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Configuring ecosystem strategies for digitally enabled process innovation: A framework for equipment suppliers in the process industries

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ABSTRACT

Digitalization offers new opportunities for equipment suppliers to support the competitiveness of process industry firms through participating in digitally enabled process-innovation initiatives. However, doing so is not without challenges as it requires equipment suppliers to align with multiple actors within an extended ecosystem to deliver complex product-service software systems as embodied sources of process innovation. This creates various challenges for the equipment supplier because it has to secure its role in an ecosystem where it must simultaneously cooperate and compete with other ecosystem actors. Therefore, it needs to consciously determine what ecosystem strategy to apply. Using multiple exploratory case studies, we investigate how equipment suppliers configure appropriate ecosystem strategies to realize digitally enabled process innovation for process industry firms. Our findings emphasize that different industrial customer contexts require different ecosystem strategies; we have identified four archetypical ecosystem strategies (orchestrator, dominator, complementor, and protector). The core insights from our research are converted into a decision tree framework to guide equipment suppliers in configuring the appropriate ecosystem strategy based on the industrial customer context. Key contingency considerations include determining an appropriate role in the ecosystem (leader or follower) and a suitable competitive approach (cooperation dominated or competition dominated).

1. Introduction

Rapid advancements in digital technologies and the widening application of big data analytics, Internet of Things (IoT), Artificial Intelligence (AI), and machine learning are propelling a new wave of opportunities for equipment suppliers to support the competitiveness of process industry firms (i.e., their customers) through digitally enabled process innovation (DEPI).¹ Examples include the implementation of autonomous industrial vehicle solutions (e.g., drills, loaders), digital fleet and site management solutions (e.g., site optimization), and real-time production diagnostics (e.g., process optimization) (Sjödin et al.,

2018; Thomson et al., 2021) For example, a large equipment supplier had implemented a smart ventilation system offering optimized ventilation of mines through collaboration with suppliers of positioning solutions, sensors, fans, and advanced analytics with the potential to achieve a reported decrease in energy costs of 54 percent for a mining company. The purpose of these digital solutions is to serve as embodied sources of process innovation for process industry firms.² These solutions increase production efficiency, improve workers' safety, and reduce environmental impacts and life-cycle costs by leveraging increased operational data transparency and augmenting human capabilities (Milewski et al., 2015; Sjödin et al., 2018; Storm et al., 2013).

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¹ Digitally enabled process innovation is of particular importance for firms in the process industries, which is the focus of this study. Since their products (e.g., copper, steel) are largely undifferentiated and commoditized with prices set on global raw material markets, the key to competitiveness for process firms is to continuously improve their production processes to lower the production cost per ton below that of competitors (Pisano, 1997; Lager, 2011; Terjesen and Patel, 2017; Von Krogh et al., 2018).

² For equipment suppliers, this trend of using digital technologies to take more responsibility for improving their industrial customers' operations has been described as digital servitization – “The transition toward smart product-service-software systems that enable value creation and capture through monitoring, control, optimization, and autonomous function” (Kohtamäki et al., 2019).

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Building on prior literature on process innovation and digitalization (OECD, 2015; Parida et al., 2019; Sjödin et al., 2018), we define digitally enabled process innovation (DEPI) as “the implementation of digital technologies such as AI, IoT, autonomous solutions, and analytics to enable new or significantly improved production or delivery methods”.

Thus, the equipment suppliers delivering these digital solutions exercise a pivotal role in supporting DEPI in process industries (Sjödin, 2019; Lager and Frishammar, 2010; Lager and Hassan-Beck, 2020, Hutcheson et al., 1996). However, taking on this role is not without its challenges. Since no single equipment supplier has all the necessary expertise, resources, or control over the process, there is often a need to align with an extended ecosystem of partners including other equipment suppliers, digitalization actors, and customers, in order to deliver complex product-service-software systems (Kohtamäki et al., 2020). Digitalization has created great uncertainty among suppliers, generating strong competition and threatening alignment as all parties aim to maximize their profits and many suppliers pursue the leading role in driving DEPI within the industry. Further complexity is added by the fact that most process industry firms have not only existing capital-intensive assets and supplier relationships but also idiosyncratic operating conditions (e.g., raw material properties), and investment priorities (e.g., bottlenecks), which influence the ecosystem setup and strategy of the equipment supplier (Hutcheson et al., 1996; Lager and Frishammar, 2010). In practice, this means that there is no ‘one-size-fits-all’ ecosystem strategy. Equipment suppliers may need to assess and configure different ecosystem strategies by selecting appropriately from numerous decision criteria. We argue that the inability to configure an appropriate strategy will mean failure to realize profits from digitalization, and many opportunities to successfully implement DEPI in process industries will be impeded or lost.

Prior literature on DEPI has discussed the important role of ecosystems (Sjödin, 2019) and open innovation (Von Krogh et al., 2018; Robertson et al., 2012), yet it provides little guidance on how an equipment supplier may configure such ecosystem strategies and under what conditions they are most applicable. The literature on ecosystems offers some insights into defining ecosystem roles (e.g., Iansiti and Levien, 2004) and recognizes the need to consider competition and cooperation (Hanna and Eisenhardt, 2018). However, these aspects have not been integrated into a common framework, and we lack an empirically oriented actionable perspective on how a focal actor (equipment supplier) can configure an appropriate strategy for a specific industrial customer (i.e., process industry firm) context. In addressing these knowledge gaps, we build on the novel and influential concept of *ecosystem-as-structure* (Adner, 2017). According to this view, the ecosystem is defined in terms of the focal value proposition (i.e., the DEPI initiative) where ecosystem actors are required to interact and to be aligned for it to come about. Against this background, our study aims to address two research gaps relating to the literature on ecosystem strategies and DEPI in process industries.

First, there is a *need to advance understanding on the conditions influencing ecosystem strategy configuration*. Numerous conditions can influence the decision on ecosystem strategy configuration, such as competition and cooperation opportunities. Indeed, prior research contends that the tensions between cooperation and competition in an ecosystem must be balanced (Das and Teng, 2000; Doz, 1996; Lado et al., 1997; Sytch and Tatarynowicz, 2014). Our contribution builds on the work of Hannah and Eisenhardt (2018) who identified three different ecosystem strategies (bottleneck, component, and system), each with a distinct balance of cooperation and competition in the context of the U.S. residential solar panel industry. However, another potential condition that influences ecosystem strategy is related to the actor’s role in the ecosystem, which did not specifically fall within the scope of Hannah and Eisenhardt’s study (2018). Research on ecosystem roles (e.g., Iansiti and Levien, 2004) have been increasingly highlighted due to the uncertainty inherent in the digitalization of industry, and this is particularly true in the context of traditional process industries. A

research gap, therefore, remains in our understanding of the intersection between roles in the ecosystem and the balance of cooperation and competition in an industrial context. Indeed, we need to come to understand how actors exercising different roles in an ecosystem, such as leader or follower, configure and apply different ecosystem strategies, and what tactics are employed to balance appropriate levels of cooperation and competition. We argue that this is particularly challenging and relevant when studying the complex setting of DEPI in the sites of process industry firms where roles may be unclear and where competing suppliers must cooperate to realize DEPI.

Second, there is a *need for a contingency perspective on appropriate ecosystem strategies based on the industrial customer’s context from the standpoint of an equipment supplier*. Key to this inquiry is understanding that context matters, that an ecosystem strategy applicable in one industrial customer’s context may not suit another context. This view finds resonance in the work of Adner (2017) who calls for placing the focal value proposition at the center of an ecosystem strategy. Yet, prior contributions have largely overlooked this point and have focused on collaborative approaches in generic ecosystems of affiliated actors (which is applicable in a consumer context such as Apple’s App Store) rather than studying ecosystem strategies applied to a concrete value proposition targeted at a specific industrial customer (Adner, 2017; Sjödin, 2019). For example, Iansiti and Levien (2004) identified three ecosystem strategies (keystone, dominator, and niche) for ecosystems of affiliated actors, but they gave little consideration to how the customer’s context would impact these strategies. Though, in industrial contexts such as process industries, it is imperative to customize ecosystems for DEPI (i.e., the value proposition) in line with the process industry firm’s idiosyncratic design requirements for technologies and existing equipment (Robertson et al., 2012; Rönnberg-Sjödin, 2013). For example, at a specific site of a process industry firm, equipment suppliers may already have established positions and relationships within the ecosystem depending on the core technologies and objectives in focus; this can create tensions and strongly impact the ecosystem strategy to be applied. Indeed, developing and delivering DEPI represents an interdependent value proposition for equipment suppliers because they need to assess collaboration within an ecosystem of multiple actors governed by the active involvement of the industrial customer. Yet, this research domain is still very much underexplored (Lager and Frishammar, 2012; Sjödin, 2019).

Against this background, this study aims to investigate *how equipment suppliers configure appropriate ecosystem strategies to realize digitally enabled process innovation in various industrial customer contexts*. We stress that the context of process innovation in the process industries provides an ideal setting for such studies because process innovation outcomes for industrial customers (process industry firms) are highly complex and contingent on the combined efforts and expertise of an ecosystem of multiple suppliers (Lager and Frishammar, 2010; Bruch and Bellgran, 2012). We build on a unique dataset of six case studies involving major equipment suppliers and their ecosystem partners that actively drive different initiatives of DEPI in diverse customer sites.

Our findings contribute to the literatures on process innovation and ecosystems. We find that, depending on the industrial customer’s context (customer’s requirements, supplier’s role in the ecosystem, balance of cooperation and competition), there are a number of different ecosystem strategies that equipment suppliers can apply in implementing DEPI initiatives. We distinguish and define four archetypical ecosystem strategies (*dominator*, *orchestrator*, *complementor*, and *protector*), and we explore the conditions in which they are applicable. We present them as core facets of a theoretical framework alongside a decision tree framework to help equipment suppliers configure an appropriate ecosystem strategy best suited to the industrial customer’s particular context. In doing so, we contribute to the literature by projecting a contingency perspective and affirming that different contexts require different ecosystem strategies.

2. Theoretical background

2.1. Digitally enabled process innovation in the process industries

Digitally enabled process innovation (DEPI) is of particular importance for firms in the process industries (e.g., mining, mineral processing, pulp, and paper production), which is the focus of this study. Since their product outputs (e.g., copper, steel) are largely undifferentiated and commoditized with prices set on global raw material markets, the key to the competitiveness of process industry firms is to continuously improve their production processes and operational efficiencies to lower the production cost per ton below that of their competitors (Lager, 2011; Pisano, 1997; Terjesen and Patel, 2017; Von Krogh et al., 2018). For the purposes of this study, we adopt Lager's (2010, p. 20) definition of a process industry as "a production industry using (raw) materials to manufacture non-assembled products in a production process where the (raw) materials are processed in a production plant where different unit operations often take place in a fluid form and the different processes are connected in a continuous flow". A major difference between process industries and other manufacturing industries is that the products supplied to them and delivered from them are materials rather than components (Frishammar et al., 2012). These industries are also characterized by large, fixed items of capital equipment (Kurkkio et al., 2011; Lager et al., 2013; Novotny and Laestadius, 2014), development work that is done in laboratories or pilot plants, and long and interconnected production chains. For these reasons, process innovation is central to the competitiveness of firms in process industries. It enhances a company's ability to cope with rising demands, and it strengthens operational resilience through increased production volume, improved efficiency, and reduced environmental impacts (Lager and Frishammar, 2012; Storm et al., 2013).

Digitalization is seen as the main enabler of process innovation, and it is increasingly becoming a competitive necessity for process industry firms seeking to continuously improve their production processes and to outperform their competition. Certainly, novel digital technologies are a major driving force in process innovation (Sjödin et al., 2018; Larsson and Wallin, 2020) (see Table 1, which shows how the use of such

technologies can mitigate the core challenges facing process industries). Most firms in the process industries are now investing heavily in digital solutions to innovate their production processes, and this is usually conducted in collaboration with equipment suppliers (Kamalaldin et al., 2020; Larsson and Wallin, 2020). For example, by 2026, the global mining equipment market is predicted to reach \$285.5 billion, primarily driven by the growth and development of digital technologies (Acumen Research and Consulting, 2018). Consequently, there is a need to place greater emphasis on digitalization and its influence on process innovation (Sjödin et al., 2018). However, this is still an emerging area and our insights remain rudimentary. Building on prior literature on process innovation and digitalization (OECD, 2015; Parida et al., 2019; Sjödin et al., 2018), we define DEPI as "the implementation of digital technologies such as AI, IoT, autonomous solutions, and analytics to enable new or significantly improved production or delivery methods". For instance, IoT technology enables mining companies to collect vast quantities of operational data remotely and in real time using internet-connected sensors. This data can then be used to continuously improve on-site efficiency, ensure a safer environment for the workforce, and monitor the operational status of machinery to optimize its performance (Pickup, 2017).

Although these examples point to a promising future, Sjödin (2019) stresses that the complexity of implementing DEPI, such as site optimization solutions, within the existing production infrastructure can involve a high degree of uncertainty for firms and their suppliers. Adding to the challenge for management, companies in the process industries often lack the internal resources and competencies to design the digital infrastructure on their own (Aylen, 2010; Reichstein and Salter, 2006), and so they attempt to involve extended ecosystems of equipment suppliers to drive their operations forward with DEPI (Hutcheson et al., 1996; Robertson et al., 2012). This is because the required knowledge and skills involved in designing and implementing DEPI lie outside the core competencies of process industry firms and, therefore, they are reliant on suppliers to offer them digital solutions and technologies as sources of embodied process innovation (Bruch and Bellgran, 2012; Lager and Hassan-Beck, 2020; Sjödin, 2019).

Table 1

Core characteristics of the process industries and their implications for digitally enabled process innovation.

Core characteristic of the process industries	Implications and opportunities for process innovation through digitalization
Long and complex supply and value chains (Lager et al., 2013; Lager and Storm, 2013; Storm et al., 2013).	Integration of IoT and predictive analytics can significantly increase transparency, streamline communication, and remove bottlenecks, which are often the result of increased complexity (Larsson and Wallin, 2020).
Asset intensive (located in few physical places); hence, changes are limited in the short term (Lager et al., 2013). Majority of product and process developments are not radical but rather incremental refinements of existing products and processes (Lager, 2002).	Increasing value of existing assets rather than replacing them is achieved by embedding digital technologies into the existing products and processes. Doing so facilitates better monitoring of the assets and processes, which provides further innovation opportunities focused on incremental improvements to the existing equipment (Lager and Hassan-Beck, 2020).
Product and process development takes place in collaboration with manufacturers of process equipment/suppliers of raw materials (Hutcheson, 1996; Lager and Frishammar, 2012; Reichstein and Salter, 2006; Storm et al., 2013).	Facilitating such inter-organizational collaboration is often achieved by using digital architectures that provide common interfaces for all involved actors, thus reducing fragmentation and rigidities imposed by incompatibility of multiple systems. This technology is central to establishing and effectively coordinating these vital collaborations (Sjödin et al., 2011; Sjödin, 2019).
Products supplied to them and delivered from them are often raw materials or ingredients (Lager et al., 2013; Lager and Storm, 2013). Focused on process improvements in terms of cost and economy of scale (Lager, 2002; Lager and Frishammar, 2012).	Gaining competitive advantage by differentiating commoditized products is rarely possible within process industries and, thus, such advantage is often gained through cost cutting and process optimization (Lager, 2011). Process industry firms integrate real-time analytics, machine learning, and big data into their existing operations to not only spot and remove inefficiencies (even a 1% decrease in cost can have a significant impact on profitability) but also to continuously optimize their processes (Kamalaldin et al., 2020).
Product development and process development are an interlinked process (Lager, 2002).	Interdependence between product and process innovation increases complexity and scope of any future innovations. Impact of such interdependence – i.e., complementarity – needs to be correctly identified and managed to maximize the success rate and value of such innovations (Hullova et al., 2016, 2019). By using advanced analytics and machine learning, firms can not only create and explore different outcomes and decrease the inherent uncertainty of the outcome but, importantly, they can also reduce capital expenditure required for designing multiple 'test runs' or developing test sites. This is currently the dominant approach in process industries when developing more radical innovations (Frishammar et al., 2014).

2.2. Ecosystems and ecosystem strategies

To succeed with DEPI, process industry firms are often dependent on the expertise of equipment suppliers who are needed to drive innovation in an ecosystem of multiple collaborating actors, including other suppliers and technology partners (Sjödin et al., 2011; Lager and Frishammar, 2010; Hutcheson et al., 1996). System-level digitalization requires equipment suppliers and digitalization partners to establish ecosystems where they jointly co-innovate (Linde et al., 2021) to bring DEPI to fruition. In these ecosystems, equipment suppliers are required to secure their roles and to cooperate with other suppliers who may be competitors. Hence, equipment suppliers need simultaneously to cooperate and to compete – a relationship that is referred to in the literature as ‘co-competition’ (Bengtsson and Kock, 2000; Brandenburger and Nalebuff, 1996). This context of co-competition requires the equipment supplier to adopt an appropriate ecosystem strategy so that neither the chance of success of the system-level innovation as a whole is constrained (Zahra and Nambisan, 2011) nor the shared value of the ecosystem is compromised (Letaifa, 2014). In addressing these issues, we draw on two literature streams concerning the roles of actors in the ecosystem and the need for a judicious balance between cooperation and competition.

2.2.1. Ecosystems and actors' roles

The term ‘ecosystem’ has garnered great interest in academia and industry over recent years (Adner, 2017; Hullova et al., 2019; Jacobides et al., 2018; Oh et al., 2016). Although ecosystems are considered the usual context for doing business in industries such as software and communication technologies (Muegge, 2013), research on ecosystems in general is underdeveloped and undertheorized (Spigel, 2017). Adner (2017) argues that the lack of clarity on how exactly an ecosystem view adds value has hindered its usability as a concept. In response, he makes a distinction between two views of the ecosystem – ‘ecosystem-as-affiliation’ and ‘ecosystem-as-structure’.

The ecosystem-as-affiliation view sees an ecosystem as a community of associated actors affiliated in a network or platform, and it focuses on interdependence and the breakdown of traditional industry boundaries (Adner, 2017). For example, Iansiti and Levien (2004) adopt this view in considering business networks as ecosystems “characterized by a large number of loosely interconnected participants who depend on each other for their mutual effectiveness and survival” (2004, p. 8). Accordingly, Iansiti and Levien (2004) distinguish between three strategies: ‘keystone’, which aims to improve connections between actors and the overall ecosystem productivity; ‘dominator’, which aims to take over and eliminate others; and ‘niche’, which aims to develop specialized capabilities that differentiate them. Although these strategies distinguish between the roles of a leader (keystone or dominator) and a follower (niche), they see the ecosystem as organized around a central actor rather than a value proposition. Adner stresses that, from a strategy point of view, the ecosystem-as-affiliation perspective “tends to focus on general governance and community enhancements, with limited insights into the specifics of value creation” (2017, p. 41).

In contrast, the ecosystem-as-structure perspective focuses on interdependent value creation because it “starts with a value proposition and seeks to identify the set of actors that need to interact in order for the proposition to come about” (Adner, 2017, p. 41). Adopting the ecosystem-as-structure view, Adner defines an ecosystem as “the alignment structure of the multilateral set of partners that need to interact in order for a focal value proposition to materialize” (Adner, 2017, p. 40). He contends that partner alignment is a vital strategic challenge that underlies a more actionable perspective on interdependence between partners. Thus, we argue that this perspective is most relevant in the context of DEPI since actors need to align activities in order to arrive at a focal value proposition.

Building on the definition of an ecosystem-as-structure, Adner defines an ecosystem strategy as “the way in which a focal firm approaches

the alignment of partners and secures its role in a competitive ecosystem” (2017, p. 47). He pinpoints four implications arising from this definition. First, “a focal firm approach” stresses that each firm develops its own ecosystem strategy even though the ecosystem consists of multiple actors. It is important to stress that ‘focal firm’ means the firm in focus, i.e., the firm from whose perspective the analysis is conducted, which can either be a leader or a follower in the ecosystem. Second, “the alignment of partners” sees alignment in terms of the focal firm’s ability to bring other partners along with it according to the positions and roles that its own ecosystem strategy envisions. Third, “secures its role” stresses that undertaking the role of leader or follower depends on the aspiration of the focal firm as well as the agreement of its partners. Fourth, “in a competitive ecosystem” underlines the fact that concern about competitiveness guides the ecosystem strategy. Thus, a key management issue in an ecosystem is setting the right balance between a shared vision and the self-interest of the actors involved to influence, facilitate, and motivate their actions (Adner, 2006; Laczko et al., 2019). However, we continue to lack insights into how these ecosystem strategies are actually configured in competitive contexts such as in DEPI initiatives, where equipment suppliers need to establish a complex balance between cooperation and competition.

2.2.2. Balancing cooperation and competition in ecosystems

Scholars continue to highlight the complex dynamics of supplier-supplier relationships (Wu et al., 2010). In an attempt to comprehend this complexity, Choi et al. (2002) pinpoint three theoretical types of supplier-supplier relationships; cooperative, competitive, and co-competitive. Bengtsson and Kock (2000) argue that co-competition is “the most complex, but also the most advantageous relationship” because firms help each other by combining their resources and capabilities whilst simultaneously exerting pressure on each other to achieve higher innovative performance. Moreover, they further categorize co-competitive relationships into three types based on the extent of cooperation and competition – namely, cooperation-dominated, equal, and competition-dominated (Bengtsson and Kock, 2000).

In a similar vein, Hannah and Eisenhardt (2018) distinguish three ecosystem strategies by which firms balance cooperation and competition. They define cooperation as “firms jointly pursuing mutual interests and common benefits” and competition as “firms pursuing their own interests at the expense of others” (Hannah and Eisenhardt, 2018, p. 3164), consistent with Das and Teng (2000). Hannah and Eisenhardt (2018) argue that prior research has generally focused on either cooperation and value creation (Adner and Kapoor, 2010; Ozcan and Eisenhardt, 2009) or competition and value capture (Jacobides et al., 2006). By conducting a study of firms in the U.S. residential solar industry, they bring these research streams together and provide insights into how firms balance cooperation and competition. They identify three ecosystem strategies; the ‘component’ strategy that favors cooperative behavior, the ‘system’ strategy that favors competitive behavior, and the ‘bottleneck strategy’ that exhibits a dialectic tension between cooperation and competition (Hannah and Eisenhardt, 2018). Whilst this distinction is useful in explaining the interplay of cooperation and competition in ecosystems, it does not take into account the actor’s role in the ecosystem. Since the ‘leader’ of the ecosystem would apply a different strategy than an actor exercising a ‘follower’ role, we argue that the actor’s role in the ecosystem is no less important than the balance between cooperation and competition in identifying the appropriate ecosystem strategy. In the present study, we bring these two aspects together in determining appropriate ecosystem strategies, particularly in the context of DEPI.

To summarize our perspective on this theoretical background, we argue that the research community’s understanding of equipment suppliers’ ecosystem strategies for DEPI remains limited and is, therefore, in need of further insightful research. Specifically, there is a dearth of studies addressing the various ecosystem strategies – how they are applied, and under what conditions they are relevant – based on

ecosystem roles, the balance of cooperation and competition, and a focus on the industrial customer's context. We argue that the context of DEPI is particularly relevant in studying such strategies since it requires the large-scale integration of equipment and systems, in addition to extensive interaction and knowledge sharing amongst ecosystem actors, if it is to work (Sjödin, 2019). Thus, it can provide important insights that contribute to the literature on process innovation and ecosystems.

3. Research methods

3.1. Research approach and case selection

This paper builds on an exploratory multiple case study (Yin, 2018) of six mining equipment suppliers in Sweden involved in DEPI initiatives and their associated ecosystems of actors working toward concrete value propositions. The Swedish mining sector is considered to be highly innovative, with a number of leading mining equipment suppliers (Nuur et al., 2018; Sánchez and Hartlieb, 2020). Furthermore, collaborations within ecosystems are evident amongst actors in the sector, which is undergoing a shift in response to digitalization and industry 4.0. Thus, the Swedish mining sector provides an ideal setting for studying ecosystem strategies in process industries. In particular, the study aims to investigate how equipment suppliers configure appropriate ecosystem strategies in order to realize DEPI. Therefore, the unit of analysis is the ecosystem strategy of each of the six studied equipment suppliers in the ecosystem in which they operate. The case study methodology helps to develop insights into theoretically novel phenomena (Edmondson and McManus, 2007) – such as ecosystem strategies for DEPI.

To this end, we selected cases based on theoretical sampling (Eisenhardt, 1989; Eisenhardt and Graebner, 2007; Glaser and Strauss, 1967). The case selection criteria were informed by the study's research question: *How can equipment suppliers configure appropriate ecosystem strategies to realize digitally enabled process innovation in various industrial customer contexts?* The research question highlights three aspects: the perspective of equipment suppliers, the context of DEPI, and a focus on the ecosystem level. Correspondingly, the case selection criteria are as follows.

First, we selected leading suppliers of mining and process equipment (e.g., underground drill rigs, loaders, ventilations systems, and crushers) to mining companies in Sweden in terms of their capital expenditure. This equipment usually involves sizeable investment by the mining companies, given its strategic importance to them. In particular, the equipment is expected to operate around the clock for up to twenty years. Thus, innovation strategy is focused on extending the lifespan, and maximizing the utilization of the existing equipment (Aylen, 2013; Lager and Storm, 2013) is central for firms in the process industries. However, doing so requires regular interaction between them and their equipment suppliers. In the process industries, such engagement is more relational than transactional, with a long-term view on operating and maintaining the equipment.

Second, all of the equipment suppliers selected are engaged in DEPI initiatives undertaken by their industrial customers (viz., the mining companies). These are fostered by the long-standing nature of the strategic provider–customer relationship highlighted above. Hence, the suppliers were invited to be part of a wider scheme of DEPI initiatives, rather than participants in one-off transactions.

Third, all the selected equipment suppliers were engaged in an ecosystem of multiple actors, including other equipment suppliers and digitalization partners, collaborating in DEPI initiatives. Examples of collaborative ecosystem relationships include strategic partnerships and joint research projects with the goal of creating new value propositions. We selected cases where we had established good contacts with multiple actors within the same ecosystem. This supported rich data collection from the various actors involved, allowing us to gain a deeper understanding of the interactive relationships between them.

3.2. Data collection

Data was mainly collected through semi-structured interviews with company informants. In each case, we focused on one equipment supplier (i.e., the focal actor – the actor from whose perspective the analysis is conducted) to investigate its strategy within the ecosystem by interviewing a number of its key informants who played active roles in the cases identified. In addition, we interviewed informants of other ecosystem actors in order to gain a wider understanding and increase validity. Although we identified additional embedded cases concerning how other actors strategize in their ecosystems, we did not investigate them extensively because our purpose was to retain the focus on one equipment supplier per ecosystem.

Informants were pinpointed using the snowballing technique; key informants were asked to suggest other people who could provide additional insights. In total, eighty different informants of eighteen companies were interviewed. Table 2 gives an overview of the cases, company informants, total time of each interview, and sources of secondary data.

The study's informants were asked open-ended questions with the support of an interview guide. The guide was developed from overarching themes on actors' roles in the ecosystem, value co-creation between different actors, cooperation and competition between actors, knowledge/data sharing, and the role of digital technologies in driving process innovation. Examples of questions asked included 'Describe your role in the ecosystem associated with the digitally enabled process innovation initiative.' 'How do you approach working with multiple actors within the ecosystem?' 'How do the customer's requirements and existing relationships influence the collaboration?' and 'How do ecosystem actors strike a balance between cooperation and competition?' Whilst the focus was on seeking answers to the specific case in question, we encouraged informants to provide insights based on their broader experience of working in ecosystem contexts. Follow-up questions were also asked to obtain further details. For example, when asked about knowledge sharing, informants emphasized that it is very much data driven. Thus, discussions on this theme were extended to address data exchange.

All interviews were recorded and transcribed, and interview transcripts served as the main basis for data analysis. These were supplemented by data from secondary sources such as company websites, internal documents, and news articles. Therefore, we were able to increase construct validity by using multiple sources of evidence (Yin, 2018) – namely, multiple secondary sources in addition to the multiple informants exercising various functional roles in different companies. This enabled us to gain a multifaceted view and an understanding from different perspectives. For example, an internal document from the mining company CusBeta on the case E4 DEPI initiative, which gives an overview of the roles and responsibilities of the different ecosystem actors and how their data is integrated into a digital architecture, validated insights that had been derived from interviews. To further increase validity, the initial findings were presented to eighteen of the study's informants (marked with * in Table 2). They participated in workshop discussions that we used to validate findings and obtain further insights for the analysis. Two authors of the present paper presented the initial findings and conclusions of the study and asked participants to share reflections. A third author took notes to support further data analysis. The key findings were further validated through discussions with four respondents from the pulp and paper sector, which validated the importance of considering the industrial customer's context for configuring ecosystem strategies to realize DEPI.

3.3. Data analysis

A thematic approach was adopted for data analysis to identify relevant themes and patterns (Braun and Clarke, 2006). Data was coded into first-order categories, which were then clustered into second-order themes, which in turn were converted into aggregate dimensions

Table 2
Overview of studied cases and collected data.

Case description	Focal equipment supplier	Informants (interview time)	Ecosystem actors	Informants (interview time)	Secondary data
E1 Process innovation initiative to create digital mine ventilation control and optimization solution for the mining company. Key value proposition includes ventilation on demand functionality. Aimed at improving air quality for workers, saving energy consumption by half, and extending the lifetime of the ventilation system.	SupAlpha Revenues: 32,400 MSEK Employees: 7800	Account manager* (75 min)	CusLambda	Head of procurement (80 min)	2 company websites
		Account manager (75 min)		Supply chain manager* (30 min)	5 internal documents
		Account manager (56 min)		Project manager (66 min)	3 news articles
		Contract manager (54 min)	DigRho	Project manager (67 min)	
		Sales & services manager (30 min)		Business development manager (61 min)	
		Business development manager (38 min)	DigIota	Sales manager (52 min)	
		Business development manager (87 min)	DigTheta	Business development manager (32 min)	
		Product manager (120 min)		Business development manager (30 min)	
		Digitalization manager (65 min)	SupEpsilon	Business models researcher* (65 min)	
		Digital operations manager* (50 min)		Automation manager (40 min)	
E2 Process innovation through the implementation of autonomous solutions for mine drilling with a cable feed system for automatic tensioning. Aimed at improving safety and productivity.	SupEta Revenues: 31,000 MSEK Employees: 13,000	Digital services manager (64 min)	CusBeta	Head of procurement* (100 min)	1 podcast
		Automation manager (53 min)		Category manager (81 min)	3 company websites
		IT manager (35 min)		Automation program manager (70 min)	4 internal documents
		Business development manager* (82 min)		Maintenance manager (53 min)	4 news articles
		Business development manager (60 min)	SupKappa	CEO* (30 min)	
				Chief technology officer* (36 min)	
				Business development manager (49 min)	
			DigRho	Business development manager (59 min)	
			SupEpsilon	Researcher* (40 min)	
			DigTheta	Business development manager (40 min)	
E3 Process innovation through large-scale digital transformation of a mine site. Connecting minerals processing equipment with IoT and control system to collect data in the cloud to monitor and optimize machine performance remotely. Aimed at improving production and reliability through predictive maintenance.	SupMu Revenues: 2400 MSEK Employees: 700	Sales & services director (37 min)	CusZeta	Procurement manager (54 min)	1 company website
		Lifecycle services manager (105 min)	SupDelta	Process automation manager (30 min)	2 internal documents
		Digitalization manager* (45 min)	DigRho	Business development manager (58 min)	1 news article
		Business development manager (30 min)			
E4 Process innovation through the use of artificial intelligence and connectivity in a mine site. Optimizing hard rock mining processes through IoT and an open digital architecture that integrates data between equipment of different suppliers. Aimed at providing real-time view of operations and delivering predictive insights to improve efficiency.	SupSigma Revenues: 100,000 MSEK	Automation manager (93 min)	CusBeta	Business development manager* (52 min)	2 company websites
		Sales and services manager (49 min)		Technology manager* (46 min)	2 internal documents

(continued on next page)



Fig. 1. Data structure and coding process.

(Gioia et al., 2013). These steps are further detailed below.

The first step in the data analysis involved a thorough reading of interview transcripts and marking relevant passages. We used MAXQDA software to facilitate the coding of common words and phrases used by informants, which resulted in first-order categories. The second step involved identifying links and patterns within the first-order categories using an iterative process. This led to the generation of second-order themes that were on a higher level of abstraction than the first-order categories. This step, which was conjointly undertaken by the researchers, was facilitated by comprehensive discussions of the data structure, which then led on to the next step. The third step involved the formation of aggregate dimensions that were on an even higher level of abstraction. They represent two overarching dimensions around which our findings revolve: the industrial customer's context of digitally enabled process innovation (section 4.1) and ecosystem strategies for digitally enabled process innovation (section 4.2). The entire data structure resulting from the data analysis is presented in Fig. 1.

As a final step, researchers synthesized the findings into an overarching framework. Each researcher independently classified the case equipment suppliers into the different ecosystem strategies distinguished. The purpose was to check the accuracy of the classification. There was considerable agreement between researchers on the classification, and discrepancies were overcome through comprehensive discussions leading to ultimate agreement. This practice of comparing cases allowed us to validate the ecosystem strategies that emerged and generate an overall decision tree framework to guide equipment suppliers in identifying the appropriate ecosystem strategy (section 4.3).

4. Findings

Based on the empirical analysis, we present our findings in three parts. Section 4.1 describes the industrial customer's context for digitally enabled process innovation, detailing key factors of consideration for applying ecosystem strategies. Section 4.2 describes the identified ecosystem strategies and their key underlying tactics. Finally, section 4.3 provides a decision tree framework for configuring ecosystem strategies to fit the industrial customer's context, and lists key criteria for making strategic choices.

4.1. Industrial customer's context for digitally enabled process innovation

A key part of our findings is related to the need to understand the industrial customer's digitalization and operational context before considering the ecosystem strategy most applicable for realizing DEPI. Accordingly, the equipment supplier would need to assess the process industry firm's (i.e., customer) requirements and drivers for process innovation, the existing supplier relationships and equipment/technologies on site, and the requirements for integrating multiple equipment and digital systems. In the current section, we discuss these issues in greater depth, and we target the three interrelated analytical themes relating to: the customer's requirements for the focal value proposition, the need for aligning roles amongst suppliers, and the co-competition requirements for suppliers on customer's site. To illustrate, an informant of SupEta described the importance of understanding the customer's context:

"The customer's requirements will play a very important role in selecting our ecosystem strategy for each case. The message we have received is the importance of collaboration and open systems that enable you to transfer data in an efficient way between different ecosystem actors. Sometimes they [the process industry firm] say that our competitor's solution is the best from a site management perspective and then we need to align to that and connect our autonomous equipment as well as planning tools from perhaps another actor. So we need to consider the whole ecosystem landscape on that site to support our customers in driving process innovation."

4.1.1. Customer's requirements for the focal value proposition

In configuring the appropriate ecosystem strategy, it is vital to understand the industrial customer's underlying requirements and what it is really after. A key part of this is delimiting the specific *process innovation scope*. This includes, for example, what the use case is in terms of technologies and process steps in focus. Engaging in a DEPI initiative for a whole operation (e.g., mine, or processing plant) is vastly different from transforming a discrete unit operation such as drilling, loading, or hauling. In particular, the scope of the initiative will also determine the scope of ecosystem involvement. Nevertheless, informants stressed the recurring need to integrate the equipment and digital systems of multiple suppliers. Since process innovation is the focus, customers underscored the need for innovation across different types of machines and process steps to drive efficiency gains. For example, optimizing only one piece of equipment could create bottlenecks in other parts of the process. Similarly, for larger digital transformation initiatives such as site optimization, many different pieces of equipment would need to be integrated into a common digital architecture to enable the identification of operational inefficiencies. The interviewed procurement managers from the mining companies explained that a key reason to purchase equipment from multiple suppliers is to avoid being locked into a single supplier. This creates complexity in integrating all the equipment for DEPI, and it complicates the nature of relationships between different suppliers. CusLambda informants stressed the importance of this integration in enabling systemic site-wide process improvements:

"You need integrated autonomous systems and machines that work together." "You define the system ... you have some units that have to work together ... you can't say I'm improving one unit without looking at the whole perspective."

A second vital component for understanding the customer's requirements is the underlying needs and *digitalization value drivers*. A crucial aspect is understanding the process industry firm's pain points, which the supplier should strive to address. Informants of the present study highlighted that the need for DEPI in the mining sector is driven by various motives including economic, environmental, and social drivers. The economic drivers include improving efficiency and effectiveness to reduce cost and increase mine throughput. An informant from CusBeta illustrated how increased production volume with no increase in costs was the aim of the DEPI in its mine steered by SupSigma:

"When I think about productivity, I think of increased utilization of the equipment, which reduces your capital requirements ... Increasing volume at the same cost is also huge for us, from the use of automated trucks and loaders."

In addition, informants highlighted the environmental and social conditions that the mining sector must address. Informants stated that DEPI initiatives were conducted to support more environmentally friendly production through, for example, more efficient use of energy leading to reduced CO₂ emission. In terms of social drivers, the mining companies had a strong strategic direction to improve the safety of their operations due to legal and social responsibility requirements. Thus, DEPI initiatives were undertaken to remove human labor from hazardous working environments in mines and processing plants and, hence, workers' health and safety were improved. For example, the head of procurement at CusBeta mentioned that the company is willing to allocate a large budget to any initiative that addresses safety concerns. Similarly, a senior project manager for mining technology at the same company explained how improving working conditions and reducing energy consumption drove DEPI initiatives, and that this would typically require the integration of different processes and equipment:

"One of the focus areas is to improve safety and working conditions for operators as they can work in a safe and comfortable environment while operating the mine. With automated machines and traffic management,

energy consumption and the need for long-term maintenance can be reduced due to optimized driving cycles.”

4.1.2. Need to align roles amongst suppliers on the customer’s site

While process industry firms are pushing for the digitalization of their operations, significant emphasis is also being placed on involving equipment suppliers in DEPI initiatives. The involvement of numerous equipment suppliers on the customer’s site (mining company’s site) creates complexity, which amplifies the need to align the roles of suppliers. In particular, informants agreed that there is *need to define and agree on ecosystem leadership and followership roles*. It is important to specify which supplier leads the ecosystem and which accept follower roles. Expectations should be aligned accordingly. An informant from SupXi stressed that role vagueness can delay or hinder efforts to move toward DEPI:

“Many larger players [are] trying to capitalize on digitalization. The challenge is that it is not fully clear what would be our role in the future, and this has delayed our efforts at collaboration.”

Although many equipment suppliers might strive to take the leading role in the same initiative, the maturity and capabilities of suppliers that enable them to assume such a leading role may vary depending on the technology in focus. Thus, there is a *need to distribute roles based on suppliers’ capabilities*. Indeed, many informants emphasized that taking a leadership role in the ecosystem should be subject to having the necessary capabilities for that role. These can include digitalization capabilities and routines for driving large scale DEPI initiatives, customer knowledge and relationships, local sales and distribution capabilities, and existing resources and staff to drive the implementation. For example, informants of SupAlpha explained that their company’s digital expertise and competences enabled it to take an ecosystem leadership role in driving DEPI:

“They can see plenty of added value from us, what I’d call real expertise in the area.” “We have a lot of competence and that’s what we are valued for. We know the industry and we have the technical know-how.” “We have expertise in these processes where our system is installed.”

4.1.3. Coopetition requirements for suppliers on the customer’s site

Informants from equipment suppliers agreed that, for any industrial customer’s site and DEPI initiative, there is a need for coopetition between suppliers, which means they must simultaneously cooperate and compete. The fact is that multiple equipment suppliers would typically be active on the site, and their interactions with each other would have implications for successfully realizing DEPI. Naturally, when engaging in a new DEPI initiative, *suppliers need to compete to maximize their own interests*, as each supplier seeks to increase the value captured. A key aspect of this competition in a DEPI context is related to knowledge and data sharing. Suppliers consider their data-driven knowledge as a competitive resource that they hold, and they would be unwilling to share it unless they gained something in return. For example, the global product manager at SupMu shared his concern:

“By being able to monitor the equipment, we can get more predictive maintenance, but we don’t get the data we need from other suppliers ... they know that we are skilled and capable ... but they don’t want to share the data, and then it is difficult to create value and meet the expectations.”

Therefore, eradicating the vagueness surrounding the knowledge and data to be shared or protected is important and is key to the successful implementation of DEPI. Furthermore, informants emphasized that competition can be viewed as an opportunity rather than a threat. For example, the head of procurement at CusBeta explained that competition between suppliers to the same mining company fosters innovation and improvement. He stated:

“I think competition is key to keep these companies on their toes and always striving to be better than each other. We have this great ecosystem of suppliers of mining equipment ... which is driving innovation through internal competition. I mean if [SupEta] went away, I think [SupSigma] would be dead within 10 years.”

At the same time, these competing suppliers need to cooperate to achieve the common goal of their customer. Cooperation between suppliers includes efforts to integrate equipment and systems into the industrial customer’s digital architecture, for instance. Through cooperation, competing suppliers complement each other’s capabilities and resources, and share certain knowledge and data in order to achieve DEPI

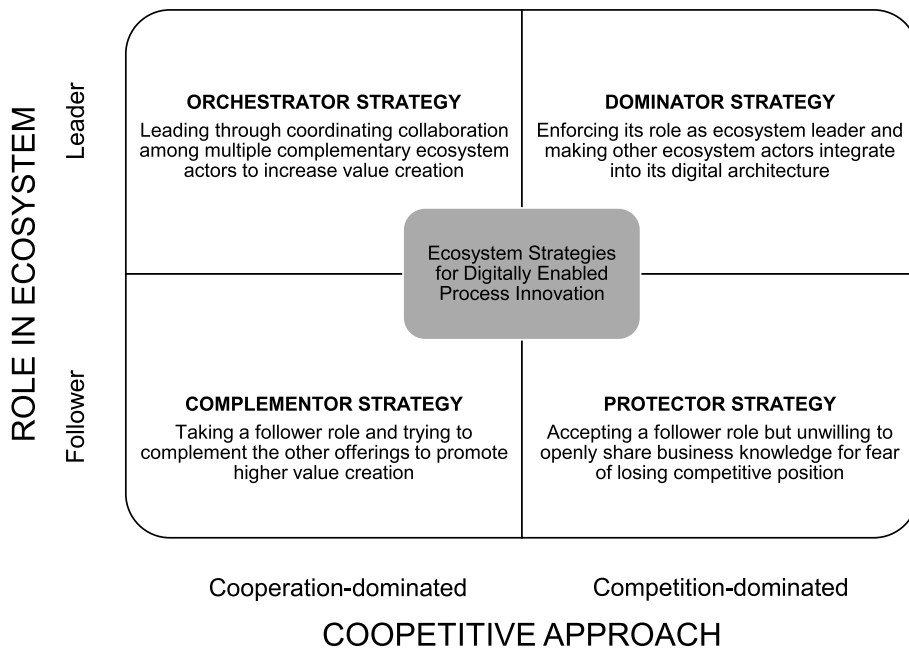


Fig. 2. A theoretical framework to distinguish ecosystem strategies for digitally enabled process innovation.

for their customers. A technology planning manager from SupGamma explained how his company had to cooperate with a competitor for the purpose of testing autonomous loading for their common customer:

“We are still at an early stage in the development of driverless, electric and connected vehicles. Although we have come a long way, there remains a lot of technological development. Just to give an example, we must learn how [a competitor’s] machines and ours can communicate with each other when testing autonomous loading.”

4.2. Ecosystem strategies for digitally enabled process innovation

We found that the industrial customer’s context for DEPI described above influences how equipment suppliers configure an appropriate ecosystem strategy. We distinguished four diverse strategies adopted by

equipment suppliers: orchestrator, dominator, complementor, and protector. Fig. 2 illustrates the core characteristics of the strategies in the form of a matrix, which highlights how each strategy is based on the supplier’s role in the ecosystem (leader or follower), and its cooperative approach (cooperation-dominated or competition-dominated). Table 3 provides a more detailed overview of the four strategies and associated tactics of each, as well as illustrative cases. In the following sections, we explain in detail the logic underlying each of the strategies.

4.2.1. Orchestrator strategy

The orchestrator strategy focuses on taking a leadership role through coordinating collaboration among multiple complementary ecosystem actors for the purpose of increased value creation. Companies following this strategy believe that the ecosystem is ‘more than the sum of its parts’ and try to manage the ecosystem accordingly. A number of tactical

Table 3
Ecosystem strategies and key tactics applied by equipment suppliers for digitally enabled process innovation.

Ecosystem strategy <i>The way in which the equipment supplier approaches the alignment of partners and secures its role in a competitive ecosystem</i>	Key tactics <i>The set of carefully planned actions devised by equipment suppliers to realize a particular strategy</i>	Illustrative cases <i>Illustrative cases of how equipment suppliers configured and applied ecosystem strategies in light of their industrial customer’s context</i>
<p>Orchestrator strategy Leading through coordinating collaboration among multiple complementary ecosystem actors to increase value creation</p>	<ul style="list-style-type: none"> • Establish an open digital architecture for joint value creation • Facilitate and incentivize explorative cooperation among ecosystem actors to enable new value propositions • Coordinate long-lasting collaboration between ecosystem actors with different capabilities to ensure successful commercialization 	<p>SupEta (E2): its capabilities in delivering autonomous solutions and developing open digital architecture, besides its strong network and reputation in the mining sector, enabled it to take a <i>leader</i> role in driving digitally enabled process innovation focused on mine drilling and automatic tensioning. It established an open digital architecture to openly exchange data between actors and coordinate collaboration, following a <i>cooperation-dominated</i> cooperative approach. It incentivized other actors to develop solutions on its architecture through reduced charges.</p> <p>SupSigma (E4): it was able to take the <i>leader</i> role in optimizing hard rock mining processes due to its reputation as a large established supplier of mining equipment, its existing relationships with all ecosystem actors, and its capability in integrating data between the equipment of multiple suppliers. It followed a <i>cooperation-dominated</i> cooperative approach, incentivizing actors to complement each other’s resources, technologies, and capabilities. SupSigma coordinated the collaboration efforts toward commercializing the co-created autonomous solution, which opened a new revenue stream for ecosystem actors.</p>
<p>Dominator strategy Enforcing its role as ecosystem leader and making other ecosystem actors integrate into its digital architecture</p>	<ul style="list-style-type: none"> • Set a closed digital architecture and pursue selective value co-creation • Take a central role in optimizing existing processes and directing other ecosystem actors to exclusively work with it • Drive restricted cooperation with ecosystem actors and enforce its own standards in order to dominate 	<p>SupAlpha (E1): its expertise in control systems, long-standing relationship with the customer in previous projects, and its market reputation enabled it to take the <i>leader</i> role in driving the digital mine ventilation control initiative. It undertook a <i>competition-dominated</i> cooperative approach, as it enforced its control system and standards, and other actors consolidated their apps and systems to it. Ecosystem actors had to compete to take assignments.</p> <p>SupMu (E3): its competence in driving predictive maintenance, high brand value for mining equipment, and long-standing relationship with the customer, enabled it to take the <i>leader</i> role in a large-scale digital transformation of its customer’s mine. It followed a <i>competition-dominated</i> cooperative approach with very limited sharing of data for fear of losing competitive advantage. Thus, it relied heavily on its own data and capabilities, with only restricted data exchange with other actors in specific operations.</p>
<p>Complementor strategy Taking a follower role and trying to complement the other offerings to promote higher value creation</p>	<ul style="list-style-type: none"> • Support unique technologies to establish an open digital architecture approach for the ecosystem leader • Establish a close connection with the ecosystem leader to increase value creation • Partner with different ecosystem actors in a supportive manner to combine each other’s resources in order to obtain a ‘piece of the bigger pie’ 	<p>SupGamma (E5): although it had some technological capabilities, it lacked competence in analytics for optimizing site’s operations; thus, it accepted a <i>follower</i> role. It integrated its equipment into the leader’s fleet management system, which connected the equipment of all sites, with open exchange of operational data to utilize it for analytics and optimization, following a <i>cooperation dominated</i> cooperative approach.</p>
<p>Protector strategy Accepting a follower role but unwilling to openly share business knowledge for fear of losing competitive position</p>	<ul style="list-style-type: none"> • Pursue limited integration into the digital architecture of the ecosystem leader due to lacking the full array of competence needed for systems integration • Seek limited or selective cooperation with other ecosystem actors in order to protect key resources due to high internal and external uncertainty • Search for opportunities to take a bigger role involving low cooperation with other ecosystem actors 	<p>SupDelta (E6): its lack of system integration competences and its relatively new relationship with the customer made it take a <i>follower</i> role with limited integration to the digital architecture of the ecosystem leader. It undertook a <i>competition-dominated</i> cooperative approach because it was unwilling to openly share data or business knowledge, preferring to protect its asset knowledge for fear of losing competitive position. Nonetheless, SupDelta continued to search for opportunities to take on a bigger role and develop its capabilities.</p>

considerations feed into this strategy.

First, informants of suppliers applying the orchestrator strategy stressed that a key tactic is to *establish an open digital architecture for joint value creation*. Through this digital architecture, the other ecosystem actors are able to connect to their individual digital solutions, and the orchestrator coordinates their joint efforts in seeking to realize higher customer value. An IT manager of SupEta commented on how it decided to go for an open digital platform approach to facilitate the delivery of autonomous solutions for mine drilling:

“When deciding between open or closed approaches to ... platform development, we decided to go for open platform. This is a more risky approach, but it also provides us and other suppliers with a greater opportunity to collaborate to realize the benefits of digitalization.”

Second, this strategy requires the orchestrator to *facilitate and incentivize explorative cooperation among ecosystem actors to enable new value propositions*. As exploring new propositions can involve considerable cost and uncertainty, it is important to establish incentives that motivate ecosystem actors to undertake this exploration. For example, this can be achieved by providing open access to data and infrastructure for IoT applications development or reducing the cost of the interoperability of different equipment and systems. A digital services manager from SupEta explained how the firm incentivized other ecosystem actors to develop solutions on its digital architecture through reduced charges:

“In the current age of digitalization, small digital companies are very important as they can provide quite unique solutions to customers. We want them to develop those solutions on our open platform, so we don't charge them high commissions for using our infrastructure. This way, we encourage quick development and adaptation of our platform.”

Third, the orchestrator should *coordinate long-lasting collaboration between ecosystem actors with different capabilities to ensure successful commercialization* because new propositions naturally have little value if commercialization is not achieved. For example, although SupSigma is a large established supplier of mining equipment, it facilitated the involvement of other actors in order to move rapidly toward commercialization. It took the lead in coordinating the efforts among suppliers in this endeavor, as its sales and services manager remarked:

“We wanted to be market leaders in offering ... autonomous solutions. This was a game changer, and we did not have all the competences in-house to offer such a complex solution. So, we decided to team up with new partners that had expertise in AI analytics and data positioning solutions. Together, we increased our chances of a successful implementation in a progressive customer's mine. This has opened up an entirely new market for all of us.”

4.2.2. Dominator strategy

Another prominent strategy applied by equipment suppliers is to opt for being a dominator in the ecosystem. Through this strategy, the supplier focuses on enforcing its role as ecosystem leader and making other ecosystem actors integrate into its digital architecture. Three key tactics are invariably employed with this strategy.

First, a common tactic amongst suppliers applying the dominator strategy is to *set a closed digital architecture and pursue selective value co-creation*. Hence, other ecosystem actors are allowed to take part in the co-creation of the value proposition selectively and only to a measured extent. An example of a supplier that chose this ecosystem strategy is SupMu, which is a large, established equipment supplier in the mining sector with a high brand value. Its brand and reputation enabled it to enforce its closed digital architecture in the ecosystem, which meant that it could maintain close control over the development of digital solutions for minerals processing. SupMu's business development manager explained the reasoning:

“It has been important for us to maintain close control over how the [digital]solutions develop. We don't want fragmented systems that don't work well together, we want to offer well-tested and innovative solutions to the end customers. This means only working with few rather than many suppliers.”

Second, the dominator has to *take a central role in optimizing existing processes and directing other ecosystem actors to exclusively work with it*. This tends to be facilitated by a long-standing relationship between the industrial customer (the mining company) and the dominator, who may have already been active in process optimization efforts. For example, in case E3, SupMu was already working on many projects with the mining company, which qualified it to be a dominator for DEPI in minerals processing. The sales and services director of SupMu explained how its long experience enabled it to take a central role:

“Although each equipment provider company wants to become a central actor, few are really suited for this role. We have more than 100 years of experience and long-standing relationships with customers. This makes us a natural coordinator for processing equipment. We have identified two companies that we want to cooperate with, and together we can offer many advanced solutions.”

Third, the dominator strives to *drive restricted cooperation with ecosystem actors and enforce its own standards in order to dominate*. Other ecosystem actors have no choice but to comply with the dominator's standards and integrate into the dominator's digital architecture if they are to partake in the value proposition. Standards dominance has a crucial role in the dominator strategy as it enables greater adoption of its standards within the industry and makes its offering the *de facto* standard, as explained by a digitalization manager from SupAlpha:

“Our control system represents the backbone of industrial applications within process industries. This means we are best suited to use our system for setting standards and to consolidate the industrial applications from other actors.”

4.2.3. Complementor strategy

Instead of taking a leader role, an equipment supplier may be a complementor in the ecosystem, adopting a follower role and seeking to complement other offerings in order to create higher value. The complementor strategy is built on three main tactics.

First, the complementor seeks to *support unique technologies to establish an open digital architecture approach for the ecosystem leader*. Informants of SupGamma, which adopted the complementor strategy in case E5, intimated that they provided technical and operational support in setting up the open digital architecture of the leading supplier. Further support is given by sharing data using the leader's digital architecture in order to address customer requirements, as explained by SupGamma's product planning manager:

“We are a small player in these projects, and we can't believe that we can be the platform orchestrator. We need to align with the customer's requirements and share our data when it is needed.”

Second, this strategy requires the complementor to *establish a close connection with the ecosystem leader to increase value creation*. This close relationship that the complementor seeks to maintain can be fostered by offering its digital expertise to supplement the ecosystem leader's experience. This is explained by the machine services manager from SupGamma, who stressed that his company provided support through their technological capabilities:

“We realized in this project we would not be the dominant actor; our competitor had the customer relationship and much more muscle. However, they can't do it on their own and the customer will not accept it. This is a big project with lots of value to be shared and if we can support it in a smaller role, leveraging our technological capabilities, we can still profit

and position ourselves as a good collaborator for taking on other projects.”

Third, the complementor tends to *partner with different ecosystem actors in a supportive manner to combine each other's resources* in order to obtain a ‘piece of the bigger pie’. The complementors acknowledge that value creation and capture are strengthened if their capabilities and resources are put together with other ecosystem actors, as explained by an informant from SupGamma who illustrated his reasoning with an example:

“We decided to have a more open strategy for working with partners and even competitors. We know we have a very good technological solution, but we can't realize it without other companies providing the 3D visualization of the site, and they could not do it without us. So, we need to partner with our competitors in some cases.”

4.2.4. Protector strategy

Alternatively, the equipment supplier may opt for the strategy of being a protector. In this case, the supplier tends to be ‘stuck in the middle’ and has to accept a follower role, as it is unable to take a leading role and unwilling to openly share business knowledge for fear of losing its competitive position. This strategy has a number of key tactics associated with it.

First, the supplier *pursues limited integration into the digital architecture of the ecosystem leader* due to lacking the full array of competence needed for systems integration. The protectors acknowledge that it is not feasible to pursue a vision of setting up their own closed digital architecture for reasons that may include a lack of capabilities and a dearth of digitally competent staff. From Case E6, a project manager from SupDelta explained the company's situation:

“We were somehow stuck in this phase for many years trying to take a platform integration role but lacking the capabilities to deliver it to our customers. We have realized that we need to take another more ... agile approach working with customers and partners to move forward.”

Second, an equipment supplier applying the protector strategy *seeks limited or selective cooperation with other ecosystem actors in order to protect key resources due to high internal and external uncertainty*. For example, the supplier may not want to share knowledge of a certain asset with other competing suppliers. An IT manager from the mining company in case E6 (SupZeta) explained why its supplier, SupDelta, takes such a protectionist approach:

“I think many suppliers are scared to share the data. They don't know how they will use it, but that means that they also don't know what others can use it for. What if someone else profits from our data?”

This reluctance to share data and knowledge with other suppliers does not necessarily mean that the protector rejects greater involvement in the ecosystem. Instead, one tactic that the protector may use is to *search for opportunities to take a bigger role involving low cooperation with other ecosystem actors*. Thus, it draws a line that marks the extent of collaboration it is willing to exercise with others, accepting only assignments that do not ‘cross the line’. Nevertheless, an informant from SupDelta offered an example of how this tactic may be challenging to apply in practice:

“We are continuously searching for opportunities to integrate more data and information into our systems ... In the end of course, we hope to develop something out of this and have a stronger role as digitalization partners with our customers.”

4.3. A framework for configuring ecosystem strategies to fit the industrial customer's context

As discussed above, our findings illustrate that equipment suppliers apply various ecosystem strategies as part of their approach to working with other ecosystem actors in DEPI initiatives. While we identified four archetypical ecosystem strategies (orchestrator, dominator, complementor, protector), the key insight emphasized by the study's informants is that the industrial customer's context influences the configuration of the appropriate ecosystem strategy. Therefore, the present study proposes a contingency perspective on ecosystem strategies. Based on a cross-case comparison of the six cases (summarized in Table 3), we have developed a decision tree framework (Fig. 3) to aid equipment suppliers in configuring the appropriate ecosystem strategy based on their industrial customer's context. The framework includes three steps focused on: 1. overall assessment of the industrial customer's context, 2. Assessing the appropriate role in the ecosystem (leader or follower), and 3. Assessing the appropriate cooperative approach (cooperation-dominated or competition-dominated). These steps are further explained below.

4.3.1. Overall assessment of the industrial customer's context

As a first step, equipment suppliers should start with an overall assessment of the context and evaluate the opportunity to contribute in a specific DEPI initiative for a specific purpose and a specific customer. A business development manager at SupEta asserted that the customer (the process industry firm) and its operational context should be the central focus when considering an ecosystem strategy regardless of the overall ambitions of the equipment supplier:

“The customer [the process industry firm] needs to be in the center of the ecosystem since they have relationship with all the actors, and they are the ones looking to innovate their production processes. There is a tendency of providers to want to put themselves in the center of the ecosystem because that is what the business model tools do, but that is not naturally the case in practice ... I think suppliers need to be aware of this fact and critically evaluate their role for any customer opportunity.”

Part of this overarching evaluation is assessing the customer's requirements in relation to integrating the equipment and the digital systems of multiple suppliers. An automation manager from SupSigma explained that this may vary from one customer to another, depending on the needs of the specific site:

“There is no one best strategy for how to work with ecosystem actors. It depends on the needs of the customer and the configuration of the site ... So, we may integrate all data into one system, or we may have two separate systems for each vendor ... For example, some customers have specific maintenance workshops for [SupSigma].”

The first level of overall assessment of the industrial customer's context establishes the foundation on which the equipment supplier conducts subsequent evaluations to configure the appropriate ecosystem strategy. This is so because a strategy that is not guided by a concrete understanding of the context where it is to be applied is doomed to fail. Conducting a thorough evaluation of the context is, thus, a vital first step that will inform the later steps in the framework.

4.3.2. Assessing the appropriate role in the ecosystem

Having assessed the industrial customer's context, the equipment supplier should then assess whether it is able to take a leadership role in the ecosystem in such a context. Data analysis highlights three guiding criteria for evaluating whether a leadership role can be pursued.

Firstly, a guiding criterion is evaluating whether the supplier has the necessary digitalization capabilities and resources. Capabilities such as systems integration and data analytics play a vital role in being able to lead the ecosystem, and not every ecosystem actor may possess these

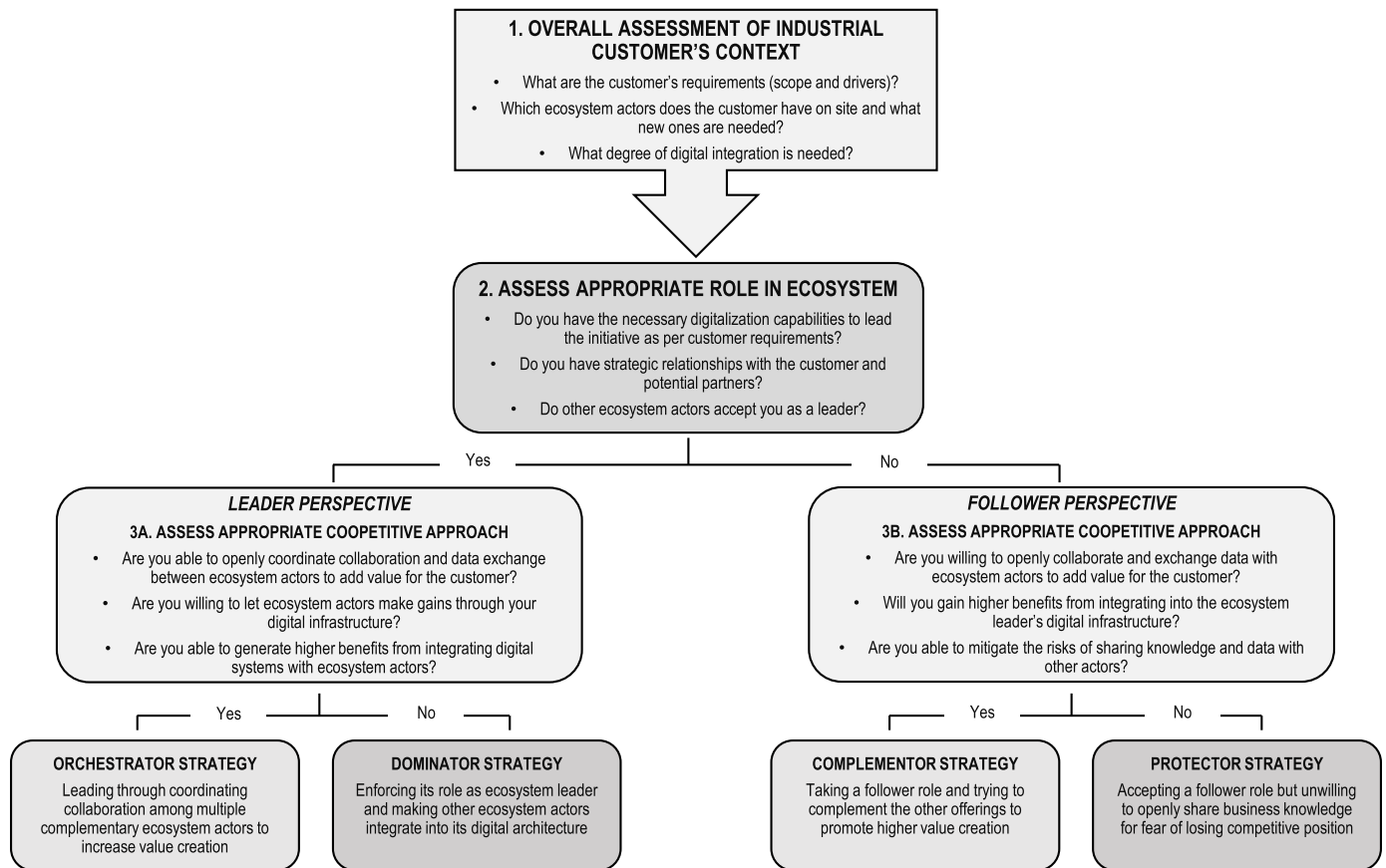


Fig. 3. A decision tree for configuring an ecosystem strategy for digitally enabled process innovation.

capabilities. It also important to consider the local service and implementation capabilities for delivering DEPI initiatives. For example, SupGamma intimated that, in certain markets, its independent dealers who were responsible for setting autonomous solutions did not have the required capabilities to adopt a leading role. Ecosystem leadership also requires possession of enabling digitalization resources to catalyze innovation. Digitalization resources include unique sources of operational data in addition to knowledgeable and experienced staff who are able to play active roles in DEPI. Expertise in the deployment of certain digital equipment or, for instance, deep operational understanding can enable the equipment supplier to take a leading role in the ecosystem and drive innovation efforts.

Secondly, a vital assessment criterion is whether the supplier has strategic relationships with the customer and potential partners. Unsurprisingly, having an existing and long-standing relationship with the customer can give the equipment supplier a unique advantage over other suppliers. An existing good relationship usually sets the foundation for further collaboration, given that the supplier has good knowledge of the customer's operations and processes. Furthermore, having existing relationships with other ecosystem actors can facilitate integration and help the equipment supplier to take a leading role in the ecosystem.

Thirdly, leadership potential is naturally subject to other actors' willingness to accept followership roles. This is largely related to the two other guiding criteria – namely, having both digitalization capabilities and strategic relationships. Data analysis shows that ecosystem actors tend to accept and trust the leadership of an equipment supplier who has the necessary capabilities and resources, and those with whom they have existing relationships. This not only strengthens trust but also allows the equipment supplier to lead in an efficient and operationally smooth manner.

While these three criteria can guide the equipment supplier in assessing whether it is able to assume a leadership role in the ecosystem, it should be noted that they are not simply a 'check list'. Although having existing strategic relationships with the customer and other ecosystem actors can significantly help the equipment supplier in taking a leading role, this does not necessarily mean that a supplier with no existing relationships will be incapable of leading an ecosystem. This may be compensated for with outstanding digitalization capabilities alongside excellent networking competencies that enable the supplier to convince the customer and other actors that it is well suited to lead the ecosystem.

4.3.3. Assessing the appropriate cooperative approach

The final assessment concerns the equipment supplier's appropriate cooperative approach. Whilst a certain level of cooperation, as well as knowledge and data sharing, is arguably always necessary, the ecosystem strategy depends on the equipment supplier's approach to balancing cooperation and competition with other actors in the ecosystem. The cooperation-dominated approach entails higher levels of collaboration with other actors and a more open exchange of knowledge and data compared to the more restricted competition-dominated approach. Here, the guiding criteria differ depending on the previous assessment – that is, the role in the ecosystem – as the cooperative approach should be assessed from either a leader perspective (3A) or a follower perspective (3B).

Accordingly, the criteria in 3A focuses on assessing the appropriate cooperative approach from a leader perspective. This assessment is guided by three criteria. Firstly, the leader will need to assess whether it is able to openly coordinate collaboration and data exchange among different ecosystem actors to add value for the customer and DEPI initiative. Secondly, the leader should assess whether it is willing to

ecosystem actors make gains through its digital infrastructure. To incentivize ecosystem actors to integrate their data into the leader's digital infrastructure, they will need to see direct benefits and a healthy prospect of capturing value. Thirdly, the leader itself should be able to capture value and generate higher benefits from integrating digital systems and exchanging data with ecosystem actors. If these criteria apply, the appropriate cooperative approach is characterized as cooperation dominated and the appropriate ecosystem strategy for the leader would be an orchestrator strategy. If not, then the appropriate cooperative approach is competition dominated. In this case, the appropriate ecosystem strategy for the leader would be a dominator strategy. For example, a dominator strategy may be most suited in the case of limited exchange of data between ecosystem actors for fear of losing competitive advantage or where the equipment supplier has such a strong relationship with the industrial customer that it can appropriate most of the returns.

From a follower perspective, however, assessing ecosystem cooperation should be guided by a different set of three criteria (3B). Firstly, the follower should assess whether it is willing to openly collaborate and exchange data with ecosystem actors to add value for the customer and DEPI initiative. This criterion is likely to be dependent on how the ecosystem leader can showcase the potential value of data exchange for the process innovation efforts. Secondly, the follower should assess whether it can capture value and gain higher benefits from becoming integrated into the digital infrastructure of the ecosystem leader. Again, this may depend on the leader's ability to 'sell' the potential profits that each actor can gain. It is, of course, important for the follower to have mechanisms in place to assess the potential benefits. Thirdly, the follower should assess whether the risks of sharing knowledge and data can be minimized or mitigated. This is necessary because a certain level of risk tends to be associated with sharing knowledge or data with other suppliers, especially in the case of knowledge or data that are strongly linked to intellectual property. If these criteria apply, the appropriate cooperative approach is cooperation dominated and, therefore, a complementor strategy is most appropriate for a follower to pursue. For example, SupGamma made a careful assessment of its situation and found that complementing the orchestrator in the ecosystem was still in its best interests in order to capture part of the revenue. However, if the criteria do not apply, the appropriate cooperative approach is competition dominated. In this case, a protector strategy is most suitable for a follower. It should be noted, however, that a protector strategy is not the goal envisioned by most equipment suppliers since value creation and value capture may be constrained, but it is rather a strategy to prepare the company to take a bigger role in the future.

Again, the criteria for assessing the appropriate cooperative approach from both perspectives (leadership and followership) are for guidance purposes and should not be seen as a strict 'check list'. For example, a supplier may find that there are certain risks in data sharing that cannot be minimized. However, it may find that the anticipated benefits significantly outweigh the potential risks, making it willing to exchange data with other suppliers.

4.3.4. Configuring the appropriate ecosystem strategy

Undertaking the three assessments outlined helps to configure the appropriate ecosystem strategy to apply in various industrial customers' contexts for DEPI. However, it is important to stress that this assessment process is not easy, and there are important tradeoffs to consider in each strategy. We argue that the recommended strategy can be considered the 'best fit' for the specific context; applying an unsuitable ecosystem strategy may lead to negative consequences. For instance, an equipment supplier that pursues a leader role without having the required capabilities might run the risk of being unable to incentivize ecosystem actors to work together and, therefore, may be incapable of coordinating efforts to achieve successful DEPI. On the other hand, an equipment supplier that realizes it does not possess the necessary capabilities to lead the ecosystem could likely benefit from a follower role such as

acting as a complementor to other actors.

To illustrate this point, SupGamma realized that it could not assume a leading role in the case studied because the other ecosystem actors were bigger players with outstanding capabilities and strong footholds in the market. In this case, the best strategy was to find a way of complementing those big players' offerings by integrating into their fleet management systems. However, informants of SupGamma stated that they had identified other cases where it could take a leading role in certain ecosystems. Yet, to forestall customer fears of being locked in, it opted for an orchestrator strategy rather than a dominator strategy in those cases. Similarly, informants of SupSigma, which applied orchestrator strategy in case E4, described that in certain sites of other customers, their site optimization system would be too expensive for the customer and not well aligned to its requirements. Thus, in those cases, SupSigma followed a complementor strategy. These examples illustrate how the suitability of different ecosystem strategies depends on the context.

The cases in the present study were considered by the informants as successful examples of applying the appropriate ecosystem strategy. The success was assessed based on having the focal value proposition of the DEPI initiative materialized through the ecosystem, where all actors profited from their investment and efforts. A common feature across these cases was that the equipment supplier followed the logic of the decision tree's assessments and the criteria discussed above. Nonetheless, throughout the data collection process, the study's informants mentioned examples from their broader experience that they considered to be unsuccessful cases, which were related to a mismatch between the ecosystem strategy and the context. It is clear, therefore, that configuring and applying the appropriate ecosystem strategy is vital for the success of equipment suppliers engaged in DEPI. The decision tree framework that we propose offers guidance to aid equipment suppliers in this endeavor.

5. Conclusion and discussion

This study has investigated how equipment suppliers configure appropriate ecosystem strategies to realize digitally enabled process innovation in various industrial customer contexts. Our findings show that, depending on the industrial customer's context (customer's requirement, roles in ecosystem, balance of cooperation and competition), there are a number of different ecosystem strategies that an equipment supplier can apply to achieve DEPI initiatives. We identify and define four archetypical ecosystem strategies (dominator, orchestrator, complementor, and protector), and we explore the conditions in which they are applicable. We present these conditions as core facets of a decision tree framework to guide equipment suppliers who are in pursuit of configuring the appropriate ecosystem strategy.

The proposed decision tree framework for configuring an ecosystem strategy for digitally enabled process innovation has implications that extend beyond the mining sector, which we studied, to broader process industries (Lager and Frishammar, 2010) and manufacturing firms (Sjödin et al., 2018). This is because process innovation in these industries is largely dependent on ecosystem collaboration and integration of emerging digital technologies (Parida et al., 2019; Sjödin, 2019). The importance of these findings is underscored by the increasingly distributed nature of innovation (Gama et al., 2017), where not only product innovation but also process innovation has become more open and distributed among multiple ecosystem actors (Robertson et al., 2012; Von Krogh et al., 2018). These insights are particularly important for understanding the current era of digitalization where ecosystems across industries are required to co-create novel DEPI arising from the advances in artificial intelligence and the application of digital technologies (Iansiti and Lakhani 2014; Porter and Heppelmann 2014; Sjödin et al., 2018).

5.1. Theoretical contributions

This study contributes to the growing body of literature on innovation ecosystems and process innovation. We do so by developing a framework for configuring appropriate ecosystem strategies for digitally enabled process innovation (DEPI) in the process industries, in which firms' core competences and competitiveness revolve around their ability to continually optimize existing production processes and introduce new ones. The framework underlines the importance of consciously assessing the appropriate equipment supplier's role in the ecosystem (i.e., leader or follower) and its cooperative approach (i.e., cooperation-dominated or competition-dominated) based on the assessment of the industrial customer's context. In doing so, the present study offers theoretical contributions in three specific ways.

Firstly, this study contributes by *increasing understanding of how an equipment supplier may strategize and align with ecosystem partners to realize digitally enabled process innovation*. To conceptualize ecosystem strategies, we build on the less-studied 'ecosystem-as-structure' view by Adner (2017). This view underlines "the alignment structure of the multilateral set of partners that need to interact in order for a focal value proposition [i.e., the DEPI] to materialize". We support the proposition that this view offers a "more actionable perspective on interdependence" since it highlights partner alignment as a key strategic challenge. For example, in the evolving area of industrial digitalization, roles are often unclear, and suppliers strive to protect their interests rather than focus on common goals (e.g., Parida et al., 2019). Our results show how equipment suppliers configure and apply various strategies and tactics to manage this challenge in increasingly competitive process industries. Whilst Adner (2017) calls for studies to identify and explain ecosystem strategy – "the way in which a focal firm approaches the alignment of partners and secures its role in a competitive ecosystem" – we propose four archetypes of such ecosystem strategies (orchestrator, dominator, complementor, and protector) and the underlying tactics that are manifested in each. In this way, we contribute to ongoing efforts to develop an empirically grounded theory of innovation ecosystems.

Secondly, we contribute by *suggesting a contingency perspective recognizing that different contexts require different ecosystem strategies*. The study shows that an equipment supplier may apply a particular strategy in one ecosystem, whilst applying a different strategy in another ecosystem, and that this is primarily contingent on the industrial customer's context. This highlights a dynamic nature of ecosystem strategies. We augment prior literature by suggesting that the industrial customer (i.e., the process industry firm) and the contextual characteristics of the focal value proposition should be at the center of ecosystem strategy configuration. This contrasts with earlier studies that have tended to view customers as receivers of a value proposition (e.g., Iansiti and Levien, 2004; Moore, 1993; Teece, 2007) rather than active agents in shaping the value proposition whose idiosyncratic requirements and operational contexts need to be considered. This perspective builds on value co-creation logic (Grönroos and Voima, 2013) that recognizes the importance of the supplier entering the customer's sphere to drive innovation and novel value creation (Sjödin et al., 2017), as in the case of DEPI. We contend that the process industry focus of this study illuminates these considerations very clearly since the collaboration of multiple suppliers is required for process innovation to materialize (Lager and Hassan-Beck, 2020). Following this contextualization, we argue that the context of the focal value proposition needs to be considered in assessing the appropriate ecosystem role (leader or follower) and cooperative approach (cooperation-dominated or competition-dominated). In doing so, our findings contradict the prevailing view that favors the dichotomous situation of either a more control-based (domination) or a more trust-based (orchestration) ecosystem strategy by lifting further considerations. In particular, we argue that seeking to be the ecosystem leader is not necessarily the right choice in every situation. In fact, the willingness of equipment suppliers to assume a follower role is often an important determinant in ensuring

alignment in DEPI ecosystems.

Thirdly, we contribute to the well-established body of literature on process innovation (Bruch and Bellgran, 2012; Frishammar et al., 2012; Lager, 2011; Pisano, 1997; Sjödin, 2019) by *demonstrating the central role of ecosystem collaboration in digitally enabled process innovation*. Indeed, the proliferation of digital technologies offers a new wave of process innovation opportunities (Sjödin et al., 2018) that are central to the competitiveness of process industry firms. These initiatives are typically driven by equipment suppliers delivering advanced technological solutions as embodied sources of process innovation (Lager and Hassan-Beck, 2020; Sjödin, 2019). However, as this study shows, no single actor holds all the capabilities, resources, and data access to realize DEPI on its own. For example, DEPI initiatives are sometimes hindered by the unwillingness among ecosystem actors to share operational data. Furthermore, excessive competition where each equipment supplier is pushing its total solution may hinder the uptake of DEPI in process industries. In contrast, we suggest a more pragmatic approach to DEPI focused on combining different solutions from various equipment suppliers into a customized solution that fits the specific industrial customer's context. We illustrate how DEPI requires conscious efforts to align an ecosystem of diverse partners, an approach that has received scant attention in previous research (e.g., Sjödin, 2019; Hullova et al., 2019), compared to the dyadic level, which has been widely studied (Bruch and Bellgran, 2012; Lager and Frishammar, 2010; Sjödin and Eriksson, 2010). We, therefore, provide additional foundations for a future research agenda on open process innovation or open operation as previously suggested by scholars (Lager and Frishammar, 2010; Robertson et al., 2012; Sjödin, 2019; Sjödin, 2019; Von Krogh et al., 2018). In particular, the ecosystem perspective may prove illuminating by uncovering the relational alignments needed to ensure process innovation in increasingly interdependent production processes.

5.2. Managerial implications

Besides its theoretical contributions, this paper holds several implications for managers involved in efforts to move toward digitally enabled innovation in the process industries. We offer three key managerial recommendations.

Firstly, it is advisable for equipment suppliers to *consciously configure the appropriate ecosystem strategy when approaching digitally enabled process innovation in various contexts* (e.g., a specific customer). The framework can guide managers of equipment suppliers in shaping their strategy when approaching DEPI in an ecosystem of multiple actors. By identifying the appropriate ecosystem strategy, the supplier can better understand its appropriate role and cooperative approach in relation to other actors and, hence, be better able to organize value creation and delivery in order to secure the benefits of DEPI.

Secondly, it is desirable to *embrace cooperation as an enabler of digitally enabled process innovation*. Our results provide important lessons concerning the need of suppliers to simultaneously compete and cooperate, highlighting the importance of acknowledging cooperation in DEPI initiatives in process industries. Competition is often a driver of innovation and an enabler of finding novel configurations of collaborating actors in process innovation. Acknowledging this reality would help managers of equipment suppliers to keep an open mind concerning cooperation with competitors and, consequently, to make decisions regarding the balance between competition and cooperation, and between knowledge sharing and knowledge protection.

Thirdly, it is sensible for industrial customers (e.g., the process industry firms) to *extend supplier evaluation to include an ecosystem perspective*. DEPI requires the procurement of complex solutions including product, service, and software components (e.g., sensors, connectivity, and analytics). It is important to emphasize that such solutions are typically reliant on cooperation among multiple interdependent ecosystem actors. Yet, standard procurement practices are typically devised with one supplier in mind. Our framework can provide

a complementary view and guide companies in understanding how their suppliers can work together within an ecosystem to achieve DEPI. Procurement and operational managers in the process industries can use the framework to map suppliers in ecosystems and evaluate their ecosystem strategies, which can serve to promote a better understanding of how to foster mutual collaboration.

5.3. Limitations and further research

Although the present study's conclusions are rather broad and offer insights into DEPI in general, we acknowledge that the study's focus is on the setting of the mining sector in Sweden. Nevertheless, we sought to validate our key findings through discussions with respondents from another process industry (pulp and paper). We suggest further research on ecosystem strategies for DEPI in other sectors as well as in other countries in order to test whether our framework has a wider applicability. For example, further studies in settings such as manufacturing and smart factories (Sjödin et al., 2018), construction, and shipping could be relevant. More specifically, we suggest further research on how ecosystem alignment may be influenced by the contextual characteristics of the sector, and how this affects realizing the potential of digitalization.

Moreover, although we suggest a contingency perspective and stress that different situations require different ecosystem strategies for DEPI, further quantitative study can strengthen and validate our conclusions. We propose a quantitative research design to study the dependent variables and the extent to which they affect the applicability of an ecosystem strategy. Studying the success of a particular ecosystem strategy in specific conditions through quantitative methods can assist in building the theory and generalizing the findings.

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