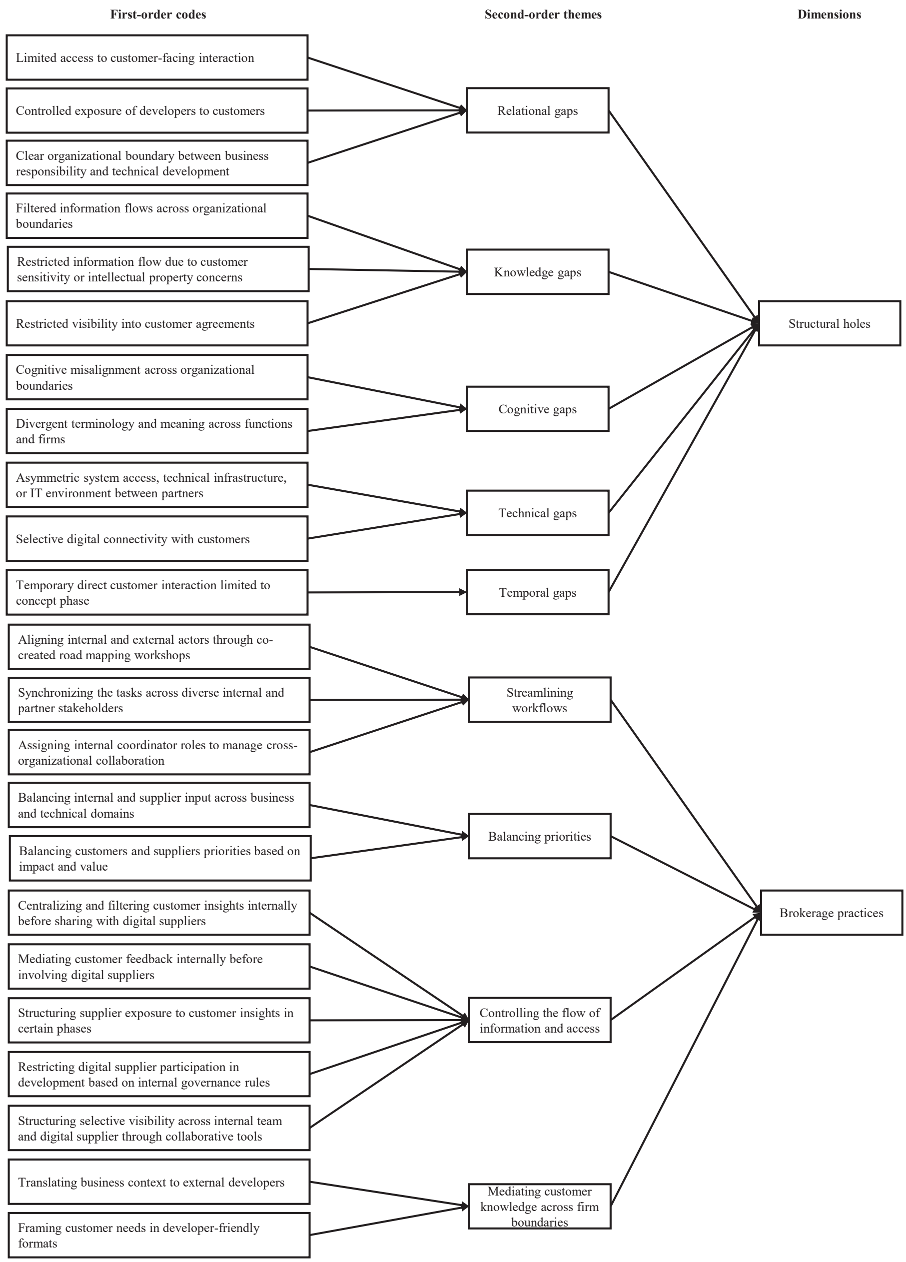

Figure 3. Data structure. Source: Authors' own work

managing customer and technology provider relationships. In C1, TechPro1 was the main actor in developing digital tools for predictive maintenance and data-driven services. In C2, TechPro2 played a key role in AutomationCo's digital transformation and in developing the production monitoring and optimization platform. In both cases, the customers are industrial machine builders using AutomationCo's systems and services. Across C1 and C2, customers did not interact directly with the technology providers. Instead, AutomationCo maintained the brokerage position by controlling customer access, platform ownership, and the selective sharing of operational and customer data with the technology providers. Cloud computing (Microsoft Azure) is the main data processing and service delivery technology. IoT-driven equipment data were collected from customer operations, supporting predictive maintenance and remote monitoring. Customer data (including fleet performance and service history) were organized within AutomationCo's platforms and shared with technology providers upon need. Similarly, equipment data was collected and shared selectively with the technology providers. TechPro1 and TechPro2 provided software development and service design expertise, and AutomationCo mainly relied on technology providers' resources. AutomationCo owns all core digital tools and platforms, ensuring that customer interactions and data processing remain in-house.

MarineCo operates in the maritime industry and collaborates with TechPro3 in C3, a technology provider, to develop and maintain digital service solutions related to equipment performance, cargo handling, and spare parts management. A central element of this collaboration is a cloud-based condition monitoring system to track crane health status and vessel equipment performance. The main customers in this DSI are vessel owners and onboard crew members. In addition, MarineCo and TechPro3 have collaborated on an optimization system for cargo load handling, which allows customers to optimize their loading processes and maximize cargo efficiency. MarineCo has also collaborated with multiple technology providers, including TechPro3, to develop an e-commerce platform for spare parts. This platform lets customers find and order spare parts online, streamlining procurement and inventory management. In C3, customers directly use some of the digital solutions, particularly cargo optimization and spare parts services. However, MarineCo remains responsible for managing customer relationships. TechPro3 acts as a technical partner rather than the customer-facing actor. AWS-based cloud services support data storage, real-time monitoring, and analytics in the condition monitoring system. IoT devices installed on vessels enable data transmission between shipboard equipment and MarineCo's cloud infrastructure. The e-commerce platform also integrates real-time inventory tracking and automated spare parts recommendations. Equipment data is collected from vessels, but MarineCo controls access and structures the data before passing it to TechPro3. TechPro3 relies on MarineCo for feedback collection and business prioritization. MarineCo provides domain expertise in maritime operations and equipment performance, ensuring the platform aligns with industry needs. TechPro3 contributes cloud infrastructure, software development, and automation expertise.

ForestCo operates in the forestry machinery industry and collaborates with TechPro3 in C4 to develop digital services for fleet management. TechPro3 is responsible for cloud-based data processing and platform development, supporting ForestCo's fleet management system. The customers of these digital services are forestry operators and fleet managers. TechPro3 and customers had structured interactions during the development phase. ForestCo acted as the facilitator by controlling the flow of customer feedback and service customization. This approach ensured TechPro3 had direct customer insights while ForestCo maintained customer relationships and business decision-making. TechPro3's cloud computing infrastructure enables scalable data storage and the integration of new platform features. Forestry equipment generates operational data, which is collected through IoT sensors. ForestCo controls equipment data access and provides suppliers with the structured datasets necessary for development. ForestCo provides domain expertise in forestry operations, ensuring that all digital services align with real-world operational needs. TechPro3 provides expertise in cloud computing and software development, ensuring smooth backend processing and system scalability.

5. Findings

Based on empirical analysis, the findings are organized in two parts, as shown in Figure 2. Section 5.1 describes the structural holes found in DSIs. Section 5.2 explains how industrial firms broker across these gaps using specific brokerage practices. The analysis is based on cross-case evidence from the four DSIs, along with representative interview quotes.

5.1 Structural holes in DSIs

We identified five types of structural holes in the cases, including relational, knowledge, cognitive, technical, and temporal gaps (Figure 4). The findings show that structural holes in DSIs are not limited to complete relational separation between technology providers and customers; rather, they appear as varying forms of gaps across different actor interfaces and dimensions of collaboration. These gap types should be understood as analytically distinct but empirically overlapping forms of disconnection that may coexist within the same triadic DSI setting.

Relational gaps are disconnections in direct interaction between key actors, such as customers, technology providers, and internal development teams at industrial firms. Relational gaps were most often described by technology providers in relation to restricted access to customers and by industrial firms as control over technology providers' access. Industrial firms largely determine who can engage with customers, access information, or participate in decision-making. This controlled exposure of external developers to customers helped centralize communication flows. However, it created discontinuities in sharing insights and expectations across firm boundaries. These relational gaps were also evident between different technology providers who were working on different DSIs for industrial firms. For example, ForestCo structured the interaction between technology providers through its quarterly planning system, where all the dependencies, links, and requirements are discussed. The degree of relational gap varied across the cases. In some settings (e.g. C4), interaction was largely mediated by the industrial firm, while in others (e.g. C3), it was selectively structured rather than completely absent.

Technology providers had different views on the relational gaps. The following quote shows how one technology provider perceives the disconnections with other technology providers as an improvement area that the industrial firm should address:

> There were two teams, TechPro2 and us, and maybe the collaboration could have been better. On the other hand, both teams individually achieved what they set out to do, at least from my perspective. Maybe it is not a failure, but building the common platform was lacking. (software consultant, TechPro1, C1)

However, some technology providers had rather positive views on being brokered and on industrial firms handling the customer relationships:

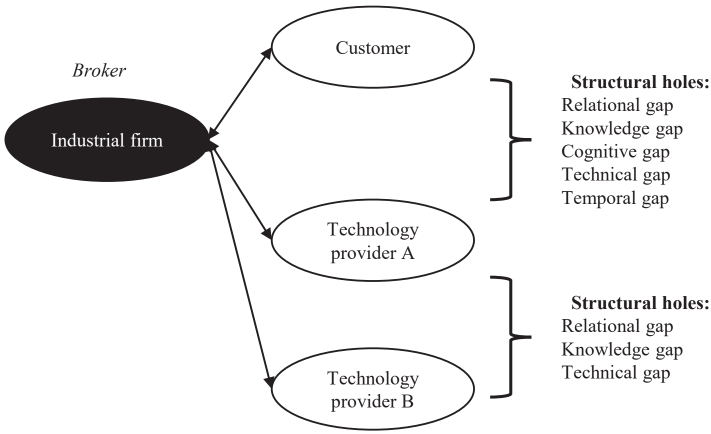

Figure 4. Structural holes in DSIs. Source: Authors' own work

> We do have feedback channels, but most direct communication is managed by the sales manager or account manager of [MarineCo]. It works for us because the feedback process is usually quite long. (Project Manager, TechPro3, C3)

These contrasting views show that relational gaps were not always seen as problematic; in some cases, mediated interaction was viewed as limiting, while in others it was considered efficient or suitable given the length and complexity of the feedback process.

Knowledge gaps formed a key structural hole across all cases. They concerned the disconnection or filtered flow of contextual and experiential knowledge across teams and firms. Knowledge gaps were described by industrial firms as concerns over sharing customer and business knowledge, and by technology providers as limited visibility into commercial, technical, or user-related context. Knowledge here refers to domain-specific customer knowledge, historical data about systems, or non-functional requirements such as localization or usage constraints. In many cases, this knowledge was filtered through templates or intermediary roles by the industrial firms and shared selectively with specific roles at the technology providers. Some information was intentionally kept internal due to IP concerns or customer agreements:

> Of course, there is a risk that, at some point, they will work for our competitors; they will have information about what we are doing and the kinds of solutions we need. We have confidentiality agreements, but they do not guarantee that the information won't reach our competitors, or that the experts won't leave the company to work with our competitors. (Digital Services Product Manager, ForestCo, C4)

In some cases, technology providers were not aware of contractual terms and the broader project scope between the industrial firms and customers, which could lengthen the concept development process:

> I don't have much financial visibility, such as into revenues and other aspects. To make the product commercially viable, different types of business constraints need to be evaluated. To assess factors like margins and return on investment, you need access to the financial data. (CEO, TechPro2, C2)

Cognitive gaps are about differences in interpretations, mental models, and vocabularies used by actors from different domains or roles. Whereas knowledge gaps concerned unequal access to customer, system, or business knowledge, cognitive gaps concerned differences in how actors interpreted priorities and meanings. Interviewees from both actor groups noted that key concepts such as readiness, success, or value were understood differently across business, technical, or customer-facing units. For example, technology providers often emphasized technical aspects such as cloud infrastructure, predictive analytics, and IoT-based monitoring, whereas customer priorities were reported to center on usability, reliability, and cost-effectiveness:

> The development teams are very IT-focused and tend to think differently about processes than our customers do, so it's often challenging to communicate the customer's idea or perspective to the development teams. (Digital Services Sales Manager, ForestCo, C4)

In these cases, the differences were especially visible at the interfaces between customer needs, provider development logics, and the industrial firms' service and business priorities.

Technical gaps are about differences in infrastructure, access, and technical resources across collaborating actors. Technical gaps were mainly described by technology providers as dependence on industrial firms for system access and testing. In DSI settings, industrial firms, technology providers, and sometimes customers operate within separate technical environments, with varying degrees of access to core platforms and operational systems. Industrial firms often retain privileged access to internal systems and customer integrations, while technology providers operate at a technical distance. As one technology provider noted:

> MarineCo knows those integrations, and they can access systems that we cannot access. And we were really relying on them with the stakeholder testing. (Enterprise Architect, TechPro3, C3)

Technical gaps are structural features of the supply network in DSIs rather than temporary issues. They constrain who can interact directly with core systems, shaping the flow of information, testing, and development. These technical constraints strengthened the industrial firm's mediating role by positioning it as the actor with the widest access to systems, integrations, and operational data.

Temporal gaps refer to disconnections that occur due to the timing and phasing of actors' interactions with other actors. Temporal gaps were mainly described by technology providers as discontinuous participation across project phases. Temporal gaps were evident in all cases when technology providers were only engaged with customers during certain project phases, such as initial planning, concept development, or prototyping, and had reduced or no visibility in other stages. In some cases, suppliers or customers were involved early on but not during implementation; in others, technology providers joined later with limited historical knowledge of decisions:

> The only phase where we had more visibility was the concept planning phase, during which we acted as observers, interviewers, and minute takers in the concept development phase alongside AutomationCo (CEO, TechPro2, C2)

Temporal gaps structurally fragment the innovation process by breaking the flow of technology provider participation over time. Across the cases, the level of separation between actors varied by phase and triadic setup. Some relationships remained strongly mediated throughout the DSI, while others involved selective direct interaction during planning, development, or testing before becoming more centralized again. When technology providers only engage with customers intermittently, they lack historical context on prior decisions or changes. Conversely, industrial firms retain continuous presence and accumulate relational and technical knowledge, reinforcing their central structural position. Temporal gaps show that structural holes in DSI settings are not fixed, as the level of separation between actors can decrease or increase during development, implementation, and service operation phases.

5.2 Brokerage practices in DSIs

Our analysis shows that industrial firms broker across structural holes in DSIs, and that brokerage practices are the means through which they selectively connect, coordinate, and mediate across organizational boundaries. Our empirical data identified four key brokerage practices: *streamlining workflows*, *balancing priorities*, *controlling the flow of information and access*, and *mediating customer knowledge across firm boundaries* (Figure 5). Across the cases, these practices were mainly carried out by industrial firms positioned between customers, technology providers, internal development teams, and sometimes multiple technology providers. These practices did not all preserve separation in the same way; some mainly focused on centralized coordination, while others selectively allowed interaction across triadic interfaces.

Streamlining workflows is a central brokerage practice to address relational, technical, and temporal gaps by aligning actors, sequencing dependencies, and keeping fragmented development work connected across organizational boundaries. In these cases, this practice was most often described by industrial-firm respondents responsible for coordinating internal teams and external providers. Workshops for shared roadmaps, sprint planning sessions, and information and communication tools streamlined communication and workflows across different areas. Assigned roles, including product or business owners, coordinated these activities. Beyond technology provider-customer relationships, industrial firms coordinated multi-party collaborations between internal teams and multiple technology providers. They identify interdependencies between technology providers, ensuring that data flows and service

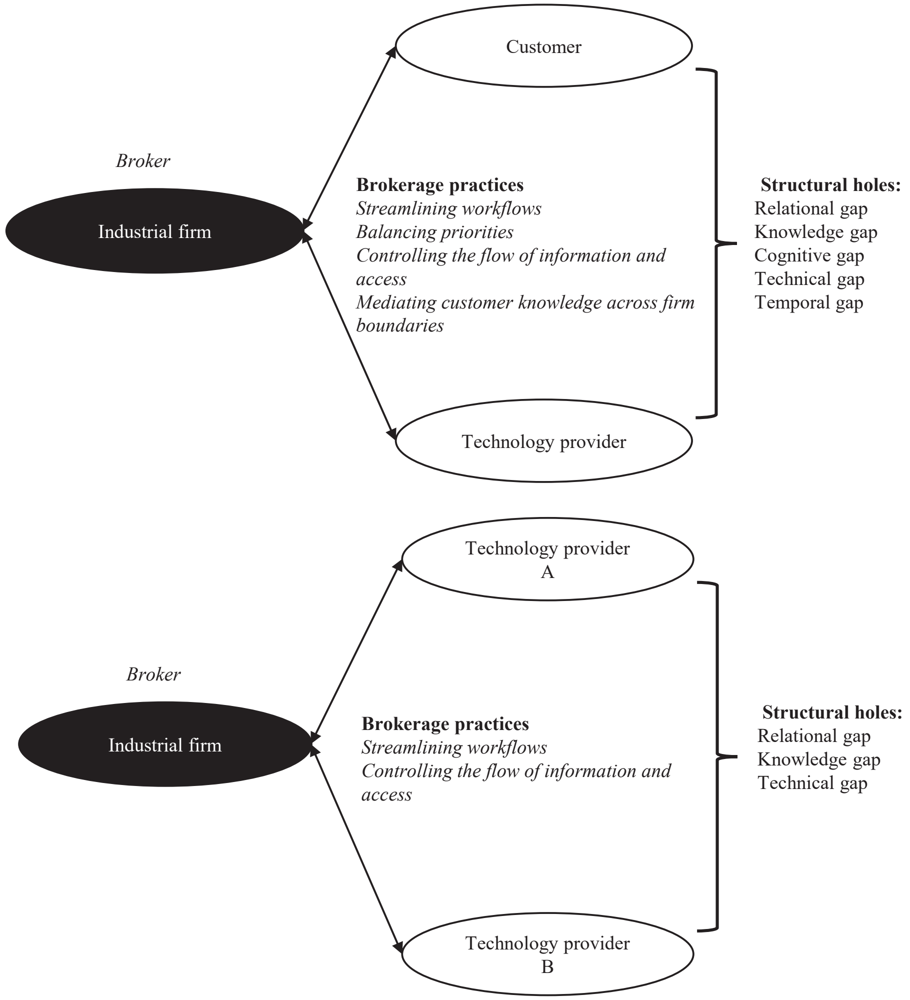

Figure 5. Industrial firms' brokerage practices in DSIs. Source: Authors' own work

integration occur across different systems, such as hardware, cloud, and customer-facing applications, as well as between the new digital components and ongoing operations:

> In projects like this, we have a separate supplier working on these screens at the factory to create the views. At the same time, we are designing the cloud architecture where the data is stored. So, we need to make sure the screens and the cloud are aligned with the data platform. But we also need to work with the teams that manufacture the machines or handle the actual machine data. When we set up a cloud, a fourth party—the IT infrastructure teams—opens ports to transfer data between locations. Therefore, in these situations, there are at least four different parties involved besides the customer. (Platform Management Lead, MarineCo, C3)

Industrial firms *balanced priorities* by acting as go-betweens for different priorities, balancing what was technically possible, what the business needed, and what customers wanted. This kind of brokerage addressed cognitive and knowledge gaps by bringing together different ways of thinking and working. Firms used quarterly planning, backlog reviews, and feature assessments to collect input from technology providers, internal teams, and customers. The following quote shows MarineCo’s practices in balancing diverse priorities:

> We talk to customers or the account managers over there individually, speak with those internal stakeholders, then sit with the development team in the refinement session, and discuss the priorities. Then, we discussed this with the external stakeholders and the development team. And then we mostly set the priority. (Digital Solutions Lead, MarineCo, C3)

Unlike practices that mainly limit access, balancing priorities involves bringing together conflicting viewpoints in the same decision process and turning them into a shared development direction. This approach was mainly described by respondents from industrial firms in product, service, and business roles, who coordinated input from customers, internal stakeholders, and technology providers. Through these practices, the industrial firms retain control over the overall development direction in DSIs:

> [After gathering all ideas or requirements], I mainly try to assess the impact of different actions. Essentially, I consider what happens if we don’t proceed, what the long-term effects might be, and how quickly we can expect to see those effects. On the positive side, I also evaluate how much impact it has and when we might see that kind of return on investment. (Head of Service Business, AutomationCo, C1)

Practices for *controlling the flow of information and access* helped industrial firms to determine what information was shared, with whom, and when. These practices addressed relational, knowledge, and temporal gaps by deciding who talked to customers and how insights were shared with technology providers:

> Not every meeting [addressing technology providers’ presence in customer meetings]. And basically, we are the ones who decide that, okay, this could be something they should attend. (Digital Solutions Lead, MarineCo, C3)

Internal teams filtered and organized customer information using tools like Confluence and Jira before sharing it. Industrial firms used these practices to keep communication clear and information secure. They set access rules based on role and phase and allowed technology provider involvement in customer work during specific phases. This practice could support coordination and information security, but it also risked creating frustration when technology providers perceived the industrial firm’s filtering as a bottleneck or as insufficiently informed. This tension was especially evident in some technology providers’ responses regarding restricted customer access and filtered feedback. For example, in C4, the interviewees from technology providers frequently questioned ForestCo’s brokerage role due to their expressed lack of trust or confidence in ForestCo’s capabilities in collecting customer information:

> The reasoning is usually that we already understand the customers and users. We have conducted some research. To me, that indicates they are not very mature in understanding their customers or how to gather customer information. This lack of understanding is the main reason they decline and refuse to do certain things. (Service Designer, TechPro 3, C4)

These findings suggest that brokerage was more readily accepted when technology providers perceived the industrial firm’s intermediation as improving coordination and customer understanding, but became challenged when filtering was seen mainly as a restriction without adding sufficient value.

By *mediating customer knowledge across firm boundaries*, industrial firms acted as translators between customers and technology providers by turning customer needs into clear, usable information for developers. These practices addressed knowledge and cognitive gaps by using templates, user stories, and journey maps to explain customer needs. This approach was mainly described by industrial-firm respondents in customer-facing and solution-development roles and by technology providers when describing how customer requirements were communicated. Internal roles like service leads and business analysts helped preserve the meaning of customer-related information as it moved between organizations. Sometimes, technology providers joined customer workshops or testing, but industrial firms stayed involved to keep things aligned. This mediating strategy was especially critical when industrial firms needed to ensure regulatory and compliance alignment with industry standards and legal frameworks:

> For example, the cybersecurity required some explanation, of course, about how different standards apply to vessels, how the process works, who is responsible for certifying a vessel, and that we have not only national standards but also international standards. Standard associations certify if a vessel complies with the rules, and they also issue the insurance for the vessel in the end . . . So, we always try to provide that understanding to the [external] developers as well. (Digital Solutions Lead, MarineCo, C3)

Taken together, the four brokerage practices show how industrial firms managed technology provider–customer interaction across the cases. In C1 and C2, customer–technology provider interaction remained largely mediated by AutomationCo across the DSI. Technology providers gained only limited customer visibility during selected planning or concept development activities, while AutomationCo centralized customer access, platform ownership, and the selective sharing of operational and customer data during development and service phases. In C3, MarineCo also remained the main customer-facing actor throughout the DSI, although customer use of some digital solutions and feedback channels created selective points of connection. C4 showed the clearest phase shift: during development, ForestCo enabled structured interaction between TechPro3 and customers to support customer insight, while in feedback customization, data access, and business decision-making, ForestCo retained a mediating role. These patterns show that the DSIs relied on calibrated shifts between separation and connection, depending on the project phase and the type of gap being managed.

6. Discussion

This study has investigated how industrial firms structure their triadic relationships with technology providers and customers in DSIs. First, our findings show that structural holes in DSIs span multiple dimensions, including relational, knowledge, cognitive, technical, and temporal gaps. Foundational work on structural holes (e.g. Burt, 2004) primarily conceptualized them as relational disconnections, i.e. gaps between unconnected actors in a network. In servitization and service triad contexts, later studies have also recognized that such disconnections matter for coordination and interaction between focal firms, suppliers, and customers, mainly where direct communication and shared interfaces are limited (Finne and Holmström, 2013; Li and Choi, 2009; Suurmond *et al.*, 2022; Tahi *et al.*, 2022).

Building on this literature, our findings show that in DSI triads, structural holes are not limited to the presence or absence of ties alone. Instead, they also occur across knowledge, cognitive, technical, and temporal interfaces that are particularly key in DSIs, where actors vary in digital expertise, customer understanding, system access, and involvement across development phases. Furthermore, the findings indicate that structural holes in DSI triads are not consistently stable. Consistent with research on changing bridge roles and brokering over time (Li and Choi, 2009; Quintane and Carnabuci, 2016), some disconnections persisted throughout the DSI, while others were selectively narrowed or widened during concept development, implementation, and service operation. To support further research, we propose the following proposition:

P1. In DSI networks, structural holes emerge from multidimensional gaps across actor interfaces, including relational, knowledge, cognitive, technical, and temporal gaps.

Second, the findings show that brokerage capability is especially important in industrial DSIs, where industrial firms depend on external technology providers for digital expertise but remain responsible for customer outcomes, service continuity, and business direction.

Previous research on service triads and digital innovation already shows that focal firms often coordinate interactions among suppliers and customers (Dhanaraj and Parkhe, 2006; Helfat and Raubitschek, 2018; Li and Choi, 2009; Suurmond *et al.*, 2022). Related studies on orchestration also highlight how a central or capability-strong actor, such as a knowledge-intensive business services (KIBS) firm, aligns others around common goals (Seclen-Luna *et al.*, 2024), and recent work conceptualizes orchestration as a form of alter-oriented brokering that facilitates others' knowledge sharing and value creation (Ritala *et al.*, 2023). Our findings refine this picture by showing that even when industrial firms do not fully orchestrate the development process because they depend on external digital expertise (Kamalaldin *et al.*, 2021), they may still sustain a central role by owning a synthesis capability within the network. This means that they filter, translate, sequence, and align customer, technical, and business knowledge across actors without necessarily owning all digital capabilities.

The industrial firms in our case studies used brokerage practices for several strategic aims, such as lowering the threat of competition posed by technology providers, building customer-related knowledge and technical capabilities in-house, mitigating risks associated with data sharing and intellectual property exposure, and directing development priorities to align DSIs with their own business models and customer strategies.

Interpreting brokerage practices in DSIs through the distinction between intermediation and modification further clarifies how these practices affect the relationship between technology providers and customers (Halevy *et al.*, 2019). Controlling the flow of information and access and mediating customer knowledge mainly sustain intermediation, as the industrial firm remains between actors and governs which information, access, or customer understanding crosses the interface. Streamlining workflows and balancing priorities move closer to modification, as they reshape how actors coordinate tasks, sequence development work, and align technical, customer, and business priorities. Brokering in DSIs therefore does not rely on a single form across the whole triadic relationship. It is dimension-sensitive: industrial firms may preserve separation around customer access, intellectual property, or data sensitivity while modifying coordination routines, knowledge interpretation, or development priorities.

Interpreting this pattern through the Tertius Gaudens/Tertius Iungens distinction clarifies the phase-sensitive nature of brokering in DSIs (Quintane and Carnabuci, 2016). C1 and C2 were more Gaudens-dominant, as AutomationCo largely kept customers and technology providers apart while selectively sharing customer and operational knowledge. C3 also relied mainly on mediated interaction, with limited Iungens elements where customers used digital solutions and feedback channels. C4 showed the clearest movement toward Iungens during development, as ForestCo enabled structured customer–TechPro3 interaction to support customer insight. However, this connection did not remove ForestCo's brokerage role, because ForestCo continued to control customer relationships, feedback customization, data access, and business decision-making. Overall, the cases suggest that DSI brokering involves calibrated shifts between Gaudens-like separation and Iungens-like connection, depending on the project phase and the dimension of disconnection being managed.

> *P2.* Industrial firms use brokerage practices in DSI networks to coordinate interactions and selectively preserve or reshape relationships across project phases and gap dimensions in pursuit of strategic goals, including protecting customer access, building internal capabilities, mitigating data risks, and steering innovation direction.

Third, based on data from industrial firms and technology providers, our findings capture both sides' perceptions regarding structural holes and brokerage practices in DSIs. The findings show that in industrial DSIs, both industrial firms and technology providers are aware of brokerage roles and network disconnections. In our cases, the continued acceptance of brokerage did not appear to depend on invisibility, as suggested in some earlier work (Hahl *et al.*, 2016), but how technology providers perceive the industrial firm as adding value through coordination, customer understanding, and technical integration, i.e. institutional legitimacy (Gonçalves and Silva, 2021; Vargo and Lusch, 2016). From a service-dominant logic perspective, such perceived competence can be understood as institutionalized trust and shared understanding that enable value co-creation across actors (Vargo *et al.*, 2024; Vargo and Lusch, 2016). For example, C4 revealed the conflicting perceptions between actors; from the industrial firm's strategic perspective, occupying a structural hole creates information benefits and control advantages; in contrast, from the technology provider's operational perspective, structural holes may appear as barriers to smooth collaboration and innovation (Smania *et al.*, 2024). This indicates that brokerage could become ineffective if industrial firms lack the ability to coordinate and understand customer needs, or if their strong desire to maintain control leads them to restrict interactions beyond what other actors see as justified. These findings suggest that structural advantages in triads do not arise solely from the network position but also depend on how actors perceive and interpret their connections and disconnections and the value of the intermediary role.

> *P3.* The continued acceptance of brokerage in DSIs depends on whether other actors perceive the industrial firm's intermediation as adding value through coordination, customer understanding, and technology integration.

7. Conclusions

This study investigated how industrial firms structure triadic relationships with technology providers and customers in DSIs. Our findings show that these relationships are shaped by multiple forms of separation, including relational, knowledge, cognitive, technical, and temporal gaps. Industrial firms manage these gaps through brokerage practices that structure workflows, balance priorities, control information and access, and mediate customer knowledge across firm boundaries. These findings show that brokerage in DSIs is not only a matter of occupying an intermediary position but also of actively managing when actors should remain separated, become connected, or interact through the industrial firm.

7.1 Theoretical contributions

This study contributes to the literature on DSIs, service triads, and industrial supply networks by exploring how industrial firms structure triadic relationships within DSIs. First, the findings extend structural hole and service triad research, which has mainly emphasized relational disconnection and limited direct communication (e.g. Finne and Holmström, 2013; Tahi *et al.*, 2022) by demonstrating how the digital context reshapes networks. Specifically, the findings advance structural holes literature from a social construct (Ahuja, 2000; Burt, 2004) into a multidimensional socio-technical framework. By identifying that structural holes in DSIs emerge from knowledge, cognitive, technical, and temporal gaps in addition to relational ones, this study provides a more granular lens for understanding disconnections in a network. Thus, this study moves the discussion beyond the binary of connected vs. disconnected by specifying that bridge decay (Li and Choi, 2009; Quintane and Carnabuci, 2016) may occur in one dimension, such as relational, while technical or cognitive gaps remain in place.

Second, the study refines research on brokerage and brokering (Halevy *et al.*, 2019; Quintane and Carnabuci, 2016) by revealing how industrial firms maintain central intermediary roles in DSI triads despite depending on external technology providers for digital expertise. As customers gain more autonomy and technology providers take on more active roles, industrial firms may lose control over customer access, digital knowledge, and development direction (Ferreira and Lind, 2023; Genzlinger *et al.*, 2020; Smania *et al.*, 2024; Ziaee Bigdeli *et al.*, 2021). Our findings show that industrial firms respond to this tension by owning a synthesis capability within the network: they filter, translate, sequence, and align customer, technical, and business knowledge through practices such as streamlining workflows, balancing priorities, controlling information and access, and mediating customer knowledge across firm boundaries. Viewed through the distinction between intermediation and modification (Halevy *et al.*, 2019) and the Gaudens/Iungens distinction (Quintane and Carnabuci, 2016), this synthesis capability explains why brokering in DSIs is both dimension-sensitive and phase-sensitive. Industrial firms may preserve intermediation around customer access, data sensitivity, and intellectual property while modifying coordination routines, knowledge interpretation, and development priorities. They may also shift between Gaudens-like separation and Iungens-like connection depending on the project phase and the dimension of disconnection being managed. The findings extend bridge decay research by showing that the focal firm's intermediary role may weaken in one dimension, such as direct customer interaction, while remaining central in others, such as data access, technical integration, customer knowledge translation, or business prioritization (Li and Choi, 2009; Quintane and Carnabuci, 2016). In this way, the study shows that industrial firms handle interdependence in DSI triads by selectively preserving, reshaping, and connecting relationships through a synthesis capability, rather than by owning all digital capabilities.

Third, the study contributes to research on intermediation in service and innovation networks by showing that the value of brokerage in DSI triads is not determined by network position alone. Prior work on structural holes has highlighted the informational and control benefits associated with intermediary positions (Burt, 2004), while more recent research has shown that brokerage may weaken as direct interaction between other actors increases (Hahl *et al.*, 2016; Li and Choi, 2009; Quintane and Carnabuci, 2016). Our findings refine this view by showing that the continued acceptance of brokerage depends on whether other actors perceive the industrial firm's intermediation as adding value through coordination, customer understanding, and technology integration. This perceived value is especially important when industrial firms combine selective separation and selective connection (Quintane and Carnabuci, 2016), because their role remains accepted only when other actors perceive the firm as enabling value creation rather than merely restricting access. Brokerage in DSI settings is therefore not simply sustained by occupying a central position, but by being recognized as a competent and legitimate intermediary (Cross and Cummings, 2004; Seclen-Luna *et al.*, 2024). Thus, brokerage in DSIs must be earned through visible synthesis and coordination work. If industrial firms restrict access without creating such value, their brokerage role can become a bottleneck rather than a source of integration. This highlights the relational conditions under which industrial firms can continue to mediate between technology providers and customers, even in settings where digital expertise is increasingly distributed and technology providers take more active roles.

7.2 Managerial implications

This study offers two managerial implications for industrial firms involved in DSIs. First, managers should diagnose the main gaps in the triadic DSI relationship before deciding how to organize access, coordination, and knowledge sharing across actors. Relational, knowledge, cognitive, technical, and temporal gaps require different managerial responses. For example, relational gaps may require clearer rules for when technology providers can interact directly with customers, while knowledge and cognitive gaps may require translation routines, shared documentation, user stories, or workshops that help actors develop a common understanding of customer needs and technical possibilities. Technical gaps may require architectural alignment and clearer data-sharing responsibilities, while temporal gaps may require routines such as roadmaps, backlog reviews, and recurring cross-functional meetings. Managers should therefore avoid treating all disconnections as problems to be closed. Some gaps may need to be bridged through direct interaction, while others may need to remain mediated to protect customer access, data sensitivity, intellectual property, or strategic priorities.

Second, senior managers should treat the industrial firm's brokerage role as something that must be earned through visible value creation rather than assumed from network position alone. In DSI triads, industrial firms remain accepted as intermediaries when their involvement helps other actors coordinate work, understand customer needs, and integrate technology. Managers should therefore assess whether their organization functions as a useful coordinator and translator or merely as a gatekeeper. This requires capabilities beyond technology, including customer interpretation, prioritization across competing interests, technical integration, and cross-organizational communication. In practical terms, customer information should be structured and protected without being filtered so heavily that technology providers lose the context needed for development. Warning signs include external providers or internal teams viewing the focal firm as slow to learn, restricting access without justification, or failing to turn customer needs into actionable guidance. When these signs appear, managers should reconsider how much interaction should remain mediated and where more direct contact is needed, while still protecting sensitive data, intellectual property, and customer relationships. More broadly, industrial firms can stay central in digital innovation networks when their brokerage role is seen as improving coordination and knowledge integration rather than merely controlling access.

7.3 Limitations

First, the study collected data from industrial firms and their technology providers, but did not include customer-side perspectives directly. This limits understanding of how customers themselves perceive structural holes, brokerage, and value co-creation processes in DSIs. Second, the empirical data are drawn from large, established industrial firms operating in mature sectors, which may bias the findings toward firms with stronger resources and established supplier-customer relationships compared to more resource-constrained contexts, such as small- and medium-sized firms. Third, the analysis adopted a triadic perspective (industrial firm-technology provider-customer), focusing on direct relationships, and a broader ecosystem view was beyond the scope of the study. Fourth, the study is based on cross-sectional data, capturing perceptions and practices at a single point in time. Therefore, it cannot completely reflect how brokerage roles and structural holes change during various stages of development or scaling. Finally, the cases primarily involve distinct digital offerings integrated with physical products (e.g. monitoring systems, lifecycle services) rather than platform-based business models, which limits their generalizability to other forms of digital service ecosystems. For example, our study did not include cases where technology providers were consistently present in the customer's operations. In all studied cases, supplier involvement was episodic and linked to specific project phases, which contributed to temporal gaps and discontinuities in contextual knowledge. However, technology providers may maintain a more lasting presence in other settings, such as platform-based models.

7.4 Future research directions

The findings open several promising avenues for future research. First, future studies could incorporate customer viewpoints to better understand how customers perceive structural holes, brokerage practices, and the value of intermediation in DSIs. This would extend the service triad literature by enabling comparison of how different actor positions interpret the same triadic setting and how such perceptions affect the stability and success of brokerage roles (Li and Choi, 2009; Suurmond *et al.*, 2022).

Second, future research could investigate how brokerage evolves over time in DSIs. Our findings suggest that structural holes may persist, narrow, or widen across the phases of concept development, implementation, and service operation, but longitudinal data are needed to examine these dynamics directly. Such research could expand on process-oriented work on changing bridge roles and brokering strategies to understand when industrial firms keep separation, when they selectively facilitate interaction, and when their intermediary role diminishes or shifts over time (Li and Choi, 2009; Quintane and Carnabuci, 2016).

Third, future studies could explore whether the same multidimensional structural holes and brokerage practices appear in other organizational contexts, such as small and medium-sized enterprises, born-digital firms, or firms with weaker installed-base positions. Comparing such settings would help clarify how resource constraints, technological dependence, and customer proximity affect the ability of firms as brokers and boundary spanners. This also strengthens the connection between the current findings and broader research on innovation and intermediation to investigate the value of open triadic configurations in comparison to the costs of integrating and coordinating that knowledge (Balachandran and Hernandez, 2018; Llopis and D'Este, 2022).

Fourth, future research could also examine how AI-enabled capabilities, such as predictive analytics and data-driven decision-making, reshape structural holes and brokering in DSI triads (Naeem *et al.*, 2025). Such capabilities may change how knowledge is generated, interpreted, and shared among industrial firms, technology providers, and customers, while also creating new questions around data access, transparency, and control.

Fifth, future research could adopt a broader multi-actor or ecosystem perspective to explore how brokerage unfolds when multiple customers, platform providers, intermediaries, and complementors are simultaneously involved. Integrating the ecosystem perspective helps connect the present findings to broader discussions of ecosystem orchestration and digital coordination (Chen *et al.*, 2019; Dhanaraj and Parkhe, 2006; Helfat and Raubitschek, 2018), thereby investigating competition over intermediary roles in digital innovation settings versus distributed brokerage roles. In particular, research could examine platform-centric DSIs, where technology providers may have a more continuous presence in customer operations. Such settings would be valuable for examining how certain gaps change as providers become more persistently involved in customer-facing processes, and how this potential higher involvement may affect intermediation roles and practices. Such research would also help connect the present study to broader discussions of platform strategy and digitally mediated ecosystem governance (Helfat and Raubitschek, 2018; Ritala *et al.*, 2023).

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Appendix 1:
Interview outlines

Manufacturer

(1) General questions about the interviewee

(2) How important is the role of service business in your company, and how has it changed in the past few years?

(3) What are the recent examples of DSIs that you have been involved in?

The next questions focus on the specific DSIs.

(4) What are the key internal units and roles involved in the process?

(5) What are the key external partnerships in the process?

The next questions focus on the specific DSIs and external technology providers.

(6) Why do you collaborate with that particular company? For which process, activities, or capabilities?

(7) Can you describe the collaboration your company has engaged in with the technology provider?

(8) Follow-up questions on goals, roles and responsibilities, coordination and cooperation activities, etc.

(9) How have responsibilities been divided or coordinated between your internal teams and external technology providers during the process?

(10) What types of challenges have you encountered in this process? How were they addressed?

(11) How have you managed conflicts and misalignments during the process?

(12) How have you involved the customers in the collaboration process?

(13) How do you share and communicate data, information, and knowledge about your business, products, and services with the technology provider?

(14) How do you share and communicate data, information, and knowledge about and from customers with the technology provider?

(15) What types of challenges and risks have you encountered when sharing information with the technology provider, and how have you addressed them?

(16) How do you prioritize the development of different digital/data-enabled services, and what factors do you consider when making these decisions?

(17) How do you see the collaboration between your firm, technology providers, and customers evolving in the future?

(18) Is there anything else you would like to add about your experiences or insights related to DSIs or collaboration between industrial firms and other collaborators?

Technology provider

(1) General questions about the interviewee

(2) Can you provide an overview of your past collaborations with industrial firms in developing digital services?

The next questions focus on the specific industrial firm and specific DSIs.

(3) What are the key internal units and roles involved in the process?

(4) What are the main units and roles you collaborate with in this process at industrial firms?

(5) What is the goal and scope of the collaboration? For which process, activities, or capabilities?

(6) Can you describe the collaboration your company has engaged in with the industrial firm? Follow-up questions on goals, roles and responsibilities, coordination and cooperation activities, etc.

(7) How would you describe the industrial firm's role in the collaboration?

(8) Have the industrial firm's customers been involved in the collaboration process? For which purposes and what has the process been?

(9) How do you collect data, information, and knowledge about the industrial firm's business, products, and services?

(10) How do you collect data, information, and knowledge about and from the industrial firm's customers?

(11) How have you been involved in the decision-making during the process? Follow-up questions on the choice of technologies, solutions, features, development priorities, collaboration process, tools, information sharing channels, etc.

(12) What types of challenges have you encountered in this process? How were they addressed?

(13) How have the conflicts and misalignments been managed during the process?

(14) How do you see the collaboration between your firm and industrial firms evolving in the future?

(15) Is there anything else you would like to add about your experiences or insights related to industrial DSIs or collaboration with industrial firms?

Appendix 2

Table A1. Interviewees list

Case ID	Interview ID	Role/position	Organization (industrial firm/ technology provider)	Date	Mode	Duration (minutes)
C1	I1	Product Manager Digital Services	AutomationCo (industrial firm)	18.01.2024	Online	74
C1	I2	Head of Service Business	AutomationCo (industrial firm)	12.05.2023	Online	53
C1	I3	Software consultant	TechPro1 (technology provider)	15.02.2024	Online	59
C1	I4	Software consultant	TechPro1 (technology provider)	17.02.2024	Online	50
C2	I5	Head of Product Management	AutomationCo (industrial firm)	08.03.2024	Online	58
C2	I6	Product Manager	AutomationCo (industrial firm)	16.02.2024	Online	62
C2	I7	CEO (involved directly in DSI development)	TechPro2 (technology provider)	25.03.2024	Online	51
C3	I8	Enterprise Architect	MarineCo (industrial firm)	03.06.2024	Online	51
C3	I9	Digital Solutions Lead	MarineCo (industrial firm)	03.05.2024	Online	58
C3	I10	Platform Management Lead	MarineCo (industrial firm)	22.03.2024	Online	52
C3	I11	Software Architect	TechPro3 (technology provider)	17.06.2024	Online	50
C3	I12	Project Manager	TechPro3 (technology provider)	19.06.2024	Online	53
C3	I13	Operations Manager	TechPro3 (technology provider)	25.06.2024	Online	48
C4	I14	Director of Global Service	ForestCo (industrial firm)	23.05.2023	Online	68
C4	I15	Digital Services Product Manager	ForestCo (industrial firm)	29.05.2023	Online	64
C4	I16	System Specialist	ForestCo (industrial firm)	30.05.2023	Online	52
C4	I17	Digital Services Sales Manager	ForestCo (industrial firm)	29.05.2023	Online	68
C4	I18	Service Designer	TechPro3 (technology provider)	04.09.2023	Online	82
C4	I19	Service Designer	TechPro3 (technology provider)	19.09.2023	Online	53
C4	I20	Industry Segment Manager	TechPro3 (technology provider)	20.09.2023	Online	56
C4	I21	Account manager	TechPro3 (technology provider)	28.09.2023	Online	54

Appendix 3

Table A2. Representative quotes

Representative quotes (interview ID)	Second-order theme
"There were two teams, TechPro2 and us, and maybe the collaboration could have also been better. On the other hand, both teams individually achieved what they were doing, at least from my perspective. Maybe it is not a failure, but building the common platform [for different projects] was lacking." (I3)	Relational gaps
"We do have feedback channels, but most of the direct communication is handled by the sales manager or account manager of [MarineCo]. It works for us as the feedback chain is usually pretty long." (I12)	Relational gaps
"Of course, there is a risk that, at some point, they will work for our competitors; they will have the information about what we are doing and what kind of solutions we need. Of course, we have confidentiality agreements but it is not one hundred percent proof that the information does not move to our competitors, or the experts can move from the company and work with our competitors." (I15)	Knowledge gaps
"I do not really have financial visibility, for example, into the revenues and so on. In order to get the product into a shape that it is commercially viable, several types of business constraints could be evaluated. In order to evaluate things like margins, return on investment, etc., you need access to the financial data." (I7)	Knowledge gaps
"The development teams are really IT-based, and they like to think with these different kinds of processes than our customers do, so it is quite challenging to always convey the customer idea or perspective to the development teams." (I17)	Cognitive gaps
"MarineCo knows those integrations, and they can access systems that we cannot access. And we were really relying on them with the stakeholder testing." (I8)	Technical gaps
"The only phase where we had more visibility was the concept planning phase where we actually were observers and interviewers and minute takers in the concept development phase along with AutomationCo" (I7)	Temporal gaps
"In projects like this, we have a separate supplier working on these screens at the factory to create the views. At the same time, we are designing the cloud architecture where the data is stored. So, we need to make sure the screens and the cloud are aligned with the data platform. But we also need to work with the teams that manufacture the machines or handle the actual machine data. When we set up a cloud, a fourth party—the IT infrastructure teams—opens ports to transfer data between locations. Therefore, in these situations, there are at least four different parties involved besides the customer." (I10)	Streamlining workflows
"We talk to the customers or the account managers over there individually, we talk to those internal stakeholders, then sit with the development team in the refinement session, and we discuss the priorities. Then, we discussed this with the external stakeholders and the development team. And then we mostly set the priority." (I9)	Balancing priorities
"[After collecting all ideas or requirements], I mostly try to judge the impact that things have. So basically, what happens if we do not do it? What would be the long-term effect, and how quickly do we expect that effect to come? And then also maybe on the positive side, how much impact does it have, and when do we see that kind of return on investment?" (I2)	Balancing priorities

(*continued*)

Table A2. Continued

Representative quotes (interview ID)	Second-order theme
"Not to every meeting [addressing technology providers' presence in customer meetings]. And basically, we are the one who decide that okay, this could be something that they should come." (I9)	Controlling the flow of information and access
"The reasoning is usually that we already understand the customers and users. We have done some research. To me, that means they are not very mature in understanding their customers or how to gather customer information. This lack of understanding is the main reason they say no and refuse to do certain things." (I18)	Controlling the flow of information and access
"For example, the cyber security required some explanation, of course, about how different standards apply to vessels, how the process works, who is responsible for certifying a vessel, and that we have not only national standards but also international standards. Standard associations certify if a vessel complies with the rules, and they also issue the insurance for the vessel in the end . . . So, we always try to provide that understanding to the [external] developers as well." (I9)	Mediating customer knowledge across firm boundaries

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