Journal of Business Research 196 (2025) 115426

Contents lists available at ScienceDirect

Journal of Business Research

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

An innovation intermediary's role in enhancing absorptive capacity for cross-industry digital innovation: Introducing an awareness capability and new intermediary practices

Andrea Kerstens [a,b,*], David J. Langley [c]

[a] TNO, the Netherlands
[b] Delft University of Technology, the Netherlands
[c] University of Groningen, the Netherlands

ARTICLE INFO

Keywords:
Absorptive capacity
Innovation intermediaries
Collaborative innovation
Digital transformation
Cross-industry innovation
Digital technologies

ABSTRACT

Emerging digital technologies enable the combination of data from different industries to create new innovation opportunities. Many firms, particularly those with underdeveloped absorptive capacity, rely on innovation intermediaries to facilitate this process. However, current theory does not fully explain how intermediaries achieve this in cross-industry settings where digital technologies drive innovation. This study investigates the question: How does an innovation intermediary contribute to the absorptive capacity of firms that collaborate in cross-industry contexts to develop digital innovations? This research examines how one intermediary enhances absorptive capacity for cross-industry digital innovation. We provide a definition for cross-industry digital innovation, a concept previously undefined in the literature. Results show the intermediary develops potential absorptive capacity but has less impact in the exploitation phase. The concept of "awareness capability," which triggers firms' search for new knowledge, is introduced. Additionally, specific practices of intermediaries are identified for each absorptive capacity phase.

1. Introduction

The digital revolution has sparked significant innovation and created opportunities for combining data across organizations and industries as a means of addressing important societal challenges in a highly dynamic, complex, and interconnected world (Grover & Lyytinen, 2023; Nambisan, Wright, & Feldman, 2019; Teece, 2010). While multiple studies have explored cross-industry innovation, defined as the creative adaptation and retranslation of existing solutions to meet the needs of other industries (Behne, Heinrich Beinke, & Teuteberg, 2021; Carmona-Lavado et al., 2023; Enkel & Gassmann, 2010), no specific definition exists for cross-industry digital innovation. We define cross-industry digital innovation as collaborative efforts between firms from different industries that leverage digital technologies to solve problems, create societal value, or drive transformation in ways that are novel. This definition builds on the principles of cross-industry innovation, extending them to the digital domain. For example, applications such as the digital twin technology first introduced in the manufacturing industry (Tao & Qi, 2019) are now being applied in hospitals, thereby advancing predictive healthcare (Erol, Mendi, & Doğan, 2020).

However, many firms face challenges in realizing the potential of these digital innovations due to challenges in effectively identifying, absorbing, and integrating external knowledge (Cohen & Levinthal, 1990; De Silva et al., 2022). For example, research has identified how constraints in resources, scale, and less-established networks hinder their capacity to fully leverage external insights (Dimakopoulou, Gkypali, & Tsekouras, 2024). These challenges become especially pronounced in cross-industry collaborations where firms must bridge knowledge gaps, to develop new data-driven innovations and business models (Grimpe & Kaiser, 2010; Liao & Marsillac, 2015; Oshri, Arkhipova, & Vaia, 2018; Wiener, Saunders, & Marabelli, 2020). We relate this challenge to absorptive capacity, defined as a firm's ability to identify, assimilate, and leverage external knowledge to enhance innovation performance (Cohen & Levinthal, 1990; Roberts et al., 2012; Camisón & Forés, 2010). In this study we explore how an innovation intermediary contributes to firms' absorptive capacity in cross-industry digital innovation.

Firms often partner with innovation intermediaries to leverage their

* Corresponding author.
E-mail address: andrea.kerstens@tno.nl (A. Kerstens).

https://doi.org/10.1016/j.jbusres.2025.115426
Received 25 September 2024; Received in revised form 25 April 2025; Accepted 26 April 2025
Available online 8 May 2025

expertise and capabilities, and tap into knowledge, networks, and resources beyond their normal operational reach. Innovation intermediaries are organizations that support firms during the various stages of the innovation process (Battistella, Ferraro, & Pessot, 2023; Dalziel, 2010; Kivimaa et al., 2019), and they play a vital role in facilitating the identification, absorption, and integration of new knowledge into firms' innovation processes. Moreover, these intermediaries are instrumental in establishing cross-industry networks that allow firms to access valuable knowledge, talent, and technologies from unfamiliar industries (Ollila & Elmquist, 2011; Polyviou, Venters, & Pouloudi, 2023).

While considerable research has explored the role of intermediaries (Agogué, Yström, & Le Masson, 2013; Caloffi et al., 2023; Howells, 2006; Kokshagina, Le Masson, & Bories, 2017; Van Lente et al., 2003), scholars are questioning whether current theory is suited to understanding cross-industry intermediation (Kokshagina, Le Masson, & Bories, 2017). Literature on crossing knowledge boundaries has been based on studies within firms or industry branches (e.g., Abi Saad, Tremblay, & Agogué, 2024; Berends et al., 2011; Edmondson & Harvey, 2018). Despite previous studies shedding light on the general functions and mechanisms of intermediaries, their role in enhancing firms' capabilities to manage the complexities of cross-industry innovation has received insufficient attention. This problem is significant because it means that theory fails to adequately account for how intermediaries facilitate critical knowledge transfers across industries. Consequently, there is a need to better understand how intermediaries contribute to firms' absorptive capacity in cross-industry digital innovation.

As such, our research question is: *How does an innovation intermediary contribute to the absorptive capacity of firms that collaborate in cross-industry contexts to develop digital innovations?*

To answer this question, we employ an abductive case study approach, focusing on the role of an innovation intermediary —an independent research and technology organization in the Netherlands— in bridging cross-industry knowledge for collaborative digital innovation. We examine six collaborative digital innovation projects guided by the intermediary, each involving multiple firms from different industries. The study centers on how the intermediary helps enhance the absorptive capacity of the group of firms collaborating across industries, specifically in the context of their relationships with one another. We investigate the role of the intermediary in processes of knowledge exchange across firms in order to support joint technological development, rather than individual firm-level technology adoption or transfer. Absorptive capacity is applied to these collective processes to capture how the intermediary enables knowledge flows and utilization among diverse partners. In order to do this, we conduct 25 interviews with individuals in relevant functions at the intermediary firm and analyze documentation from various stakeholders involved in the innovation processes of each collaboration.

The results of this study shed light on the intermediary's practices in augmenting collaborating firms' absorptive capacity. Notably, our study introduces the concept of the "awareness capability" within absorptive capacity, emphasizing the unique role played by intermediaries in initiating the innovation process within one industry by introducing knowledge and experience in digital innovation from another industry. This capability acts as a catalyst, triggering curiosity, prompting a sense of urgency, and expertly guiding the search for external knowledge. Furthermore, we uncover previously unidentified practices related to the intermediary's role in enhancing knowledge acquisition, knowledge assimilation, knowledge transformation, and knowledge exploitation.

The remainder of this work is structured as follows. Section 2 delineates the theoretical background to our work, in which we detail the current knowledge on the use of digital technologies as a basis for innovation, the role of absorptive capacity in the innovation process and the role of intermediaries in facilitating cross-industry innovation. In Section 3, we describe the research methodology employed for our study and provide insights on the data used to support our research. In Section 4, we describe our findings on roles and specific practices identified from our analysis of the six cases. In Section 5 we discuss the outcomes of our work and devise contributions to research. Section 6 outlines practical implications, Section 7 our study's limitations and future research avenues, and Section 8 provides our conclusion.

2. Background

2.1. New digital technologies and their challenges

The emergence of digital technologies has revolutionized innovation activities across various industries (Nambisan, Wright, & Feldman, 2019; Teece, 2018). This is because, on the one hand, digital technologies provide extensive new opportunities to enhance products and processes and, on the other hand, they also drive changes in managerial practices, organizational structures, supply chain dynamics, and business models (Bleicher & Stanley, 2016). This transformation signals a cross-industry paradigm shift, with data-intensive digital technologies enabling unprecedented collaboration and value creation across traditionally separate industries (Ciarli et al., 2021). As these technologies blur sectoral boundaries, they open up new opportunities for firms to redefine their roles and strategies, as their operating environment rapidly evolves.

Within this context, firms are leveraging digital technologies to innovate, remain competitive, and meet shifting customer expectations (Hinings, Gegenhuber, & Greenwood, 2018; Lasi et al., 2014). These tools also empower organizations to optimize resource allocation, improve environmental performance, and advance sustainability goals, aligning with broader societal demands (George, Merrill, & Schillebeeckx, 2021; Pan & Zhang, 2020). By integrating digital solutions into their core strategies, firms can unlock new growth opportunities and adapt to dynamic market conditions, achieving both economic and environmental benefits (Caputo et al., 2021).

However, these opportunities come with significant challenges. Many firms face barriers such as limited technological expertise, insufficient digital strategy capabilities, financial constraints, cybersecurity risks, and a lack of standardization (Kiel, Arnold, & Voigt, 2017; Mittal et al., 2018; Teece, 2018). Moreover, as digitally enabled markets diversify, acquiring and integrating the necessary knowledge to overcome these obstacles becomes critical (Brynjolfsson & McAfee, 2014; Horváth & Szabó, 2019). For managers, this dual reality of opportunity and challenge underscores the need for robust strategies to harness the potential of digital technologies while mitigating their risks.

2.2. The role of absorptive capacity in innovation

Developing and recombining diverse knowledge, as can arise from various aspects of digitalization, has proven to be a fruitful method for creating successful innovations (Gkypali, Filiou, & Tsekouras, 2017; Nooteboom et al., 2007). To acquire and exploit the opportunities stemming from external knowledge, absorptive capacity is essential (Gebauer, Worch, & Truffer, 2012; Spithoven, Clarysse, & Knockaert, 2010). Cohen and Levinthal (1989) initially defined absorptive capacity as the ability of firms to identify, assimilate, and exploit external knowledge to form innovations. Zahra and George (2002) expanded the definition of absorptive capacity and identified four complementary components: acquisition, assimilation, transformation, and exploitation of external knowledge.

Table 1
Innovation intermediaries capabilities that enhance absorptive capacity of firms, based on current literature.

Firm development of absorptive capacity	Role innovation intermediary	Practices innovation intermediary
Acquisition	Foresight and diagnosing opportunities	Advanced knowledge searching (Howells & Thomas, 2022) Following up on technology specific and sector specific trends (Howells, 2006; Knockaert, Spithoven, & Clarysse, 2014) Demand articulation and matching with cooperation partners (Bessant & Rush, 1995; Cannavacciuolo, Capaldo, & Rippa, 2015; Chen & Lin, 2018; Klerkx & Leeuwis, 2009) Promote access to scientific and technological knowledge, networks and resources (Rossi et al., 2022; Russo et al., 2019)Identification of technology transfer opportunities (Lichtenthaler, 2013)
Assimilation	Creating a learning environment	Providing strategic resources (Doloreux & Turkina, 2023; Howells, 2006; Kanda et al., 2018; Knockaert, Spithoven, & Clarysse, 2014; Polzin, von Flotow, & Klerkx, 2016)Facilitating knowledge translation, providing feedback, and technical and project support (Randhawa et al., 2017)Engage firms with technology transfer experts (Lichtenthaler, 2013)Facilitating engagement and efficient knowledge exchange (Knockaert, Spithoven, & Clarysse, 2014)Network building, bridging, and defining innovation system architecture (De Silva, Howells, & Meyer, 2018)
Transformation	Facilitating adaptation and integration	Innovation process management (Batterink et al., 2010) Providing platforms such as testbeds and pilot projects for field-testing and measurement, evaluation and showcasing (Matschoss & Heiskanen, 2017)Promote access to high value-added knowledge-intensive services (Russo et al., 2019) Coordinating networks, including agents promoting change (Doloreux & Turkina, 2023; Rossi et al., 2022)Making collective sense of the transition, portraying potential benefits, and promoting the construction of new technological architectures (Rossi et al., 2022)Orchestrating the ecosystem resources (Ng, Luo, & Park, 2022) Facilitating ecosystem / community welfare, value alignment and engagement (Randhawa et al., 2017)
Exploitation	Strengthening value creation and capture	Providing information to third partners who support commercialization of innovation (Cannavacciuolo, Capaldo, & Rippa, 2015)Assisting commercial exploitation on local and international markets (Van Lente et al., 2003)Branding and legitimation (Kanda et al., 2018)Knowledge integration, patenting and licensing support (De Silva, Howells, Khan & Meyer, 2022; Rossi et al., 2022)

Acquisition involves identifying relevant external knowledge, while assimilation focuses on analyzing and understanding it. Transformation refers to combining prior and new knowledge, and exploitation involves implementing external knowledge within the firm's environment.

These four components allow to distinguish between potential absorptive capacity, determined by acquisition and assimilation capabilities, and realized absorptive capacity, determined by transformation and exploitation capabilities (Zahra & George, 2002). Potential absorptive capacity reveals a firm's receptiveness to external knowledge, while realized absorptive capacity reflects its capacity to leverage absorbed knowledge and transform it into innovation.

In cross-industry contexts, where diverse knowledge is available, the innovation design space expands significantly (Enkel & Gassmann, 2010; Gassmann, 2006). Digitalization serves as an illustrative example of cross-industry innovation, where skills and expertise are shared across traditional industry boundaries. This trend creates significant opportunities for joint value creation and expanded market potential (Caputo et al., 2021). However, firms may struggle to fully grasp and utilize the multitude of available opportunities, as they often remain confined within their familiar design space. These challenges are particularly noticeable in organizations that may have limited resources, such as SMEs, who may perceive venturing into diverse external knowledge as a risky endeavor (Coad et al., 2013), as obstacles can arise when integrating new knowledge and bringing it to market readiness (Brunswicker & Van de Vrande, 2014; Radziwon & Bogers, 2019). In such situations, third-party support from innovation intermediaries, can assist firms in boosting their absorptive capacity.

2.3. The role of intermediaries in facilitating innovation through absorptive capacity

Optimizing the absorptive capacity of firms is crucial for successful cross-industry innovations, as they represent an open collaborative activity (Chesbrough & Bogers, 2014) with uncertainties and complexities (Lane & Maxfield, 2005), requiring the involvement of different actors specializing in specific parts of the process. This presents an opportunity for intermediaries to support firms in innovation processes (De Silva, Howells, & Meyer, 2018).

Existing literature highlights various roles and practices of innovation intermediaries in enhancing firms' absorptive capacity (Table 1).

Previous studies have touched upon intermediaries' operations in cross-industry contexts but have not fully explored or explained their capabilities in addressing the unique challenges posed by such collaborations. Gassmann, Daiber and Enkel (2011) examined how intermediaries support firms in their innovative activities, bridging the gaps between different industries, and they concluded that there are three different types of intermediaries: the innovation broadener, who is able to realize an innovative idea from a very distant context; the innovation leverager, who acts within a narrower technological field of expertise but can lead innovation projects further into the adaption phase; and the innovation multiplier, who relies on their customers to identify analogies from another industrial ambit. More recently the study of Lyng and Brun (2020) discusses the importance of engaging with intermediaries to overcome knowledge barriers in cross-industry innovation. However, further exploration into the nuances of intermediation in cross-industry contexts is necessary to fully comprehend its impact on innovation processes.

3. Methodology

Our study employed a qualitative abductive case study analysis of six projects involving TNO, the largest independent research and technology organization in the Netherlands. The unit of analysis is the collaborative set of firms engaged in cross-industry projects facilitated by TNO

the innovation intermediary. The study examines how the intermediary supports the firms' collective ability to acquire, assimilate, transform, and exploit knowledge to drive digital innovation.

By focusing on a single innovation intermediary, we maintained a homogeneous context across projects, allowing the digital, cross-industry nature of the projects to inform our findings. This design also helped establish trust with the respondents, minimizing social desirability bias and enabling a comprehensive understanding of the phenomenon (Yin, 2018). While this single-case design limits generalizability, the unique attributes of TNO as a transition intermediary, having a large scale, systemic focus, and mission-driven agenda, align with key characteristics of intermediaries in similar contexts. This provides a basis for cautiously extending findings to other intermediaries operating in complex, collaborative, and cross-industry environments.

To analyze our qualitative data, we used abduction as an inference method (Dubois & Gadde, 2002). This involved data analysis to identify patterns, relationships, and mechanisms to account for the innovation intermediary's role in enhancing absorptive capacity for collaborative digital innovation. The process of abduction was iterative, refining our propositions through further data collection and analysis in relation to existing theory (Bamberger, 2019; Golden-Biddle, 2020; Sætre & Van de Ven, 2021).

3.1. Research setting

TNO, the largest independent applied research and technology organization in the Netherlands, aims to boost industry competitiveness and societal well-being in a sustainable manner (TNO, 2022). With over 4,500 research and consultant professionals, TNO focuses on nine social themes aligned with national economic and social goals. Acting as a "transition intermediary" (Caloffi et al., 2023), their ambition is to make the Netherlands a digital leader in Europe by supporting various domains and industries, including smart industry, digitalizing SMEs, smart mobility, and digital health technologies.

3.2. Data collection

Data collection for this study spanned a 10-month period from November 2020 to August 2021. To identify relevant cross-industry innovation projects involving digital technologies, we reached out to and contacted strategic consultants within TNO who had experience with such projects that included organizations from different industries. Ultimately, we included 14 consultants as part of our initial data set.

In February 2021, we conducted the first round of semi-structured interviews with these 14 contacts. The questions, aimed to gather insights into project content, the roles of the interviewees and TNO, project timelines, the cross-industry nature of the projects, and the availability of information sources for data triangulation.

Six projects qualified for the second round of semi-structured interviews (Appendix A), as they met the inclusion criteria allowing us to (a) examine TNO's role as an innovation intermediary throughout the innovation process of the involved firms, and (b) explore how the digital nature of the projects, with data and knowledge from different sectors, influenced TNO's intermediary role. This ensured alignment with our theoretical framework established in the previous section (Yin, 2018). The industries involved were classified according to the European Union's official NACE codes, which offer a comprehensive framework for economic activities (Eurostat, 2016). Including multiple industries in the project sample was important to ensure diversity, given the limited research on this topic.

The second round of interviews took place in March, April, and May 2021 (Appendix B). The purpose was to delve deeper into how the innovation intermediary specifically contributed to potentially influencing firms' absorptive capacity. The questions aimed to uncover the role and practices taken by TNO in the consultancy projects. Additionally, the interviews provided insights into motivations, project-related frustrations, and practical observations.

The second-round interviews involved the same interviewees as the first round, and when possible, an additional colleague referred by the interviewee who could provide further project insights. We conducted a total of 11 in-depth interviews for this part of the study. An overview of the six projects, and information on the interviews and additional information sources can be found in the appendix.

The second-round interview protocol was based on Flatten et al. (2011) multidimensional measurement scale for absorptive capacity. The interviews began with a recap of the project description, followed by an introduction to the study's topic: the role of independent organizations in supporting collaborative innovation with a focus on digital technologies. The professionals were then asked about TNO's involvement in the project. Based on their responses, specific practices related to the absorptive capacity framework of Zahra and George (2002), as specified in Table 1, were identified, and questions were asked regarding TNO's assistance, the consultant's assessment of the firms' practices across different industries prior to the project, and the outcomes of the partnership with TNO. The semi-structured approach allowed the interviewees the freedom to provide detailed answers and address additional aspects that they considered valuable for the research.

To ensure data validity, the interviews were recorded and transcribed with the interviewees' permission. Additionally, archival data from both internal and external sources were utilized. Internal data sources included white papers, project presentations, project reports, and online blog articles. External data sources consisted of webpages and online videos.

3.3. Data structure and analysis

The interview transcripts and additional information sources provided by the consultants were analyzed using the qualitative data analysis software ATLAS.ti. The analysis followed three coding steps, consistent with established practices in qualitative analysis (Gioia, Corley, & Hamilton, 2012). Open coding was initially conducted by the first author to create first-order codes, preserving the authenticity of the data by using terms mentioned by the interviewees and found in project documents. After the initial open coding phase, the first and second author compared and discuss their interpretations to further refine the codes and minimize individual bias, and improve the reliability of the codes. These first-order codes were then combined to form second-order themes and aggregate dimensions, aiming to identify patterns related to the elements of absorptive capacity (Grodal, Anteby, & Holm, 2021). A codebook was maintained to ensure consistency and triangulation happened by cross-referencing interview data with project documents.

Through an abductive approach, propositions were generated based on the analysis. These propositions were evaluated using criteria such as empirical data consistency, theoretical plausibility, generalizability, testability, and novelty (Sætre & Van de Ven, 2021). Appendix C illustrates the coding scheme employed in the analysis, and the illustrative quotes can be found in Table 2 of findings.

4. Findings

In this section, we present the findings and insights derived from the interviews, starting with Table 2 which summarizes our newly identified intermediary practices that served to enhance absorptive capacity for

Table 2
Newly identified practices of the innovation intermediary, including a wholly new role, to support cross-industry digital innovation, based on our empirical findings (see Appendix C for a summary of the coding scheme).

Firm development of absorptive capacity	Role innovation intermediary	Practices innovation intermediary	Illustrative quotes
Awareness	Initiating search for external knowledge	Introducing novel digital solutions	*"Up until today a lot of information within the supply chain is exchanged manually, with SCSN we try to get firms into the digital age […] What we often see at manufacturing firms is that there is often a technology push scenario, where firms are not often aware that improvements are possible to their processes and partly by us pushing a solution, they realize that a number of things are more convenient, that it is not directly a search for external knowledge, but that […] knowledge is placed with the firms and has already been partly translated to help them to see those improvements."* ***Medior consultant, SCSN*** *"is there even a search? Now what you see when I talk about digitization in the manufacturing sector [is] an awareness that if you as a firm aren't able to keep up […] you might intrinsically feel like "damn if I don't, then I'm missing something, I have to come along, otherwise I might not exist in 5 years". […] Now convince them that they have to go across […]. So I think it is an exaggeration to say that many firms are now looking for external knowledge in this area. It may also be arousing curiosity what we have done."* ***Project leader, CESI***
		Introducing ideas from other industries	*"You actively look for external knowledge that could help with their specific problem. In the community of practice, you actually try to present things a bit out of the box, and go through that process together with everyone in a session. You think with each other, what knowledge is valuable in this specific problem. Let's invite someone on this topic, then you first get a lot of information and then you could think with that group "what does this mean for us and our industry?"* ***Senior innovation orchestrator, AgriTech*** *"I think just by being in the consortium they will have to hear about others. What other industries are doing so I think that's why they do it. But do they make changes because of that? In some instances, yes."* ***Medior researcher, IEBB*** *"we have done several sessions, for example about the charging structure for electric vehicles and the coherence of digital and energy management. We then involved the cities and brought in people from outside who told stories about it. So that they could also absorb the latest state of knowledge."* ***Senior researcher, RUGGEDISED***
		Using digital transformation mission policies to promote industry transitions	*"EU policy stimulates the energy and building industry move towards digital, through the research program we contacted firms to motivate them to use IoT technologies"* ***Senior consultant, InterConnect*** *"We see that the building industry needs that because of what the government is considering […] basically we were really asking them. How can you collaborate with someone that is not obvious for you so for example in a digital platform. If you look into social housing associations, they are a very old institution, and so they don't really look outside. They think they can do their business the way they've always done."* ***Medior researcher, IEBB***
Acquisition	Foresight and diagnosing opportunities	Following up on digitalization trends from other industries	*"We notice a strong increase of technological innovation in the agricultural industry. Some use robots or drones, but we also see AI and VR applications."* ***Medior consultant, AgriTech*** *"We start projects by interviewing several partners to really know where industries stand here and what could be possible."* ***Medior researcher, IEBB***
		Making abstract knowledge on digitalization understandable	*"We have worked a lot to translate abstract ICT technologies in concrete use cases which firms can work with"* ***Medior consultant, SCSN***
		Facilitating problem and solution matching across industries	*"we have had a different kind of sessions with the industry associations, so-called topic teams, about data sharing in supply chains in which we then talk with firms about "What problems are we facing now? How are we trying to solve these? And what kind of techniques would contribute to this?"* ***Senior researcher, SCSN***
Assimilation	Creating a learning environment	Engage firms from various industries with digital technology experts	*"We contacted several industry associations and started with workshops on the topic of digitalization, with experts in the field."* ***Medior consultant, SCSN***
		Providing cross-industry collaborative and experimental support	*"Collaboration is the reason why we started. This project is to really accelerate that because we don't think the construction industry, does a good job in general in communicating with each other and learning from each other. It's like everybody does its own thing. So, the purpose was really to change that"* ***Medior researcher, IEBB*** *"I'm analyzing the decision-making process of social housing associations. […] Because they have to redesign the process a little bit. We're also asking them to experiment in a way: how are they making changes because of the new knowledge we provide."* ***Medior researcher, IEBB*** *"The physical pilot provided a space for the firm to really experiment with the smart energy solutions […] It was not in the vicinity of the firm, it was a small test space and an eventual stepping stone to exploitation which is still a big step."* ***Senior researcher, Interconnect***
		Facilitating cross-industry engagement and efficient knowledge exchange	*"We create a consortium, so it means that through partnership you are supposed to learn from others. So, it's not only about, telling you as a firm how you should do it differently, but you as a firm also learning from other firms and we do that by having open information sharing […] We meet every 2 – 3 months and tell each other everything. Then we share the results of our research and we also ask each other to give feedback."* ***Medior researcher, IEBB*** *"a large number of firms, about 10 and 15 […] who are all interested in a servitization, […] Their conclusion was "this is difficult […] and how should we proceed?" So they actually say "Help us". So now is indeed the interesting step to draw up work methods*

(*continued on next page*)

Table 2 (*continued*)

Firm development of absorptive capacity	Role innovation intermediary	Practices innovation intermediary	Illustrative quotes
			or, if necessary, research agendas, with which we can indeed help such a group further on a theme, a real community of practice." ***Senior researcher, SCSN***
Transformation	Facilitating adaptation and integration	Facilitating digital integration	*"We [have] ten service providers who thus facilitate [the transformation] process for the end users. So those manufacturing firms are actually connected by such a service provider and they are now taking over the entire onboarding process. As TNO, we focus more on general matters and connecting those service providers instead of connecting those manufacturing firms."* ***Senior researcher, SCSN***
		Facilitating integration across industries	*"we saw that all those manufacturing firms were very specialized in their own process and ICT firms then knew a lot of general things and then we made those combinations of knowledge and made models of it."* ***Medior consultant, SCSN***
			"The biggest risk in SCSN is that you create standards that are not implemented by all parties. So it's really a group story, connecting all those different stakeholders that was the biggest risk for us and we continued to manage that constantly." ***Medior consultant, SCSN***
			"You can imagine that there are not 20 factories in the Netherlands that supply salt spreaders. Everyone is, say, a sector of niches, […] if they exist they are de facto large in their industry. […] That means as a need that talking to their other OEM very quickly is not threatening. Because they also use steel or electronics, but they make biscuit baking machines, so it doesn't matter. We therefore see that the multiformity of those industries makes it easy to talk to each other. […]How do you deal with the implementation of new ICT technology? Then they help each other." ***Project leader, CESI***
		Building trust across industries	*"used other types of standards within Europe. That's a big part of basic trust. We also set up that not-for-profit foundation. These are all small elements that generate confidence for those manufacturing firms."* ***Medior researcher, SCSN***
Exploitation	Strengthen value creation and capture	Facilitating value creation across industries	*"It is therefore the intention to make that knowledge applicable, for that you work with a front runner and then you show that it is possible in practice. It's great if that firm knows how to make a profit or makes it its business to do that. But for the ones that comes after the front runners, we don't really have an offer for that at all."* ***Senior researcher, CESI***
		Monitoring long term exploitation	*"I don't think the we are monitoring on a long term[…] For the exploitation phase that would take some monitoring on a long term you know. So, I can say OK, I give you this new assessment framework. But then you would have to see over 5 years do they actually use it and we don't do that, but that's the ambition. That's the ambition to provide them with a new way to do things and so that they can use that themselves without us."* ***Medior researcher, IEBB***

cross-industry digital innovation. The structure of Table 2 mirrors that of Table 1 from the literature, following the absorptive capacity phases, the role of the intermediary in those phases and the practices applied by the intermediary in those roles. Table 2 adds one previously unidentified phase of absorptive capacity, "Awareness", and the novel role of initiating search for external knowledge. For the previously identified phases and roles, Table 2 also presents newly identified practices, describing novel ways that the intermediary enhances knowledge absorption. Finally, Table 2 presents illustrative quotes from the interviews in support of the novel practices.

4.1. Transition as motivation

In all six projects, the intermediary played a crucial role in initiating a digital innovation journey through a technology push, meaning that they proactively shared knowledge relating to digital technologies and their potential for enabling a societal transition, even before the firms had prior awareness or expressed explicit demand. It is noteworthy that this role as an initiator and advocator was not predetermined for the projects, and emphasizes the intemediary's proactive stance in reaching out to firms and stakeholders who could contribute to or benefit from new digital innovations. This can be attributed to the intermediary's strategic objective of advancing the Netherlands as a digital leader in Europe and aiding its partners and clients in addressing the challenges of digitalization across various domains and sectors. Refer to Appendix D for relevant quotes illustrating the motivations behind these projects.

4.2. Preparing firms for innovation by creating awareness

To initiate the innovation journeys, the intermediary undertakes preparatory actions as revealed in the interviews. First, they identify the relevant stakeholders required to achieve the project's objectives. This is accomplished through leveraging their existing network, engaging in discussions with project partners, leveraging social media platforms like LinkedIn, and conducting geographical analyses of firms and sectors.

Once the stakeholder landscape is established, efforts are made to assess the needs of firms across different industries, focusing on digital aspects. This involves conducting interviews or group discussions, and participating in on-site observations to gain insights into the daily operations of the firms. These actions serve to promote awareness of external digital knowledge and facilitate the initiation of knowledge acquisition. Notably, the intermediary's role in kickstarting the absorptive capacity process is particularly significant for firms that were previously less proactive in seeking external digital knowledge for innovation purposes. This observation emphasizes the intermediary's contribution to societal innovation performance by initiating R&D activities in firms that may have been less active in this domain.

4.3. Improving potential absorptive capacity

In all six projects examined in this study, the intermediary's objective was to enhance the potential absorptive capacity of the participating firms, focusing on their acquisition and assimilation capabilities,

especially in the digital context. To describe our findings, we adopt the components outlined by (Zahra & George, 2002).

4.3.1. Acquisition

To enhance knowledge acquisition capabilities of firms, various actions are taken, with knowledge sharing events playing a central role. These events, such as workshops, symposia, and webinars, facilitate the exchange of relevant knowledge between the intermediary and firms, as well as among the firms themselves. The intermediary employs storytelling techniques to convey the purpose and benefits of innovation with digital technologies, tailored to the specific industries and firms involved. Shared visions are developed through conversations and consideration of industry interests. Standardizing terminology and promoting interoperability of data are also effective strategies observed in certain projects.

Additionally, these knowledge sharing events foster a sense of community among the participating firms, establishing a non-obvious network that facilitates ongoing collaboration and communication. In some cases, this community evolves into a new supply chain for the cross-industry digital innovations, enabling their production and eventual market introduction. Alongside tacit knowledge, codified knowledge in the form of research papers, action agendas, roadmaps, and websites is shared between the intermediary and firms.

4.3.2. Assimilation

The intermediary plays a crucial role in facilitating knowledge sharing events, enabling receivers to process and understand the shared knowledge. The intermediary employs various techniques to enhance assimilation capabilities among the participating firms.

First, the intermediary appoints experts to be present during knowledge sharing events, allowing real-time responses to queries raised by participating firms, thereby fostering a deeper comprehension of the subject matter. Additionally, in inaugural project events or follow-up gatherings, the intermediary creates conducive environments for market parties to engage in brainstorming sessions centered around the core topic. This collaborative exercise engenders multi-dimensional perspectives and compels firms to think beyond their customary reference frames. Consequently, this process provides opportunities for firms to think innovatively with digital technologies and elevates the overall R&D trajectory, previously limited by financial constraints or conventional thinking patterns.

The utilization of "pressure cooker" workshops constitutes another instrumental technique employed by the intermediary to structure collaborative discussions. These workshops encompass the division of participants into small groups for focused deliberations, followed by collective debates in larger groups. The primary aim is to foster swift and substantial progress in formulating requisite innovations. By iteratively repeating these workshops, participants share successful approaches and challenges faced, while also delineating the necessary steps for individual firms to attain innovative solutions. Thus, the assimilation capacities of the entire cohort are notably enhanced.

The intermediary convenes these working sessions, effectively creating a "community of practice" tailored to the project's objectives. This community serves as a network, uniting firms and relevant stakeholders, such as local governments, who share a collective interest in advancing the project. As a facilitating agent within this community, the intermediary stimulates a culture of collective learning, where participants motivate one another to embrace innovative methodologies and promptly adapt to emerging needs. These requirements might entail inviting experts from the intermediary organization or other external parties to elaborate on specific topics, aiding comprehension of external knowledge and its potential value for each firm.

Moreover, the intermediary plays a crucial role in shaping pilot experiments, collaborating closely with participating firms to process novel knowledge within experimental settings. By situating these pilots outside the firms' immediate contexts, unencumbered ideation is facilitated, and insights gleaned from real-life experiences enhance tangible knowledge assimilation. Digital components are also leveraged, furnishing comprehensive and comprehensible data regarding the effects of new technologies on existing processes. To further strengthen assimilation capacities, some projects extend financial resources in the form of innovation vouchers, empowering firms to engage with external knowledge and supportive partners they may have previously eschewed due to financial constraints.

Furthermore, the intermediary undertakes "action research" initiatives, as observed in the project IEBB. By initially conducting participant observations within firms' operational environments, the intermediary gains valuable insights into their daily workings. Subsequently, the intermediary prescribes novel strategies, based on these observations, urging firms to adopt innovative practices. This external guidance instigates a departure from traditional approaches, ultimately facilitating a deeper understanding of the working principles underlying the recommended changes.

4.4. Limited impact on realized absorptive capacity

The interviews suggest an involvement of the intermediary in assisting with improving the transformation capabilities of the firms but a much lower involvement to support exploitation. These two capabilities form the realized absorptive capacity (Zahra & George, 2002).

4.4.1. Transformation

The interviews highlighted the intermediary's efforts in facilitating adaptation and integration of external knowledge with firms' existing knowledge. In the SCSN project, a separate foundation was established in collaboration with the main project partner, enabling various service providers to assist individual firms in implementing a common data sharing language. This approach allowed the foundation to oversee the involved ecosystem of firms in the long term, with the intermediary playing a coordinating role in the background. This can be seen as the intermediary providing access to other intermediaries for in-firm assistance, thereby facilitating digital knowledge integration.

4.4.2. Exploitation

The intermediary's impact on the final step of absorptive capacity, i.e., creating value in use by implementing external knowledge as a new innovation in the market, appeared limited. In the AgriTech project, innovation vouchers were provided to offer financial aid for developing marketable digital innovations. This support could be used for hiring experts or conducting practical experiments. However, the intermediary's involvement in long-term monitoring, as suggested in the IEBB project, did not materialize for advancing exploitation.

5. Discussion

This study contributes to current theories on innovation intermediaries by examining the multifaceted role of an innovation intermediary in facilitating absorptive capacity across all its four phases in cross-industry digital innovation. Thereby we extend theory that has been based on previous empirical studies (e.g., Abi Saad, Tremblay, & Agogué, 2024; Berends et al., 2011; Edmondson & Harvey, 2018) that predominantly were conducted within individual firms or industry branches. Our findings have identified new intermediary practices and reveal both the intermediary's effectiveness in enhancing firms' potential absorptive capacity and previously unrecognized capabilities that add depth to the existing absorptive capacity literature.

Our unit of analysis is the innovation intermediary, and its role in contributing to the absorptive capacity of firms involved in cross-industry collaboration for digital innovation. Specifically, our research focused on how the intermediary facilitates the processes and mechanisms that enhance the firms' ability to absorb, assimilate, and apply knowledge within these collaborative settings. The intermediary serves as the focal point for our analysis, examined within the context of its interactions with, and influence on, the firms. The process under investigation is knowledge adoption. In our cases, the knowledge adoption includes its exchange, assimilation, and application as they relate to the development of cross-industry digital innovations. While these processes encompass aspects of knowledge acquisition and transfer, the focus is on their integration and utilization to enable joint innovation. We apply theory on absorptive capacity to explain the facilitating role of the intermediary, as it gives a lens to understand the phases that firms go through for knowledge absorption and application. Intermediaries support firms in overcoming challenges related to knowledge absorption and application, which are crucial for successful innovation. The intermediary in our cases had societal transitions as its motivation, and absorptive capacity theory explains clearly the range of ways that it could help the sets of firms to be aware of, acquire, assimilate, transform and exploit the knowledge needed. In applying absorptive capacity, it became apparent to us that some activities of the intermediary were not adequately explained by theory.

Specifically, our findings offer the following contributions to the literature and specifically that of intermediary support in innovation processes (De Silva, Howells, & Meyer, 2018).

5.1. Expanding absorptive capacity theory with the "awareness capability"

First, our research unveils a novel component, the "awareness capability", which emphasizes the intermediary's unique role in starting the innovation process, and adds a previously unidentified phase to the theory of absorptive capacity (Cohen & Levinthal, 1990; Zahra & George, 2002). Functioning as a phase zero catalyst before client firms even consider seeking access to external knowledge, this capability involves sparking curiosity, stimulating urgency, and expertly guiding the search for external knowledge, especially in overlooked domains or those beyond traditional supply chains. Key newly identified practices in this novel phase (presented in Table 2) include introducing novel digital solutions, introducing ideas from other industries, and using digital transformation mission policies to promote industry transitions. These findings emphasize the intermediary's indispensable contribution in triggering firms' motivation to pursue such acquisition, prior to the previously identified phase of knowledge acquisition.

In one project, CESI, a digital sustainability enhancement project utilizing IoT, cloud computing, and deep learning in manufacturing, the awareness capability takes prominence due to the fast-paced developments in the digital landscape. Stakeholders require interdisciplinary comprehension of both digital intricacies and sustainable manufacturing complexities. This ensures digital solutions harmonize with manufacturing processes, a depth unnecessary for single-industry manufacturing projects.

As such, we offer the following propositions:

Proposition 1. (*Absorptive capacity hinges on the presence of an "awareness capability," a crucial phase zero facilitated by intermediaries, creating curiosity, stimulating urgency, and guiding firms in managing the complex set of opportunities brought about by emerging technologies. This awareness capability serves as a prerequisite for successfully identifying relevant knowledge for innovation.*) *Proposition 1a: For complex cross-industry digital innovation opportunities, intermediaries' awareness capability is more important than for less complex, intra-industry opportunities.*

5.2. New practices for enhancing knowledge acquisition

Second, in exploring the intermediary's role in enhancing knowledge acquisition through foresight and opportunity diagnosis, our research reveals previously undiscovered practices during the conventional phases of knowledge absorption, as shown in Table 2. These include making abstract knowledge on digitalization understandable, and building trust across industries.

We find that intermediaries facilitate access to abstract digitalization knowledge by acting as knowledge brokers, translating complex technical information into actionable insights for client firms. For example, they enhance knowledge acquisition through the translation of abstract, and quite technical, ICT specifications into concrete, practically applicable functionalities. As such, intermediaries bridge the gap between scientific and technological knowledge, networks, and resources (Rossi et al., 2022; Russo et al., 2019). Additionally, intermediaries follow up on technology-specific and industry-specific trends (Howells & Thomas, 2022; Knockaert, Spithoven, & Clarysse, 2014), ensuring that clients are aware of the latest developments and opportunities. While we found a similar practice of monitoring trends from other industries, our study emphasizes its specific focus on digitalization trends, adding a new dimension to the discourse.

Proposition 2. (*Intermediaries play a critical role in making abstract knowledge on digitalization more accessible and aligning it with the specific needs and challenges of client firms, thereby enhancing knowledge acquisition for innovation.*) *Proposition 2a: For complex cross-industry digital innovation opportunities, intermediaries' expertise in making abstract knowledge accessible and aligning it with industry-specific contexts is more important than for less complex, intra-industry opportunities.*

5.3. New practices for knowledge assimilation

Third, with regards to advancing knowledge assimilation, our research identifies three supplementary practices, as shown in Table 2 (Engage firms from various industries with digital technology experts; Providing cross-industry collaborative and experimental support; Facilitating cross-industry engagement and efficient knowledge exchange), designed to cultivate a conducive learning environment, going beyond what is found in existing literature.

Concurrently, we notice practices similar to those previously described in the literature. During knowledge assimilation, we observe that the innovation intermediary adopts several key practices to facilitate the integration of acquired knowledge into the client firms' processes and operations. This includes providing strategic resources, such as access to specialized expertise, and technology-related assets (Doloreux & Turkina, 2023; Kanda et al., 2018; Knockaert, Spithoven, & Clarysse, 2014; Polzin, von Flotow, & Klerkx, 2016), and actively engaging in knowledge translation, for example offering workshops to facilitate firms' engagement with technology transfer experts, such as in the SCSN project, to bridge the gap between external technical knowledge and internal understanding (Lichtenthaler, 2013; Polyviou, Venters, & Pouloudi, 2023). Intermediaries also promote efficient knowledge exchange and engagement across industries (Knockaert, Spithoven, & Clarysse, 2014), helping to build networks, and define the architecture of the innovation system (De Silva, Howells, & Meyer, 2018).

In light of these established practices, our research highlights the unique contribution of innovation intermediaries in new ways. These encompass providing cross-industry collaboration and experimental support, such as in the InterConnect project where a physical pilot of

smart energy solutions offered building maintenance firms the opportunity to experiment with the digital possibilities, and to work together to bring this knowledge into their existing processes and departments. This highlights how intermediaries' multifaceted networking and resource provision are instrumental in providing cross-industry collaborative and experimental support, strengthening the firms' capacity to effectively assimilate external knowledge on digitalization into their innovation activities.

Proposition 3. (*Intermediaries play an important role in providing collaborative and experimental support for client firms, thereby enhancing knowledge assimilation for innovation.*) *Proposition 3a: In the context of complex cross-industry digital innovation opportunities, intermediaries' expertise in providing collaborative and experimental support is more important than for less complex, intra-industry opportunities.*

5.4. New practices for knowledge transformation

Fourth, in relation to knowledge transformation, where the intermediary facilitates adaptation and integration, our findings add new practices as shown in Table 2 (Facilitating digital integration; Facilitating integration across industries; Building trust across industries). These practices, play an essential role in the intermediary's support for knowledge adaptation and integration. It is important to note that, although we observed these practices in two of the projects, mostly the intermediary was only marginally involved in knowledge transformation processes, if at all. The latter phases absorptive capacity involve commercially sensitive, close-to-market activities that client firms may be reluctant to open up to such external influence. Nevertheless, the practices identified in the SCSN and CESI projects may inform theory development.

To begin with, the intermediary played an essential role in advancing digital integration within client firms. This practice involves helping firms incorporate digital technologies and solutions into their existing processes and operations. While existing literature acknowledges the importance of coordinating networks, including change agents (Doloreux & Turkina, 2023; Rossi et al., 2022), and orchestrating ecosystem resources (Ng, Luo, & Park, 2022), our findings reveal that intermediaries go beyond stimulating mere technological adoption. They actively guide firms in redesigning their workflows, and business processes, to fully leverage digital innovations, such as in the SCSN project connecting digital service providers to the network. This approach ensures that the assimilated knowledge is not only integrated but also optimized for enhanced performance and competitiveness.

Next, the intermediary promoted integration across diverse industries. In the context of complex cross-industry digital innovation, client firms often need to collaborate with organizations from various industries. For example, in the CESI project, we saw how the intermediary promoted knowledge integration between non-competitors of different industries: manufacturers of salt-spreading machines and biscuit-baking machines. As such, intermediaries play a crucial role in facilitating these cross-industry partnerships by identifying potential collaborators, mediating negotiations, and aligning the interests and objectives of different stakeholders.

Lastly, the intermediary focused on building trust among diverse sectors involved in the innovation process. Trust is a critical factor in successful knowledge transformation, particularly in cross-industry settings where diverse stakeholders with varying interests collaborate. Our research identified the specific practices employed by intermediaries to foster trust, such as transparent communication, conflict resolution mechanisms, and shared risk management. In particular, by setting up the SCSN platform as a not-for-profit foundation, existing and potential participating firms could be confident in the platform's incentives and power dynamics. Such practices provide valuable insights into the dynamics of trust-building in knowledge transformation, highlighting intermediaries' role as a trust facilitator in complex innovation ecosystems.

Proposition 4. (*Intermediaries play an important role in fostering digital integration, promoting integration across industries, and building trust for client firms, thereby enhancing knowledge transformation for innovation.*) *Proposition 4a: For complex cross-industry digital innovation opportunities, intermediaries' expertise in fostering digital integration, promoting integration across industries, and building trust is more important than for less complex, intra-industry opportunities.*

5.5. New practices for knowledge exploitation

Finally, for knowledge exploitation, where the intermediary strengthens value creation and capture, our research identifies additional practices shown in Table 2 (Facilitating value creation across industries; Monitoring long term exploitation). Again, it is essential to note that in most cases, the intermediary currently does not fully engage in knowledge exploitation practices, possibly due to commercial sensitivity. This highlights the untapped opportunities for the intermediary to strengthen value creation and capture in its role as a facilitator of innovation. Future empirical research can explore the extent to which these practices improve client firms' knowledge exploitation.

Proposition 5. (*Intermediaries may play an important role in their clients' knowledge exploitation, by enhancing value creation across industries and by monitoring long-term exploitation.*) *Proposition 5a: For complex cross-industry digital innovation opportunities, intermediaries' role in enhancing value creation across sectors and monitoring long-term exploitation is more important than for less complex, intra-industry opportunities.*

6. Practical implications

This research also has practice and policy implications for supporting innovation ecosystems, particularly in cross-industry digital collaborations. Policymakers should recognize the important role of innovation intermediaries in enhancing firms' potential absorptive capacity, especially during the early phases of knowledge acquisition and assimilation. By supporting intermediaries through funding, infrastructure, or regulatory incentives, governments can enable these entities to bridge knowledge gaps, facilitate industry-specific adaptation of abstract digital concepts, and build trust among diverse stakeholders. Policies that encourage the establishment of structured experimental and collaborative platforms could further promote the transformation of acquired knowledge into actionable strategies, laying the groundwork for meaningful steps towards societal transitions. However, given the intermediary's limited impact on the exploitation phase, policymakers could consider complementary measures, such as incentivizing industry players to include intermediaries during phases of scaling and commercializing collaborative innovations.

For managers, this research shows the strategic importance of partnering with innovation intermediaries to advance their organizations' absorptive capacity, in complex settings for digital transformation. Managers can proactively engage intermediaries to gain access to tailored knowledge resources and experimental frameworks that align with their industry contexts. Additionally, firms can focus on steps to boost trust in their collaborative environments, aided by intermediaries, to enhance knowledge transformation into innovative solutions. However, given our finding that the intermediary's role is diminished in the exploitation phase, there is an argument that managers must take added steps that ensure the continuation of knowledge absorption across industry boundaries, to successfully commercialize and scale digital

innovations. This calls for long-term strategic planning that aligns intermediary contributions with firm-level exploitation efforts, ensuring sustained value creation from collaborative innovation initiatives.

7. Limitations and future research

On its own, studying a single innovation intermediary, although suitable for abductive research, is only one step in the research process towards developing and validating new theory. There is a risk in generalizing from the situation of a single innovation intermediary as its culture and strategy could be unusual. For example, this may explain why all the projects in this study supported potential more than realized absorptive capacity. Some other intermediaries may have easier access to finance at later stages of innovation projects, which may influence their impact on firms' realized absorptive capacity. Also, the one intermediary in this study can be classified as a "transition intermediary", whereby we acknowledge that our findings may not transfer directly to all other types of intermediaries (Caloffi et al., 2023). This is an important limitation and requires future research to investigate the situation at other types of intermediaries in different countries and contexts. From Caloffi et al. (2023)'s typology, the intermediary classed as "university incubators" appear furthest removed from our transition intermediary, as these incubators focus on the birth of new businesses and entrepreneurs, meaning that our findings may be of limited value in such cases. On the other hand, the types of intermediaries classed as "innovation system intermediaries" or "cluster intermediaries" also focus on facilitating the exchange of knowledge across industry boundaries, meaning that we expect our findings to apply to these intermediaries.

A second limitation relates to our complex cross-industry setting, and the application of our findings to other settings, such as simpler within-industry contexts. In cross-industry settings, knowledge acquisition involves unfamiliar sources, requiring broader search strategies and partnerships with organizations in different fields, than in single-industry settings. Our findings show that intermediaries may have a particularly valuable role in bringing highly diverse knowledge from outside firms' usual domains to their awareness, and the firms themselves may need to invest more in exploratory activities to identify and access such valuable knowledge than they would in simpler contexts. Also, in our cross-industry setting, assimilating knowledge may be more challenging due to differences in language, methodologies, and mental models across industries. Assimilation may require intermediaries to translate, interpret and align diverse knowledge to a greater extent than in single-industry contexts. Next, transformation and exploitation in cross-industry settings may require a significant reconfiguration of the firm's established routines, and may offer opportunities for disruptive innovations. These steps may demand non-trivial organizational innovation to integrate disparate insights and create novel solutions, potentially in unfamiliar markets or regulatory environments, making implementation riskier and more complex.

A third limitation, relating to the underlying notion throughout the literature on innovation intermediaries, that these organizations and the innovation projects they are involved in form a homogenous set that may be explained by a single theoretical framework, may be inaccurate. Research into a wider set of intermediaries may uncover important differences and boundary conditions, or develop a typology. For example, some intermediaries may adopt a directive stance, taking the initiative to orchestrate new innovation ecosystem, while others focus on supporting networks of firms that approach them with specific questions. There may be particular specializations, such as the various centers in the Catapult network in the UK, as opposed to more generalist intermediaries, such as TNO in the Netherlands, studied in this paper. There will also be differences in the maturity of the technologies underlying the digital innovations that intermediaries support, with significant differences between the challenges posed by mature versus emerging technologies, such as generative AI. How important such differences are in optimizing collaborative innovation projects remains an unanswered question in this literature.

Finally, there are multiple perspectives and units of analysis when studying the outcomes of the work of innovation intermediaries, and no single perspective can provide a full account of their functioning and performance. In the present study, we adopted the perspective of the intermediary organization itself, interviewing consultants and applied researchers working there, with a focus on the outcomes of the activities, so called practices of the intermediary. Another outcome could be the effects as perceived by the innovative firms involved in the digital collaborations, another is the effects as perceived by those firms' customers, and yet another is the effects on the innovation performance of the industry. More studies are required to develop a full and impactful account of the outcomes of innovation intermediaries on the development of cross-industry digital innovation.

8. Conclusion

This study explored the role of innovation intermediaries in facilitating absorptive capacity for cross-industry digital innovation. In an increasingly complex and interconnected world, cross-industry knowledge integration is crucial for successful innovation, and innovation intermediaries can effectively bridge diverse industries to overcome barriers and enhance innovation. The selected intermediary organization played a key role in societal transitions driven by emerging digital technologies, creating awareness among firms and addressing their blind spots. This awareness capability emerged as a vital, previously overlooked component of absorptive capacity.

Furthermore, we also extend the literature by uncovering previously unrecognized practices of an intermediary regarding external knowledge acquisition and assimilation, and we highlight the difficulty the intermediary had in also stimulating transformation, and exploitation.

These novel findings shed light on the crucial role of innovation intermediaries, extending current theory on innovation processes in complex, cross-industry settings. Practitioners can use the insights presented in our study to strategically engage with intermediaries, recognize their unique contributions at different stages of the innovation process, and effectively leverage their expertise to manage the complexities of innovating across industries.

During the preparation of this work the authors used ChatGPT in order to improve readability. During the use of this tool/service, the authors maintained full editorial control over the writing, and take full responsibility for the content of the publication.

CRediT authorship contribution statement

Andrea Kerstens: Writing – review & editing, Writing – original draft, Validation, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **David J. Langley:** Writing – review & editing, Writing – original draft, Supervision.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix

Appendix A. Project sample.

Project	Description	Digital technologies	Industries (NACE code)
1. AgriTech	Innovation program to automate greenhouse horticulture in the province of South Holland.	Deep learning, Robots, IoT sensors	Information & communication (J62/J63), Agriculture (A01)
2. SCSN	Supports digital collaboration in the supply chain. SCSN is a communication standard enabling the machine building industry to share data across firms' borders in an easier, safer, and more reliable way.	Open data sharing infrastructure	Information & communication (J62/J63), Manufacturing (C)
3. CESI	Bring awareness of sustainability potential in manufacturing industry with use of digital technologies	IoT, cloud computing, deep learning	Information & communication (J62/J63), Manufacturing (C)
4. InterConnect	Create a pilot to bringing efficient energy management within reach of the end-users by interoperable Solutions. Connecting Smart Homes, Buildings and Grids.	Artificial Intelligence, Blockchain, Cloud and Big Data, IoT	Construction (F), Information & communication (J62/J63), Electricity supply (D35)
5. IEBB	The Integral Energy Transition for Existing Construction consortium aims to make the energy transition in the existing construction industry feasible, affordable and scalable. One program focuses on various digital developments that are needed for the transition.	Digital twins, Robots, AI, Virtual/ Augmented/ Mixed reality	Construction (F), Information & communication (J62/J63), Electricity supply (D35), Real estate activities (L)
6. RUGGEDISED	Guide, coordinate and facilitate the implementation of various smart solutions which combine ICT, e-mobility and energy solutions, in Rotterdam, Glasgow and Umeå.	Open-data decision platform, IoT sensors, Machine learning,	Construction (F), Information & communication (J61/J62/J63), Electricity supply (D35), Passenger rail transport, interurban (H49)

Appendix B. Interviewees first and second round.

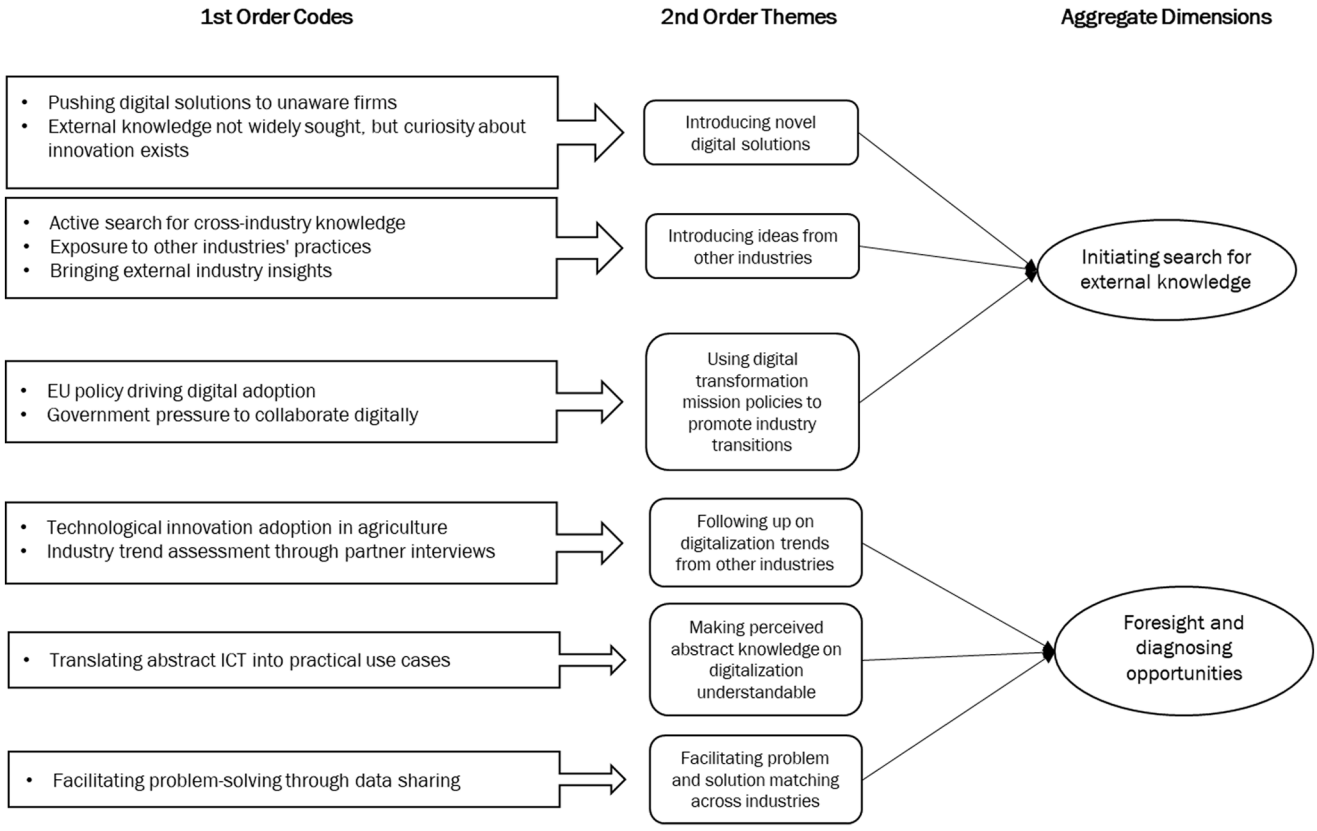
Function	Focus area	Date	Function	Focus area	Date
Senior researcher	Energy transition	2/02/2021	Senior consultant	Sustainable construction and buildings	16/02/2021
Senior researcher	Digital innovation	2/02/2021	Medior innovation orchestrator	Energy transition	24/02/2021
Senior innovation orchestrator	Circularity in industry	4/02/2021	Medior researcher	Digital innovation	25/02/2021
Medior researcher	Energy transition	8/02/2021	Medior consultant	Circularity in industry	1/03/2021
Senior researcher and consultant	Digital innovation	8/02/2021	Senior researcher	Environmental planning	2/03/2021
Medior consultant	Agrifood	11/02/2021	Medior researcher	Sustainable construction and buildings	10/03/2021
Senior consultant	Hightech industry	16/02/2021	Medior consultant	Hightech industry	10/03/2021

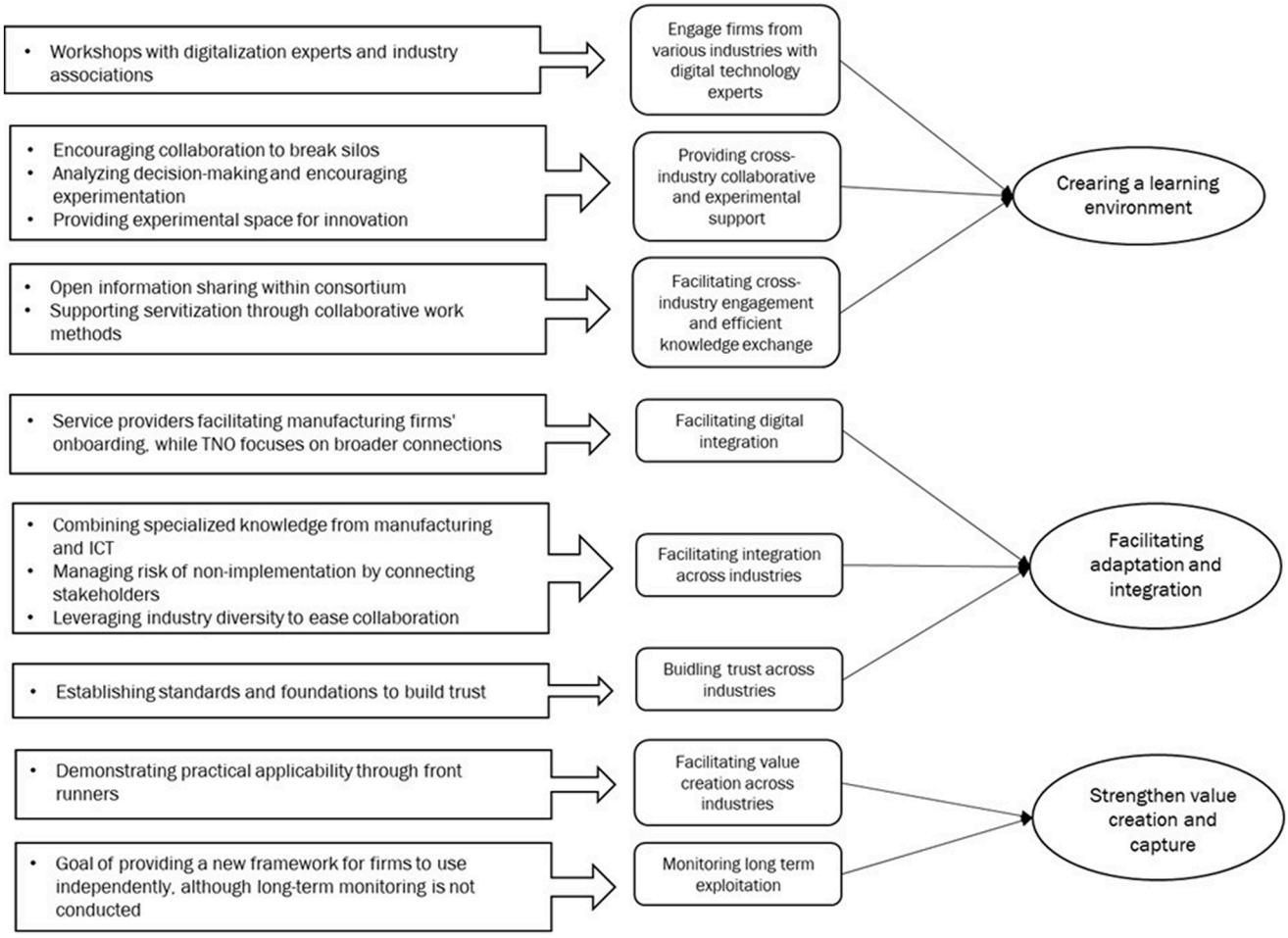
First round interviews.

Second round interviews.

	AgriTech	SCSN	CESI	InterConnect	IEBB	RUGGEDISED
Function interviewee 1	Medior consultant	Senior Researcher and consultant	Senior researcher (Project leader)	Senior researcher	Medior researcher	Senior researcher
Date interview 1	8/04/2021	1/04/2021	1/04/2021	19/03/2021	24/03/2021	4/05/2021
Duration interview 1	24 min	28 min	27 min	27 min	21 min	24 min
Function interviewee 2	Senior innovation orchestrator	Medior Consultant	Senior researcher	Senior consultant (Project leader)	Medior researcher	–
Date interview 2	29/04/2021	10/05/2021	29/04/2021	24/03/2021	29/04/2021	–
Duration interview 2	25 min	23 min	22 min	23 min	29 min	–
Additional information sources	website, program plan	webinar, website	workshop slides, study report, website	website,project proposal, booklet, 2 YouTube videos	website, project proposal, milestone report	3 research papers, website

Appendix C. Coding scheme.





Appendix D. Quotes on motivation behind the projects.

Project	Quote
AgriTech	"To stimulate the application of new technological solutions in the horticultural cluster in the province of South Holland in order to maintain and expand our position as a globally leading sustainable and innovative horticultural cluster." ***Program plan***
SCSN	"To this day, a lot of information input happens manually and exchanged over the phone, which is not very 2021 in my opinion. The aim of SCSN is therefore really that we get those companies on board in the digital age." ***Consultant***
CESI	"This project is about applying circularity and sustainability in the context of Smart Industry, the digitalization of the manufacturing industry" ***Senior researcher***
InterConnect	"The solutions developed within the scope of InterConnect will allow a digitalization of homes, buildings and electric grids based on an Internet of Things (IoT) architecture. By including digital technologies based on open standards, it will guarantee the interoperability between equipment, systems and privacy/cybersecurity of user data." ***Booklet***
IEBB	"In the Netherlands, we want to become energy neutral in the future, actually be CO_2 neutral in the built environment by 2050. We really need to work together and so what this project is truly trying to do is to gather this knowledge that is scattered across the Netherlands. It's bringing together about 20——30 more or less partners and really try to bridge the knowledge in many different parts of this transition." ***Researcher***
RUGGEDISED	"The project is about limiting CO_2 emissions. That is the main goal and ICT has actually become much more of a kind of facilitating technology for it. In the beginning there was much more emphasis on the ICT of those Smart Cities, but now it gradually has moved in the direction of climate Neutral Cities." ***Senior Researcher***

References

Abi Saad, E., Tremblay, N., & Agogué, M. (2024). A multi-level perspective on innovation intermediaries: The case of the diffusion of digital technologies in healthcare. *Technovation, 129*, Article 102899.

Agogué, M., Yström, A., & Le Masson, P. (2013). Rethinking the role of intermediaries as an architect of collective exploration and creation of knowledge in open innovation. *International Journal of Innovation Management, 17*(02), Article 1350007.

Bamberger, P. A. (2019). On the Replicability of Abductive Research in Management and Organizations: Internal Replication and Its Alternatives. *Academy of Management Discoveries, 5*(2), 103–108.

Batterink, M. H., Wubben, E. F., Klerkx, L., & Omta, S. (2010). Orchestrating innovation networks: The case of innovation brokers in the agri-food sector. *Entrepreneurship and regional development, 22*(1), 47–76.

Battistella, C., Ferraro, G., & Pessot, E. (2023). Technology transfer services impacts on open innovation capabilities of SMEs. *Technological Forecasting and Social Change, 196*, Article 122875.

Behne, A., Heinrich Beinke, J., & Teuteberg, F. (2021). A framework for cross-industry innovation: Transferring technologies between industries. *International Journal of Innovation and Technology Management, 18*(03), Article 2150011.

Berends, H., Garud, R., Debackere, K., & Weggeman, M. (2011). Thinking along: A process for tapping into knowledge across boundaries. *International Journal of Technology Management, 53*(1), 69–88.

Bessant, J., & Rush, H. (1995). Building bridges for innovation: The role of consultants in technology transfer. *Research Policy, 24*(1), 97–114.

Bleicher, J., & Stanley, H. (2016). DIGITIZATION AS A CATALYST FOR BUSINESS MODEL INNOVATION A THREE-STEP APPROACH TO FACILITATING ECONOMIC SUCCESS. *Journal of Business*. Management(12.

Brunswicker, S., & Van de Vrande, V. (2014). Exploring open innovation in small and medium-sized enterprises. *New frontiers in open innovation, 1*, 135–156.

Brynjolfsson, E., & McAfee, A. (2014). *The second machine age: Work, progress, and prosperity in a time of brilliant technologies*. WW Norton & Company.

Caloffi, A., Colovic, A., Rizzoli, V., & Rossi, F. (2023). Innovation intermediaries' types and functions: A computational analysis of the literature. *Technological Forecasting and Social Change, 189*, Article 122351.

Camisón, C., & Forés, B. (2010). Knowledge absorptive capacity: New insights for its conceptualization and measurement. *Journal of Business Research, 63*(7), 707–715.

Cannavacciuolo, L., Capaldo, G., & Rippa, P. (2015). Innovation processes in moderately innovative countries: The competencies of knowledge brokers. *International Journal of Innovation and Sustainable Development, 9*(1), 63–82.

Caputo, A., Pizzi, S., Pellegrini, M. M., & Dabić, M. (2021). Digitalization and business models: Where are we going? A science map of the field. *Journal of Business Research, 123*, 489–501.

Carmona-Lavado, A., Gimenez-Fernandez, E. M., Vlaisavljevic, V., & Cabello-Medina, C. (2023). Cross-industry innovation: A systematic literature review. *Technovation, 124*, Article 102743.

Chen, S.-H., & Lin, W.-T. (2018). Analyzing determinants for promoting emerging technology through intermediaries by using a DANP-based MCDA framework. *Technological Forecasting and Social Change, 131*, 94–110.

Chesbrough, H., & Bogers, M. (2014). Explicating open innovation: Clarifying an emerging paradigm for understanding innovation. *New Frontiers in Open Innovation. Oxford: Oxford University Press, Forthcoming*, 3-28.

Ciarli, T., Kenney, M., Massini, S., & Piscitello, L. (2021). Digital technologies, innovation, and skills: Emerging trajectories and challenges. *Research Policy, 50*(7), Article 104289.

Coad, A., Frankish, J., Roberts, R. G., & Storey, D. J. (2013). Growth paths and survival chances: An application of Gambler's Ruin theory. *Journal of business venturing, 28*(5), 615–632.

Cohen, W. M., & Levinthal, D. A. (1989). Innovation and Learning: The Two Faces of R&D. *The Economic Journal, 99*(397), 569–596.

Cohen, W. M., & Levinthal, D. A. (1990). Absorptive Capacity: A New Perspective on Learning and Innovation. *Administrative Science Quarterly, 35*(1), 128–152.

Dalziel, M. (2010). Why do innovation intermediaries exist. *DRUID Summer Conference*.

De Silva, M., Howells, J., & Meyer, M. (2018). Innovation intermediaries and collaboration: Knowledge–based practices and internal value creation. *Research Policy, 47*(1), 70–87.

Dimakopoulou, A., Gkypali, A., & Tsekouras, K. (2024). Technological and non-technological innovation synergies under the lens of absorptive capacity efficiency. *Journal of Business Research, 176*, Article 114593.

Doloreux, D., & Turkina, E. (2023). Intermediaries in regional innovation systems: An historical event-based analysis applied to AI industry in Montreal. *Technology in Society, 72*, Article 102192.

Dubois, A., & Gadde, L.-E. (2002). Systematic combining: An abductive approach to case research. *Journal of Business Research, 55*(7), 553–560.

Edmondson, A. C., & Harvey, J.-F. (2018). Cross-boundary teaming for innovation: Integrating research on teams and knowledge in organizations. *Human Resource Management Review, 28*(4), 347–360.

Enkel, E., & Gassmann, O. (2010). Creative imitation: exploring the case of cross-industry innovation. *R&D Management*, *40*(3), 256-270. x.

Erol, T., Mendi, A. F., & Doğan, D. (2020). The digital twin revolution in healthcare. 2020 4th international symposium on multidisciplinary studies and innovative technologies (ISMSIT).

Eurostat,. (). Glossary:Statistical_classification_of_economic_activities_in_the_European_Community_(NACE). Retrieved 20–04-2021 from https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Glossary:Statistical_classification_of_economic_activities_in_the_European_Community_(NACE.

Flatten, T. C., Engelen, A., Zahra, S. A., & Brettel, M. (2011). A measure of absorptive capacity: Scale development and validation. *European Management Journal, 29*(2), 98–116.

Gassmann, O. (2006). Opening up the innovation process: Towards an agenda. *R & d Management, 36*(3), 223–228.

Gassmann, O., Daiber, M., & Enkel, E. (2011). The role of intermediaries in cross-industry innovation processes. *R&D Management, 41*(5), 457–469.

Gebauer, H., Worch, H., & Truffer, B. (2012). Absorptive capacity, learning processes and combinative capabilities as determinants of strategic innovation. *European Management Journal, 30*(1), 57–73.

George, G., Merrill, R. K., & Schillebeeckx, S. J. (2021). Digital sustainability and entrepreneurship: How digital innovations are helping tackle climate change and sustainable development. *Entrepreneurship Theory and Practice, 45*(5), 999–1027.

Gioia, D. A., Corley, K. G., & Hamilton, A. L. (2012). Seeking Qualitative Rigor in Inductive Research: Notes on the Gioia Methodology. *Organizational Research Methods, 16*(1), 15–31.

Gkypali, A., Filiou, D., & Tsekouras, K. (2017). R&D collaborations: Is diversity enhancing innovation performance? *Technological Forecasting and Social Change, 118*, 143–152.

Golden-Biddle, K. (2020). Discovery as an abductive mechanism for reorienting habits within organizational change. *Academy of Management Journal, 63*(6), 1951–1975.

Grimpe, C., & Kaiser, U. (2010). Balancing Internal and External Knowledge Acquisition: The Gains and Pains from R&D Outsourcing. *Journal of Management Studies, 47*(8), 1483–1509.

Grodal, S., Anteby, M., & Holm, A. L. (2021). Achieving rigor in qualitative analysis: The role of active categorization in theory building. *Academy of Management Review, 46*(3), 591–612.

Grover, V., & Lyytinen, K. (2023). The pursuit of innovative theory in the digital age. *Journal of Information Technology, 38*(1), 45–59.

Hinings, B., Gegenhuber, T., & Greenwood, R. (2018). Digital innovation and transformation: An institutional perspective. *Information and Organization, 28*(1), 52–61.

Horváth, D., & Szabó, R. Z. (2019). Driving forces and barriers of Industry 4.0: Do multinational and small and medium-sized companies have equal opportunities? *Technological Forecasting and Social Change, 146*, 119–132.

Howells, J. (2006). Intermediation and the role of intermediaries in innovation. *Research Policy, 35*(5), 715–728.

Howells, J., & Thomas, E. (2022). Innovation search: The role of innovation intermediaries in the search process. *R&D Management, 52*(5), 992–1008.

Kanda, W., Hjelm, O., Clausen, J., & Bienkowska, D. (2018). Roles of intermediaries in supporting eco-innovation. *Journal of Cleaner Production, 205*, 1006–1016.

Kiel, D., Arnold, C., & Voigt, K.-I. (2017). The influence of the Industrial Internet of Things on business models of established manufacturing companies–A business level perspective. *Technovation, 68*, 4–19.

Kivimaa, P., Boon, W., Hyysalo, S., & Klerkx, L. (2019). Towards a typology of intermediaries in sustainability transitions: A systematic review and a research agenda. *Research Policy, 48*(4), 1062–1075.

Klerkx, L., & Leeuwis, C. (2009). Establishment and embedding of innovation brokers at different innovation system levels: Insights from the Dutch agricultural sector. *Technological Forecasting and Social Change, 76*(6), 849–860.

Knockaert, M., Spithoven, A., & Clarysse, B. (2014). The impact of technology intermediaries on firm cognitive capacity additionality. *Technological Forecasting and Social Change, 81*, 376–387.

Kokshagina, O., Le Masson, P., & Bories, F. (2017). Fast-connecting search practices: On the role of open innovation intermediary to accelerate the absorptive capacity. *Technological Forecasting and Social Change, 120*, 232–239.

Lane, D. A., & Maxfield, R. R. (2005). Ontological uncertainty and innovation. *Journal of evolutionary economics, 15*(1), 3–50.

Lasi, H., Fettke, P., Kemper, H.-G., Feld, T., & Hoffmann, M. (2014). Industry 4.0. *Business & information systems engineering, 6*(4), 239–242.

Liao, Y., & Marsillac, E. (2015). External knowledge acquisition and innovation: The role of supply chain network-oriented flexibility and organisational awareness. *International Journal of Production Research, 53*(18), 5437–5455.

Lichtenthaler, U. (2013). The collaboration of innovation intermediaries and manufacturing firms in the markets for technology. *Journal of Product Innovation Management, 30*, 142–158.

Lyng, H. B., & Brun, E. C. (2020). Innovating with strangers; managing knowledge barriers across distances in cross-industry innovation. *International Journal of Innovation and Technology Management, 17*(01), Article 2050008.

Matschoss, K., & Heiskanen, E. (2017). Making it experimental in several ways: The work of intermediaries in raising the ambition level in local climate initiatives. *Journal of Cleaner Production, 169*, 85–93.

Mittal, S., Khan, M. A., Romero, D., & Wuest, T. (2018). A critical review of smart manufacturing & Industry 4.0 maturity models: Implications for small and medium-sized enterprises (SMEs). *Journal of Manufacturing Systems, 49*, 194–214.

Nambisan, S., Wright, M., & Feldman, M. (2019). The digital transformation of innovation and entrepreneurship: Progress, challenges and key themes. *Research Policy, 48*(8), Article 103773.

Ng, H. Y., Luo, Y., & Park, H. (2022). The role of intermediaries in nurturing innovation ecosystems: A case study of Singapore's manufacturing sector. *Science and Public Policy*.

Nooteboom, B., Van Haverbeke, W., Duysters, G., Gilsing, V., & van den Oord, A. (2007). Optimal cognitive distance and absorptive capacity. *Research Policy, 36*(7), 1016–1034.

Ollila, S., & Elmquist, M. (2011). Managing Open Innovation: Exploring Challenges at the Interfaces of an Open Innovation Arena. *Creativity and Innovation Management, 20*(4), 273–283.

Oshri, I., Arkhipova, D., & Vaia, G. (2018). Exploring the effect of familiarity and advisory services on innovation outcomes in outsourcing settings. *Journal of Information Technology, 33*(3), 203–215.

Pan, S. L., & Zhang, S. (2020). From fighting COVID-19 pandemic to tackling sustainable development goals: An opportunity for responsible information systems research. *International Journal of Information Management, 55*, Article 102196.

Polyviou, A., Venters, W., & Pouloudi, N. (2023). Distant but close: Locational, relational and temporal proximity in cloud computing adoption. *Journal of Information Technology, 02683962231186161*.
Polzin, F., von Flotow, P., & Klerkx, L. (2016). Addressing barriers to eco-innovation: Exploring the finance mobilisation functions of institutional innovation intermediaries. *Technological Forecasting and Social Change, 103*, 34–46.
Radziwon, A., & Bogers, M. (2019). Open innovation in SMEs: Exploring inter-organizational relationships in an ecosystem. *Technological Forecasting and Social Change, 146*, 573–587.
Randhawa, K., Josserand, E., Schweitzer, J., & Logue, D. (2017). Knowledge collaboration between organizations and online communities: The role of open innovation intermediaries. *Journal of Knowledge Management*.
Roberts, N., Galluch, P. S., Dinger, M., & Grover, V. (2012). Absorptive capacity and information systems research: Review, synthesis, and directions for future research. *MIS Quarterly*, 625–648.
Rossi, F., Caloffi, A., Colovic, A., & Russo, M. (2022). New business models for public innovation intermediaries supporting emerging innovation systems: The case of the Internet of Things. *Technological Forecasting and Social Change, 175*, Article 121357.
Russo, M., Caloffi, A., Rossi, F., & Righi, R. (2019). Innovation intermediaries and performance-based incentives: A case study of regional innovation poles. *Science and Public Policy, 46*(1), 1–12.
Sætre, A. S., & Van de Ven, A. (2021). Generating theory by abduction. *Academy of Management Review, 46*(4), 684–701.
Spithoven, A., Clarysse, B., & Knockaert, M. (2010). Building absorptive capacity to organise inbound open innovation in traditional industries. *Technovation, 30*(2), 130–141.
Tao, F., & Qi, Q. (2019). Make more digital twins. *Nature, 573*(7775), 490–491.
Teece, D. J. (2010). Business models, business strategy and innovation. *Long range planning, 43*(2–3), 172–194.
Teece, D. J. (2018). Profiting from innovation in the digital economy: Enabling technologies, standards, and licensing models in the wireless world. *Research Policy, 47*(8), 1367–1387.
Tno. (2022). *Mission and Strategy*. Retrieved 4–3-2022 from https://www.tno.nl/en/about-tno/mission-and-strategy/.
Van Lente, H., Hekkert, M., Smits, R., & Van Waveren, B. (2003). Roles of systemic intermediaries in transition processes. *International Journal of Innovation Management, 7*(03), 247–279.
Wiener, M., Saunders, C., & Marabelli, M. (2020). Big-data business models: A critical literature review and multiperspective research framework. *Journal of Information Technology, 35*(1), 66–91.
Yin, R. K. (2018). *Case study research and applications : Design and methods* ((Sixth ed.).). SAGE.
Zahra, S. A., & George, G. (2002). Absorptive Capacity: A Review, Reconceptualization, and Extension. *Academy of Management Review, 27*(2), 185–203.

Andrea Kerstens, is a medior scientist at TNO Vector, Centre for Societal Innovation and Strategy, in The Hague, The Netherlands, specializing in collaborative business models and innovation orchestration at the intersection of digital technologies and sustainability. In addition to this position, she is a PhD candidate in innovation management at Delft University of Technology, where her research centers on innovation intermediaries in cross-sector partnerships, particularly in implementing and scaling innovations to tackle wicked problems in the built environment.

David J. Langley, is Full Professor of Digital Transformation & Strategy at the department of Innovation Management and Strategy at the University of Groningen. Working in the area of internet innovations, since 1991, he has set up and led research projects in a wide variety of industries, including telecoms, energy, banking and the public sector. His research findings and advice has been implemented by many organizations, including Achmea, Ahold, Avro, Eneco, KPN, Philips, Rabobank, Randstad, Unilever, UPC, Vodafone, and the Dutch government. His scientific research has been published in leading journals, including Organization Science, Journal of Product Innovation Management and Journal of Business Research.