# Developing the Innovation Capabilities of SMEs: The Role of Intermediary Firms in Knowledge Ecosystems

**Author(s):** Shahzad, Khuram; Hafeez, Shahid; Heimo, Teppo; Mäenpää, Antti; Mubarak, Muhammad Faraz; Evans, Richard

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# DEVELOPING THE INNOVATION CAPABILITIES OF SMES: THE ROLE OF INTERMEDIARY FIRMS IN KNOWLEDGE ECOSYSTEMS

**Khuram Shahzad**
School of Technology and Innovations, University of Vaasa, Finland
Innovation and Entrepreneurship InnoLab, University of Vaasa, Finland
khuram.shahzad@uwasa.fi

**Shahid Hafeez**
School of Technology and Innovations, University of Vaasa, Finland
Innovation and Entrepreneurship InnoLab, University of Vaasa, Finland
shahid.hafeez@uwasa.fi

**Teppo Heimo**
Innovation and Entrepreneurship InnoLab, University of Vaasa, Finland
teppo.heimo@uwasa.fi

**Antti Mäenpää**
School of Management, Regional Studies, University of Vaasa, Finland
antti.maenpaa@uwasa.fi

**Muhammad Faraz Mubarak***
Faculty of Computer Science, Dalhousie University, Halifax, NS B3H 1W5, Canada.
m.mubarak@dal.ca

**Richard Evans**
College of Digital Transformation, Faculty of Computer Science, Dalhousie University, Halifax, NS B3H 1W5, Canada.
r.evans@dal.ca



**Abstract**–Knowledge ecosystems drive growth by enabling firms to access diverse, specialized, and distributed resources from ecosystem members, allowing them to address complex product innovation challenges that would be difficult to tackle independently. This approach facilitates complementary value creation. However, small- to medium-sized enterprises (SMEs) encounter significant challenges within such ecosystems due to their limited size and limited resources. This

research contributes to the extant studies on knowledge ecosystems by investigating how collaborations within these ecosystems enable SMEs to both explore and exploit knowledge, enhancing their innovation capabilities. Drawing on empirical data from 33 semi-structured interviews and two focus groups involving multiple stakeholders (18 SMEs, 1 large firm, and 14 intermediary firms) from a knowledge ecosystem in Ostrobothnia, Finland, this study finds that knowledge co-creation through collaboration significantly improves SMEs' technological and collaborative capabilities, leading to growth and market expansion. Intermediary firms play a dual role, going beyond knowledge brokering by providing capacity-building support that helps SMEs better contextualize and utilize external knowledge. This study advances both theoretical and practical understanding by demonstrating how intermediary firms function not only as facilitators but also as active capacity builders in the knowledge exploitation process. This nuanced understanding contributes to the ongoing discourse on ecosystem dynamics and SME innovation. From a practical perspective, SMEs should leverage core partners and intermediaries to address their inherent resource constraints and drive innovation performance. This approach enables them to expand their networks, co-develop technological solutions, and potentially secure future funding.

***Index Terms***–Innovative capabilities; SMEs; knowledge ecosystems; intermediary firms; knowledge exchange.

**Managerial Relevance Statement**

This study provides important insights for managers of SMEs engaged in collaborations within knowledge ecosystems. It supports the significance of recognizing and using knowledge-based collaborative ties within such ecosystems. By categorizing collaborations into core partners and

supporting intermediary firms, SME managers can align their efforts with the distinct goals and objectives of each type of firm within the ecosystem. Understanding that internal innovations and capabilities of SMEs are influenced by the diversity and activities of actors in the ecosystem, managers can navigate these interactions to expand organizational boundaries and access wider networks and innovative ideas. Co-creation within ecosystems can lead to various advantages, including the development of technological solutions, innovation process capabilities, and opportunities for new markets and customers. Similarly, embracing the roles of intermediary firms as key facilitators and connectors within the ecosystem can further enhance SMEs' innovation capabilities. By engaging in joint projects and leveraging the resources of intermediary firms and knowledge exchange mechanisms, SMEs can address strategic innovation challenges effectively.

## 1. INTRODUCTION

Internal innovation capabilities are crucial for the competitiveness of SMEs, enabling them to adapt to changing market conditions, respond to emerging technological trends, and differentiate themselves from competitors [1]. SMEs, defined in Europe as firms with fewer than 250 employees and an annual turnover of less than 50 million euros, are often less bureaucratic and more agile in their strategy development and decision-making processes than larger firms [2]. However, they face significant barriers to developing internal innovation processes, including limited cognitive abilities and resources [3], [4], reluctance to invest in Research and Development (R&D) activities [5], and a lack of access to knowledge and innovation ecosystems. Previous research supports this notion [6], [7], emphasizing the importance of collaborating with other firms within ecosystems to drive growth and innovation [2], [3]. Consequently, knowledge ecosystems have become essential for SMEs' development of innovation capabilities [8], [9], [10], [11]. However, current literature provides limited insights into how collaborations within these

ecosystems enable SMEs to both explore and exploit knowledge, ultimately improving their innovation capabilities.

Knowledge ecosystems, comprised of users and producers of knowledge that collaborate to develop new knowledge in a pre-competitive setting and within close spatial proximity to one another [10], [11], [12] are designed to address innovation and technological challenges that may lead to knowledge exploitation and actor-specific appropriation [13]. Collaboration within knowledge ecosystems primarily involves partnerships between heterogeneous complementary actors (e.g., customers, suppliers, and competitors) and is based on sharing knowledge for core business activities [2]. These collaborations are anchored by intermediary firms, such as technology and knowledge brokers, innovation consultancies, incubators, science parks, and research institutes [14], [15]. By developing knowledge ties between complementary actors and offering knowledge-intensive services and resources, intermediary firms provide SMEs with support for their core business activities at both the organizational and system levels of innovation [16], [17]. Such ecosystems enable SMEs to co-evolve their innovation capabilities, create value through knowledge exchange with ecosystem partners, and address complex innovation challenges through a shared vision and collaborative roadmap.

Over the past decade, much research has examined the collaboration that takes place within different types of ecosystems, including platform, entrepreneurial, innovation, and knowledge ecosystems. This includes identifying the distinct sources of value creation for firms and building innovation communities [10], organizing knowledge ecosystems through prefigurative and partial forms [13], examining knowledge and business ecosystems and financial support networks [11], and understanding the capabilities required to transition from a knowledge ecosystem to a capability-based digital platform [18]. Despite this extensive research, there is limited evidence on

how SMEs enhance their innovation capabilities through knowledge exploration and exploitation within ecosystems. Specifically, literature is scarce regarding understanding how SMEs leverage geographically co-located knowledge sources, such as heterogeneous complementary actors and intermediary firms, to improve their innovation performance. In this study, knowledge exploration is defined as the process of searching for, creating, and transferring new knowledge among collaborating actors within ecosystems, while knowledge exploitation refers to the application of this jointly created knowledge to refine knowledge bases, build capabilities, and enhance firm competitiveness.

This important research gap warrants further exploration, with several researchers calling for future studies on resource mobilization in ecosystem-based collaborations [19] and the role of intermediaries in developing SMEs' innovation capabilities [20]. Consequently, this study aims to examine the collaborations within knowledge ecosystems that support SMEs in exploring and exploiting knowledge to develop their innovation capabilities. The research question addressed in this study is: *How can SMEs improve their innovative capabilities through collaboration within knowledge ecosystems?*

This paper presents an empirical study of a knowledge ecosystem in the Ostrobothnia region of Finland, highlighting the collaborative ties between SMEs and other actors within the ecosystem. Specifically, drawing on the knowledge-based view, this study contributes to the current literature on knowledge ecosystems [10], [11], [13] and innovation capabilities [21], [22], [23] by demonstrating that knowledge exploration and exploitation enable SMEs to develop their innovative capabilities. The study makes two main contributions. First, while previous studies have demonstrated that inter-organizational collaboration with external actors, such as universities [22] and government agencies [21], assists SMEs in developing their R&D and innovation capabilities

[24], [25], this study explains the synergetic effect of collaborations between heterogeneous complementary actors and intermediary firms on the development of SMEs' innovative capabilities. Second, while previous studies on knowledge ecosystems emphasize knowledge exploration [11], [13], there is a lack of empirical evidence on knowledge exploitation mechanisms. This study extends current understanding by broadening the scope of knowledge ecosystems from exploration to exploitation.

## 2. THEORETICAL BACKGROUND

### 2.1 Innovative Capabilities Development

Innovative Capability (IC) is a multidimensional concept involving the continuous transformation of knowledge and ideas into new products, processes, and systems to benefit the firm and its stakeholders [26]. Due to its close association with organizational innovation and transformation, researchers have approached the conceptualization of IC from various perspectives, considering both product and process innovation viewpoints. For example, some argue that ICs are the specific abilities of a firm to manage and create innovation over the long term [27], continuously improving exploration and exploitation capabilities to help introduce new products and services to meet market requirements [24]. Despite various conceptualizations, most researchers agree that ICs are high-order, organizational-level capabilities that are essential for driving firms' innovation [25], [28]. In this regard, Weber and Heidenreich [23] (p. 335) define ICs as "unique organizational level abilities to explore, acquire, and exploit novel knowledge to develop innovative products, services, and processes." This definition highlights the importance of firms developing advanced organizational capabilities to leverage external knowledge for innovation, in line with the knowledge-based view of organizational innovation. This perspective demonstrates the need for firms to adapt to their external environment by gathering, analyzing, and interpreting knowledge

from customers, competitors, and other value chain actors [29], [30]. These capabilities enable firms to better understand their external context, integrate newly acquired knowledge, and reconfigure their operations, enabling continuous learning [31].

Current research has highlighted that external knowledge, combined with organizational capabilities, enhances the development of IC [32]. Frishammar *et al.* [33] posited that a firm's internal and external collaboration enhances ICs pertinent to various innovations. Such collaborations can result in two kinds of knowledge: (1) internally generated knowledge, and (2) externally acquired knowledge [34]. The former is embedded in the practices, beliefs, and norms of the firm [35], while the latter is acquired by forming collaborations with different actors in the external business environment [10]. Existing research has also highlighted specific actors and the nature of SMEs' collaborations with different actors to enhance their ICs; for example, government agencies support SMEs in building their innovation-related capabilities through policy measures [21], while universities and research institutes can assist firms in R&D activities [22]. Such external collaborations and knowledge acquisition can catalyze innovation outcomes in SMEs and enhance their innovative capabilities [36]. As a result, this study, building on the knowledge-based view, suggests that SMEs' collaboration with partners within a knowledge ecosystem can complement their internal knowledge bases, which is considered critical for developing and strengthening their innovative capabilities.

## 2.2 Knowledge ecosystems and innovative capabilities development

The concept of knowledge ecosystems emerges from knowledge exchange and transfer within territorial models, such as industrial clusters, regional clusters, industrial districts, and regional innovation systems, which operate in close spatial proximity to one another [10], [11], [37], [38].

Researchers on these models argue spatial proximity is important in many aspects such as, collaborations in the same spatial proximity intensify the flow of local knowledge across firms' boundaries [37], synergizing the innovation and economic growth of regional firms [39], formation of strategic alliances that enhance employees' social interactions [40]. These social interactions further promote strong personal ties among employees, leading to trust and increased frequency of communication between heterogeneous firms [41]. A high level of trust and communication improves the efficiency and efficacy of knowledge transfer and learning. Over time, firms collaborate, enabling them to develop their organizational ability to utilize network partnerships through the provision of effective and efficient pathways for external knowledge search, intake, absorption, and application [42].

The proximity dimensions play a significant role in enhancing knowledge access and supporting inter-organizational collaborations [43], [44]. Geographical proximity, in particular, facilitates trust and cooperation among partners, while technological relatedness can determine the success of collaborations [45]. These proximity factors, including organizational and social proximity [46], influence the efficiency of knowledge flows and innovation outcomes in ecosystems. In this context, the current literature on collaborative innovation and knowledge transfer recognizes the role of territorial models in providing the conceptual dimensions (i.e., spatial proximity, social capital, tacit knowledge flow, common learning, and heterogeneity of actors) for the development of ecosystem constructs [10], [11], [47]. Despite their similarities, knowledge ecosystems and territorial models can be distinguished based on two underlying dimensions: actors' interdependencies and co-evolution [3], [47]. Actors' interdependencies refer to the dependence of ecosystem actors on complementing their internal tangible and intangible resource limitations to develop innovations, which they cannot do independently [13]. In an ecosystem, actors share a

sense of belonging and commitment to the common cause of collaborative outcome and value [46]. Resource complementarity**,** combined with geographical proximity [44], [46], fosters trust and credibility within ecosystems, which in turn increases opportunistic behavior and minimizes uncertainties in collaborations. In contrast, territorial models involve task sharing, but they do not promote the complementarities needed to create long-term interdependencies [38], [47].

Second, actors in knowledge ecosystems co-evolve their capabilities by realigning their roles, activities, and positions within collaborations. This process leads to evolving dynamics of both collaboration and competition within the knowledge networks of the ecosystem [10], [48]. Proximity dimensions, such as social and organizational proximity, are critical in facilitating the co-evolution of roles, activities, and relationships, particularly in complex environments like knowledge ecosystems [49], [50]**.** Table 1 summarizes the key dimensions of the knowledge ecosystem conceptualized in this study.

Table 1. Conceptualization of the key elements in knowledge ecosystems

| **Element** | **Conceptualization** | **Manifestation in this research** |
|---|---|---|
| Interdependencies | Each actor has an independent entity focusing on product design, quality assurance, marketing, and customer support resources. Simultaneously, the company feels collective learning and shares the same fate. [51] | The success of new knowledge exploration depends on joint activities and efforts by the ecosystem members, meaning that individual entities cannot explore such knowledge alone. |
| Spatial proximity | Spatial proximity is the geographical co-location of business entities centered around the anchor tenet actor. [11] | Close spatial proximity has been observed in the sample where all participating firms are co-located in the same region. Intermediary firms act as anchor actors. Actors are located within 20 km of the studied ecosystem. |
| Value | Value has been described as trust and a collective sense of belonging to a particular group. Actors share common values and language that enhance their feeling of belonging to a specific community. [52], [53] | Actors within the observed ecosystem have trustworthy relationships with each other due to previous collaboration experiences facilitated by close spatial proximity and the intermediary firms. A collective sense of belonging to a group prevails where each actor is jointly motivated to examine new knowledge for their internal innovations. |

| | | |
|---|---|---|
| Co-evolution | Over time, the co-evolution of capabilities, roles, and alignment structure is redirected by one or more actors in the economic community. [54] | Co-evolution in this research is conceptualized based on previous collaboration experience among the ecosystem actors (i.e., they have previously collaborated, which has evolved into ecosystem-based collaborations). |
| Stakeholders | Stakeholders include various actors, including business entities, networking among business entities, complementors, value chain actors, and governing actors. [47] | Ecosystem stakeholders consist of two layers of actors i.e., heterogeneous complementary actors' (i.e., value chain – business actors) and intermediary firms (i.e., non-business actors providing support and connection to other ecosystem members). |
| Outcome | The outcomes of ecosystem collaborations can be economic, innovation, competitiveness, and entrepreneurial development. [11], [47] | The primary outcome in the observed ecosystem relates to SMEs acquiring knowledge from collaborations and exploiting it internally to build their innovative capabilities that can lead to the generation of new business models, product innovations, expanded product portfolios, and the ability to use new technologies in their operations and processes. Intermediary firms achieve their objective of facilitating their broader role in economic and entrepreneurial growth in the region. |

Knowledge ecosystems consist of two structural layers of actors: core value chain actors and facilitating actors (e.g., intermediary firms). Core value chain actors include large firms, SMEs, customers, suppliers, and competitors. Facilitating actors, on the other hand, are categorized as intermediary firms, which include universities and research institutes, public sector firms, and other intermediaries such as technology and knowledge brokers, innovation consultancies, and incubators [14], [15]. Prior studies have highlighted the important role of intermediary firms in knowledge transfer and brokerage within territorial models [14], [55], identifying that they perform activities that orchestrate the innovation process [14], [56] and use their own capabilities to shape collaborations among ecosystem members [17]. Together, these actors execute joint knowledge search and exploration activities, facilitated by intermediary firms operating in close spatial proximity [11], [13]. Although research institutes play a critical role in the knowledge ecosystem through collaborative research programs [10], the inclusion of core value chain actors

and intermediaries in collaboration provides valuable input for new knowledge exploration [10], [13].

Previous research on proximity has also emphasized the role of social and organizational proximities as equally crucial in enabling efficient knowledge-sharing [46]. Proximity to knowledge gatekeepers, such as universities, has been highlighted as an essential factor in developing innovative collaborations [43]. In knowledge ecosystems, proximity dimensions interact to determine the effectiveness of collaborations and innovation outcomes [49].

Extant studies on knowledge ecosystems have mainly explained two sources of value creation in knowledge ecosystems: facilitating the innovation process of individual firms and creating an innovation community [10]. They also discussed the co-evolution process of these ecosystems and the role of managers in realigning the ecosystem structure. Similarly, Järvi *et al.* [13] provided empirical evidence on the organization of knowledge ecosystems, highlighting two forms of knowledge search process: prefigurative and partial. Clarysse *et al.* [11] emphasized the importance of knowledge ecosystems for local firms in sourcing new knowledge and acquiring support from non-competing actors, such as universities, which also helps SMEs in obtaining public funding for innovation. Abbate *et al.* [18] discussed the transition of knowledge ecosystems to capability-based digital platforms. The role of geographical and organizational proximity in forming effective collaborations and leveraging local knowledge sources has been a recurring theme in studies focusing on ecosystem dynamics [44], [46]. While previous studies have explored knowledge ecosystems from various perspectives, most have focused on large firms. This limitation highlights a significant research gap regarding the role of collaborations within knowledge ecosystems in improving the innovative capabilities of SMEs. As a result, this study

examines how SMEs engage in collaboration to explore and exploit knowledge, ultimately improving their innovation processes and performance.

## 3. METHODOLOGY

### 3.1 Research design

A qualitative research design was used to analyze and develop an in-depth understanding of the observed knowledge ecosystem through a multiple-case study approach [57]. This approach is considered suitable when researching a real-world case to frame a broader picture of the phenomenon under consideration [58] and to understand complex business systems [59]. Furthermore, the approach used has been successfully applied in previous studies (e.g. [10], [60], [61], [62]) where researchers have examined ecosystem-based collaborations from various viewpoints. The selected research design helps address the research questions concerning 'how' and 'why', extends current knowledge, strengthens existing theories, and further develops current understanding in our research settings. Thus, it has enabled us to analyze the parallel, interlinked, and diverse interacting actors within a knowledge ecosystem in the Ostrobothnia region of Finland and involves a combination of SMEs, large firms, and intermediary organizations, including both public and private entities. The region is also home to a well-known technology cluster where different ecosystem actors actively collaborate to develop new innovative solutions. Although this study aims to appreciate the perspectives of SMEs and intermediaries within the knowledge ecosystem, we purposely captured the other ecosystem actors, such as a large firm to explore its varying interactions with SMEs and intermediaries as well as its roles in offering business opportunities for SMEs to develop their innovative capabilities. This large firm functions as a catalyst and a hub firm in the knowledge ecosystem we study that engages with both SMEs and

intermediaries to jointly plan and execute co-creation projects, thus enabling SMEs to explore and exploit new knowledge.

A purposive sampling technique was used to achieve maximum variation [57], [63], considering two constructs: participants' roles within their firms and the industries in which the firms operate. Such a non-random sampling strategy allowed us to select objectives and qualified respondents to collect the requisite data. The study aimed to capture a strategic perspective on ecosystem collaborations, implementation phases, and operational matters by including participants from three tiers within organizational structures. Maximum variation was achieved by interviewing a variety of firms from different industries, to gain a broad understanding of collaborations within knowledge ecosystems and their implications for SMEs.

3.2 Data collection procedure

The selected ecosystem represents the *conceptual* dimension of ecosystem research design, which is one of the three dimensions (i.e., conceptual, structural, and temporal) contained in the methodological framework proposed by Phillips and Ritala (2019) to study an ecosystem. The focus of system-based inquiry in the conceptual dimension is on the *boundaries* (i.e., defining ecosystem types and scope) and the *perspectives* (i.e., addressing the perspectives of different actors and environments), which is also true in the ecosystem observed in the current research. To address conceptual aspects, two focus-group workshops were conducted with various ecosystem actors, including representatives from SMEs and intermediary firms. The first workshop was held in 2021 (lasted 1 hour and 15 minutes) and was centered on SME innovation and digitalization, aiming to evaluate participants' perceptions of innovation and digitalization from an ecosystem perspective. The second workshop was also held in 2021 (lasting 1 hour and 14 minutes). The focus of the second discussion was on the coopetition strategy of firms from an ecosystem

perspective. The discussions that emerged from the focus groups provided a foundation for understanding the topic of innovation and the capabilities of SMEs from a knowledge ecosystem perspective.

Semi-structured, anonymized, interviews were conducted based on the recommendations of Gioia *et al.* [64] and the study settings. This technique, being flexible, allows researchers to examine more deeply a phenomenon and enhance the interaction and two-way communication between the interviewee and interviewer, enabling interviewees to share contemporary and retroactive insights [65]. With help from key informants, identified participants were sent personalized emails containing an interview invitation and a brief description of the research project.

Two separate interview protocols were designed, aligning with the research objectives, to interview ecosystem actors. One protocol focused on questions related to heterogeneous complementary actors in the ecosystem to elicit information regarding interactions within the ecosystem. The other protocol centered on questions related to intermediary firms to gather information regarding their role in knowledge brokerage. The rationale for developing these two questionnaires was based on the characteristics of the sample, which included participants from various types of firms, and the diverse roles of actors within the knowledge ecosystem. All interviews were conducted and recorded online using Zoom and Microsoft Teams software; the sessions ranged from 35 to 90 minutes in length. Interviews were conducted until a saturation point was reached and no additional insights could be found [63].

3.3 Data analysis

We conducted a thematic analysis to analyze the data, as it is a well-suited approach for reorganizing, analyzing, sorting, and identifying trends in qualitative data that help in reporting

repeating or frequent patterns [66]. It explains data and interprets the procedure of selecting codes and categories in emerging themes [65]. We adopted a qualitative, iterative, and abductive approach for data analysis. To identify themes and relationships, we began by reading the full transcripts of eight interviews (i.e., two from the manufacturing sector, two from the service sector SMEs, and four from intermediary firms). It helped us to become familiar with the data and initiate open coding. Then, three members of the research team individually reviewed all transcripts to comprehensively understand the responses, and all team members discussed emerging themes in the data. In the next step, we comprehensively searched secondary data on collaborating actors' websites, LinkedIn blogs, and social media handles. Insights from secondary data were then compared with emerging themes from respondents' responses. For instance, we compared relevant phrases from secondary data with respondents' responses from primary data. Such a process enabled us to complement primary data with secondary data and reduce researcher bias during the analysis process. Through such a process, we find the specific roles and agendas of the intermediary firms, and other collaborating actors in the studied ecosystem. At this point, a semi-ignorance of existing literature was applied to reduce confirmatory biases in qualitative data, as suggested by Gioia *et al.* [64]. Through an iterative approach, we identified key themes that emerged in the data from all interviews with two different sets of actors (complementary partners and intermediary firms). Following this process, we conducted within and cross-case analysis to further derive first-order quotes, second second-order and aggregated themes. In doing so, first-order categories were derived from primary data, complemented by secondary data. Once first-order quotes were derived, the research team met again to discuss each quote line by line refined first-order codes, and added additional quotes based on the iterative feedback. As suggested by Gioia *et al.* [64], and executed by Mancuso *et al.* [67], first-order quotes were categorized into

second-order themes. Second order themes have been developed based on empirical data from respondents and reflect the literature on different capabilities of SMEs, thus this way we combine theory and practice through an abductive approach, linking ecosystem collaborations with SMEs' innovative capabilities. To further robust the findings and results of our research, we utilize NVivo 12 to identify other emerging concepts, such as contextual factors and conceptual dimensions of the ecosystem studied. Finally, we grouped second-order themes into aggregated themes. The aggregated themes were informed by the literature on innovative capabilities [25], [26], [68], and ecosystem collaborations [10], [47]. The dimensions and structure of the data are presented in Table 2.

Table 2. The coding scheme of ecosystem-based collaboration

| **First order quotes** | **Second order themes** | **Aggregated theme** | |
|---|---|---|---|
| • *"Going into ecosystem interactions helped us to (get access) wider knowledge networks"* – **PM1**<br>• *"We get valuable knowledge through these collaborations and helped us to find new partners to discuss and develop innovative ideas"* – **GM** | Awareness of collaborative networks | Collaborative capabilities development | **Development of innovative capabilities through collaborations within the knowledge ecosystem** |
| • *"Collaboration revealed other companies' strengths and skills, prompting us to engage in open innovation and co-creation with companies in related industries"*- **HBI**<br>• *"Finding the right partner was the most valuable outcome for us"* - **AE**<br>• *"The challenge has been a lack of information on networks and identifying partners for co-creation beyond our supply chain… the ecosystem engagement helped us to know more about potential partners in co-creation"* - **GM** | Learning about partner management | | |
| • *"In collaborative projects, we learn about new technologies that help us to develop digital competencies"* – **CM**<br>• *"We have used research facilities of the university for our product development; it increases our capability to see the future of 3D printing of copper"* – **MD**<br>• *There is an opportunity to be heard, for example, Finnish Energy (lobbying). They have found new technological opportunities that they couldn't have found otherwise* – **HBI** | Technological learning | Technological capabilities development | |
| • *"Our customer (large firm) brings knowledge on emerging technologies and co-creation projects with other partners are helping us to build new technological solutions"* – **MD** | Technological co-creation | | |
| • *"We collaborate with our customers and competitors; this benefited us greatly, and it added to our learning and capability to offer more services/products to our customers"* – **PM1** | Capability to capture new markets | Capabilities to develop | |

| | | | |
|---|---|---|---|
| • *"Customers bring knowledge on the international market and increased our ability to introduce new products and expand our operations to new market territories (internationalization)"* – **HBI** | | business and new markets | |
| • *"We bring companies to collaborative projects to show them new business opportunities, orientation to potential international markets, and possible modes of entry"* – **PM2**<br>• *"We provide business design services, mainly with small-sized companies. Then, if we go into more details, it's the prototyping of business design and opportunities companies can gain"* - **IM** | Business development | | |
| • "*Through collaborations, we learned about sharing the spillovers; even with competitors, we did it*" – **CEO7**<br>• "*Engaging in collaborations helped us to find partners with common interests… with competitors, we have been able to bring innovations to our products*" – **CEO4**<br>• "*We have made business proposals together with the competitors to win larger projects"* - **CEO5** | Operational capabilities | Innovation process capabilities development | |
| • "*Big benefit of collaborations is that together we grow bigger; the gained knowledge builds futuristic mindset*" – **CEO5**<br>• *"Collaborations helped us to gain knowledge and increase our capability to recognize new opportunities*" – **CEO3** | Strategic capabilities | | |
| • *"Although the new technologies are not affecting the core competence of the company, they are affecting the processes of the company"* – **PM1**<br>• *"New knowledge on new technologies, business opportunities, and customer thinking is important for us to stay competitive, so collaborations are a good way of accessing new knowledge"* – **CEO3**<br>• *"Exploring and testing new innovative ideas require a considerable amount of money and resources… this opportunity (ecosystem collaborations) helped us to exchange our ideas with like-minded companies and bring it to co-creation without thinking of the money that much"* - **CM** | Triggers and motivations for collaboration | Enablers of Ecosystem Collaboration | **Contextual factors** |
| • *"Biggest challenge was to intake companies having direct competition and does not complement their product portfolios"* **PM2**<br>• *"Our product is unique but built on new technologies and sharing technological knowledge can lead us to loss of competitive advantage"* – **HBI**<br>• *"Biggest challenge was trust, it can be an enabler too but if you don't have trustworthy relations, it is hard to collaborate on something concrete"*- **AE** | Risks and challenges in collaboration | Barriers to Ecosystem Collaborations | |

These aggregated themes represent the abstract dimensions of the analysis. Figure 1 describes how the themes and subthemes intertwine. The reliability and validity of the results were ensured through triangulation of the data [69]. The authors individually reviewed the transcription of primary and secondary data to verify the validity of information and reduce the risk of ambiguous

interpretation. This was followed by cross verifying the analysis and findings among the authors to develop a shared interpretation of the collected information. In addition, a three-step process was followed for triangulation: the results were reconciled with focus group discussions conducted on two separate occasions by the co-authors with SMEs and representatives of the intermediary firms. Secondary data from various sources (e.g., firms' websites and reports), were analyzed to supplement the interviews. Finally, the theoretical setting was refined.

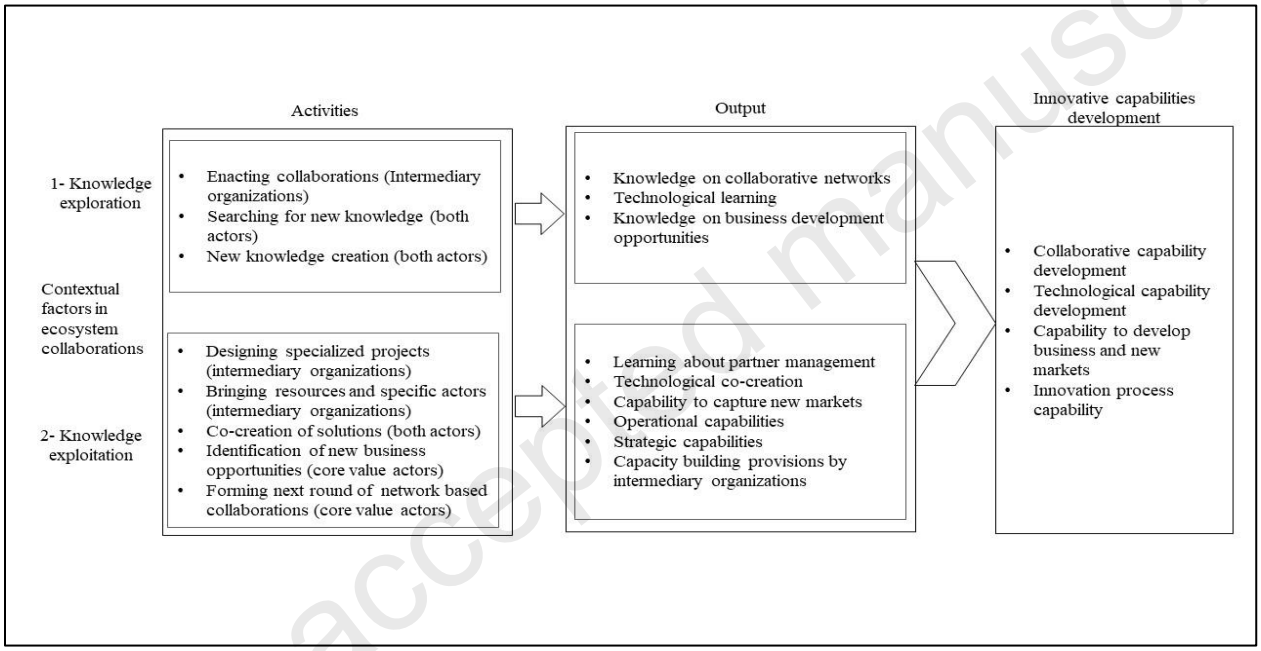


Figure 1. Knowledge exploration and exploitation for innovative capabilities of SMEs

## 4. Results

### 4.1 Profile of Respondents

Participants in this study included top-level management, middle-level managers, and operational-level employees. Selection criteria were determined based on information provided by key informants, employing multiple criteria as outlined by Yin [70], such as the characteristics of the ecosystem in which they operated, their spatial proximity to other ecosystem members, collaboration with stakeholders within the ecosystem, and active engagement in collaborative activities. In addition, the selection of participants was based on their relevant experience and

expertise related to the topic. This criterion ensured that the selected knowledge ecosystem had sufficient interactions and collaboration with ecosystem actors addressing issues related to the ICs of SMEs. The sample included SMEs, a large firm, and intermediary firms. Among the SMEs, approximately 69% operate in the services sector, and 31% are from the manufacturing sector. Please see Appendix 1a for a description of interviewees from core value chain actors, part of this study.

A total of 33 semi-structured interviews were conducted with selected interviewees (i.e., 18 SMEs, 1 large firm, and 14 intermediary firms) from May 2021 to February 2022. Please see Appendix 1b for a description of the intermediary firms included as part of this study.

4.2 Description of dimensions of knowledge ecosystem

This section presents the interactions between knowledge ecosystem actors and the conceptual dimensions of the observed ecosystem. The ecosystem comprises two structural layers of actors: (1) heterogeneous complementary actors, including SMEs, their suppliers, customers, competitors, and firms from other industries, and (2) anchor actors, represented by intermediary firms that serve as facilitators and collaborators. Intermediary firms were identified as keystone actors, facilitating knowledge exchange, innovation processes, and capacity builders in the studied knowledge ecosystem. The collaboration between heterogeneous complementary actors was important for executing the collaborative projects and achieving set outcomes.

From the spatial proximity perspective, all ecosystem actors were located within close spatial proximity to one another (within 25 km), enabling strong social ties to be formed among heterogeneous complementary actors and making intermediary organizations keystone actors in collaborations. Despite already having interdependencies in their traditional supply chains, most heterogeneous complementary actors collaborated at the inter-organizational level, extending their

collaborations beyond their traditional supply chain actors to include technology providers, competitors, and firms from other industries. This cross-industry interaction enabled firms to leverage the skills, resources, and competencies of collaborating firms, enhancing specific knowledge, resources, and experiences for new knowledge creation and reinforcing interdependencies among ecosystem actors. In-depth analysis shows that competitors bring complementary skills and resources to collaborations, while suppliers and peer SMEs have a significant role in the development of mutually beneficial technologies, and customer-supported collaborations by providing important insights for new ideas in product development; pushing for new solutions and process efficiency; and act as a strategic partner for long run projects.

We identified three distinct roles of intermediary firms, i.e., *knowledge brokers*, *innovation facilitators*, and *capacity builders* to enact ecosystem collaborations. In their *knowledge brokerage role*, intermediary firms utilized their expertise to identify and connect diverse knowledge sources to facilitate the exchange of innovative ideas and help them find partners with complementary skills. Such a role is played by organizing matchmaking and awareness events, e.g., workshops, seminars, delegation meetings, company visits, and exchange of expertise. They also act as neutral actors and enable trust-building among competitors (coopetition). Trust-building initiatives in coopetition include evaluating the skills and competencies of competitors, facilitating social interaction among top management, providing co-working space, and enhancing openness and transparency in communication.

Similarly, we found that sample intermediary firms acted as *innovation facilitators* as they were involved in designing, executing, and implementing collaborative research and industry projects to enhance ecosystem actors' organizational level capabilities and enhance their offerings. These firms were involved in leading and facilitating a variety of projects, such as projects related

to mapping innovation competencies of SMEs, enhancing SMEs' learning on emerging technologies implementation and utilization, and helping SMEs in developing innovative products and services. They also facilitated projects that aimed to support SMEs in finding new markets and customers, developing collaborative platforms for manufacturing sector SMEs, and testing innovative ideas and new technologies through technology labs.

The empirical evidence indicates that intermediary firms also played the role of *capacity builders* by providing capacity-building provisions. This rather new role is defined by carefully examining the broader agenda, activities, and roles performed by intermediary firms on operational and strategic levels within the studied ecosystem. Such a role was enacted by developing specialized training programs and mobilizing resources to overcome previously identified competencies and skills gaps among collaborating SMEs. They also redesign collaborative projects to support the application of newly generated knowledge into organizational and ecosystem-level solutions. In doing so, intermediary firms actively support the entire project lifecycle, ensuring the successful absorption of collaboration output and effective use of public funds. The capacity-building role of intermediary firms also had important implications for redefining roles, responsibilities, and re-alignment of structural dependencies among ecosystem actors, leading ecosystem actors to co-evolve over time. Table 3 explains the utilization of the conceptual dimensions of the knowledge ecosystem in current research.

Table 3. Empirics on conceptual dimensions of studied knowledge ecosystem

| Ecosystem dimension | Empirics |
|---|---|
| Inter-dependencies | "We collaborated with an open mind to learn about new technologies. Recognizing the potential of our partners, we invested our resources and are now about to launch new services that would have been difficult to develop alone"- **GM**<br>"Improving digitalization capabilities required us to collaborate with competitors and complement resources in co-creation. The goal was precise, and we got partners committed to the common cause. We formed relations to work on an open innovation base concept technology development"**- PM1** |

| | |
|---|---|
| Co-evolution | "We, as an intermediary, learned from our previous experience on facilitation. Based on learning, we decided to go for the ecosystem approach and engage other intermediaries to get financial and strategic support for collaborations; in this way, we can engage companies in utilizing the project outcome rather than just creating the project and not following the outcome utilization" – P**M2**<br><br>"In the initial phases, we were more focused on knowledge search, but over time, we realized the potential of and skills of our partners who can help us utilize the created knowledge. Within the collaboration, we formed a new project to see possibilities of utilizing this knowledge in the development of a collaborative platform for manufacturing companies… this also created space for new entrants" – **MD** |
| Spatial proximity | "The physical distance is still a challenge if we want to collaborate with international companies in our industry…Then we look for companies and collaborations in the local context for knowledge and information sharing because knowledge is key in our industry" - **PM1**<br><br>Although initial trust is there because most of us (collaborators) know each other already. But proper confidence was built by mixing teams between partner companies and doing things together at co-located spaces – **AE** |
| Strong social ties | "The personal chemistry and reputation of entrepreneur matters a lot especially when most of the companies in the same industry knows each other well" – **CEO7**<br><br>"Contractual approach is good for IPR protection, but what matters most is the skills of collaborator and their reputation. Since most of the collaborating companies came together either known by the university or through another company reference" – **HBD** |
| Outcomes | "The main goal is to develop a shared platform for production and product development companies. For the same reason, we complement each other with skills, expertise, knowledge, and resources" – **MD**<br><br>"Digital technologies are changing competitive advantage in our industry and bring many opportunities. For us, going into collaborations is the best way to gain knowledge and know-how on using new technologies for business opportunities" – **HB)** |
| Stakeholders | The presence of intermediary organizations and heterogeneous complementary actors, including SMEs, their customers, suppliers, and competitors - **(Appendix 1a & 1b)** |

4.3 Ecosystem collaboration and innovative capabilities development

The study's empirical analysis shows that collaboration within the observed knowledge ecosystem significantly benefits all participating actors, underscoring the critical role of collaboration in supporting SMEs' development of innovative capabilities. These collaborations enable SMEs to acquire new knowledge and provide resources and opportunities to integrate externally acquired knowledge into their organizational offerings. However, most SMEs lack the resources to absorb innovative ideas fully and face traditional innovation challenges.

4.2.1 Developing Collaborative Capabilities

The results show that collaboration within ecosystems supports SMEs in raising their awareness of knowledge and innovation networks in the early phase. In this context, intermediary firms play a significant role in identifying and making connections between actors, forming collaborations by utilizing their expertise and skills to match-make different actors and help them find common ground for collaboration activities. Match-making and partner selection were facilitated by intermediary firms through workshops, seminars, and knowledge search projects, enhancing interactions between actors and fostering shared understanding. Intermediary firms increased SME awareness of broader knowledge and innovation networks with SME representatives emphasizing the value of these interactions for finding business opportunities and engaging in open innovation-based collaborations. As mentioned by the respondent:

*"These collaborations open our mind for the importance of open innovation and co-creation. We feel open innovation and co-creation bring value to our company, and they are also important for the future competitive advantage of the company"* – **(GM)**

While raising awareness of knowledge and innovation networks was seen as a stepping-stone, it was complemented by the SMEs learning about how to manage partner relationships to build collaborative capabilities. In this regard, the purposefully designed projects provided SMEs with an opportunity to explore co-creation opportunities with heterogeneous complementary actors, aiming to collaborate on the development of solutions. Empirical evidence suggests that such a process strengthened SMEs' ability to identify, evaluate, and prioritize those partners most suitable for developing long-term and effective collaborations. In the respondent's words:

*"When it comes to developing solutions together, we started a specialized project that promotes co-learning by doing things together (at the same place)* - **(PM3)**

*"Knowing your partners in collaborations is vital, especially knowing their skills, commitment, and quality of collaboration (performance against promised targets) matters a lot. When you*

*collaborate reputedly and work closely in teams, it helps you in forming future collaborations also"* – **(CEO4)**

4.2.2 Developing technological capabilities

All SMEs expressed interest in learning about emerging technologies to enhance their business operations. They believed that superior knowledge of these technologies could give them a competitive edge by improving efficiency, creating new business opportunities, and enhancing customer experiences. However, as one respondent explained, they lack knowledge of technology implementation and utilization, and have concerns about the cost-benefit ratio implementation:

*"The challenges about technologies are strategic challenges, for example biggest one is, what is the cost-benefit of new technology utilization?"* – **(GM)**

*"Digitalization is like a horrible jungle. We need a lot of knowledge before starting to implement technologies"* – **(PM3)**

Collaboration within knowledge ecosystems was observed to support SMEs in developing their technological capabilities through technological knowledge search and co-creation. This process enabled SMEs to interact with technology providers and solution developers, learning how to utilize emerging technologies in various processes. Empirical data also showed that, beyond technological knowledge exchange, core value actors co-developed technological solutions in a variety of projects, thereby enhancing SMEs' technological capabilities. Technological knowledge sharing included the sharing of case studies and best practices with university research experts. This form of co-creation enabled SMEs to develop customized solutions for digitalization challenges. During the knowledge search, actors shared experiences, challenges, and benefits of technology use, while technology providers highlighted trends and applications across industries. Initially, firms exchanged knowledge on platform development, forming their concepts of

technology implementation. In the next phase, they collaborated intensively to develop these platforms, indirectly improving their technological capabilities. As one respondent stated:

*"The co-creation is a cost-effective way to use technologies. Using this (co-creation) approach, our company has been able to learn and exchange information on the implementation process of 3D Manufacturing in our manufacturing systems… it has helped us greatly to integrate new technology in our system and build digital related competencies"* – **(MD)**

4.2.3 Developing capabilities to create new business models and markets

Further analysis demonstrated that co-creation processes enhanced SMEs' business models and facilitated new market development capabilities. Collaborating in co-creation projects with ecosystem partners improved SMEs' learning in product development, as diverse industry actors contributed their knowledge and market expertise. This collaboration encouraged SMEs to broaden their perspective on market trends, expand their customer bases, and identify new opportunities beyond their existing offerings. As one respondent highlighted:

*"Going into collaborations benefited us in two ways; one, it helped us learn to look for different options in the market and develop new solutions. Second, we also got to know the different perspectives and increase our abilities to improve the (existing) products"* – **(PM1)**

Intermediary firms were found to support SMEs' market development capabilities by offering design and prototyping services. These services help SMEs understand the benefits, challenges, opportunities, and risks of developing new products. Intermediaries also provided platforms and orchestrated projects to enhance interactions and knowledge sharing between international firms and local SMEs, aiding in finding strategic fits and suitable modes of internationalization. An intermediary representative noted:

*"We bring these SMEs to match-making events to find potential partners, arrange seminars to raise awareness on their international business development, and engage with them to see their products and to evaluate their internationalization potential"* – **(CEO10)**

4.2.4 Developing Innovation Process Capabilities

Despite a focus on focal value, complementary actors in the knowledge ecosystem formed network-based partnerships to secure business opportunities. Empirical evidence indicated that SMEs use their collaborative capabilities to identify and choose partners for business value appropriation with interviewees noting that combined knowledge search and co-creation processes strengthen their relationships with competitors and complementors, allowing for further exploration and collaboration. For example, two manufacturing firms, who initially lacked resources for expansion, collaborated through ecosystem interactions to develop joint business proposals and execute larger projects. Similarly, a network of firms shared knowledge spillovers, while another project saw SMEs, competitors, and customers working together to develop new products using digital technologies. This collaboration integrated diverse skill sets, enhancing knowledge sharing and technological integration.

*"The customer perspective is most important for us; sometimes, we get bigger orders and don't get enough time to produce the solution. There comes collaboration when we look to our partners (including competitors) who might also have a solution ready for the customers. We collaborate to deliver the solution to the customer on time. Of course, it's a two-way process…… this has increased our operational capability to take large orders. We can say that collaboration brings good opportunities for us"* – **(CEO3)**

*"Ecosystem participation helped us streamline our business and opened new business gates for us…. It has improved our expertise and knowledge to look and identify new business opportunities and clarify what is possible or not"* – **(GM)**

*"Through these collaborations (ecosystem), we learned a lot of benefits and problems in collaborations… (due to this learning) we are moving forward to develop a common platform for production and product development to ensure that the cooperation between our company and the outsourced product development and production company works seamlessly"* – **(HBD)**

In addition, all SMEs highlighted the significance of collaborations in enhancing their strategic vision. They noted that such collaborations increase their capacity to review industry trends,

identify future challenges, and take advantage of business opportunities in their external environment. By engaging with a broader array of actors, SMEs can shift their focus from daily operations to recognizing new opportunities and fostering a growth-oriented mindset. This approach helps build strategic capabilities. The respondents explained this as follows:

*"Ecosystem participation helped us streamline our business and opened new business gates for us…. Basically, it has improved our expertise and knowledge to look and identify new business opportunities and clarify what is possible or not"* – **(GM)**

4.2.5 Contextual factors affecting ecosystem collaborations

The study's empirical analysis uncovered several important triggers and barriers to collaboration within knowledge ecosystems. SMEs primarily sought technological knowledge for implementing emerging technologies, tested innovative ideas, or sought partners for co-creation activities. The challenges in collaborating in ecosystems included aligning goals between partners, integrating competitors due to risks of knowledge leakage and Intellectual Property Rights (IPR) issues. Although challenges were identified, the intermediary firms addressed these through match-making events, workshops, and contractual approaches to protect IPRs.

*"Co-creation and collaborations always bring opportunities for our company. These collaborations also help us to understand emerging technologies which are important for our company's competitive advantage"* – **(HBD)**

*"The major challenges (in coopetition) include setting the benchmark to participate and protecting strategic knowledge from the competitors"* – **(CEO1)**

## 5. DISCUSSION

This study examined collaborations within knowledge ecosystems from the perspective of SME-specific appropriation, addressing current calls for future studies on developing SMEs' innovative capabilities [2], [9], [20]. Specifically, the study addressed the important research question of how SMEs enhance their innovative capabilities through ecosystem collaborations. The results show

that such collaborations help SMEs overcome innovation challenges by engaging in a knowledge search process followed by co-creation projects to exploit the acquired knowledge. This research advances the current understanding of knowledge ecosystem collaborations and their critical role in developing SMEs' innovative capabilities.

Existing research emphasizes the importance of establishing strong social ties in supply chains and knowledge-sharing partnerships [71]. Collaboration within knowledge ecosystems enables SMEs to develop collaborative capabilities that are critical for identifying and selecting partners beyond their value chain networks. Intermediary firms serve as anchor tenants, providing support by raising SME awareness of innovation and knowledge networks [14], [72]. This matchmaking role is important for less experienced SMEs seeking external collaboration. Partnerships with diverse core value chain actors improve SMEs' abilities to identify, evaluate, and select relevant partners while reducing risks associated with knowledge exchange, such as IP leakage. Furthermore, co-creating solutions allows SMEs to learn about the strengths and skills of their ecosystem partners, embedding these insights into their organizational memory. Consequently, SMEs in knowledge ecosystems are better equipped to develop collaborative capabilities and effectively identify partners for knowledge networks.

Most SMEs struggle with technology adoption and innovation [73]. This study shows that collaboration within knowledge ecosystems can enhance SMEs' technological capabilities for implementing and using technology. Such development relies on technological learning and co-creation through structured ecosystem interactions. While existing research emphasizes learning with non-business actors [73], [74], this study demonstrates that co-creating with diverse complementary actors effectively leverages technological learning, particularly in resource-scarce

and uncertain business environments. Consequently, these technological capabilities enable SMEs to scan, contextualize, and integrate new technological opportunities into their operations.

Ecosystem collaborations help SMEs create business models and market capabilities, while extensive co-creation activities improve intermediary firms' understanding of these models, allowing them to evaluate and strengthen SMEs' product portfolios for international markets. This finding aligns with previous research that shows that diverse collaborations improve firms' marketing capabilities and customer bases internationally [75]. In addition, these collaborations help establish trust among partners, enabling competitors to explore shared business opportunities. This highlights that collaboration within knowledge ecosystems can lead to network-based partnerships for value exploitation [10] and contributes to current discussions on knowledge generation and exploitation within ecosystems [10], [11], [13]. Furthermore, specialized networks within ecosystems are seen to enhance SMEs' project portfolios and customer bases through coopetition and spillover sharing. Effective use of knowledge flows in collaborations allows SMEs to develop a strategic vision beyond traditional supply chain issues [76]. Thus, knowledge ecosystem collaborations promote value co-creation and appropriation, enhancing SMEs' innovative process capabilities.

Finally, the results show that intermediary firms play a critical role in helping SMEs exploit identified opportunities through capacity-building activities. Specifically, they can transition from knowledge brokers to enablers, developing specialized co-creation activities that improve SMEs' ability to integrate generated knowledge into practical solutions. These efforts develop SMEs' skills in understanding, contextualizing, and utilizing external knowledge. While intermediary firms provide important capacity-building services, collaborations with complementary actors are also considered critical for opportunity exploitation. Intermediary firms, as non-business actors,

support economic development and innovation, whereas business actors focus on enhancing their market competitiveness through innovation and operational efficiency. Figure 2 presents the study's empirically driven research framework illustrating how knowledge is explored and exploited within knowledge ecosystems to develop SMEs' innovation capabilities.

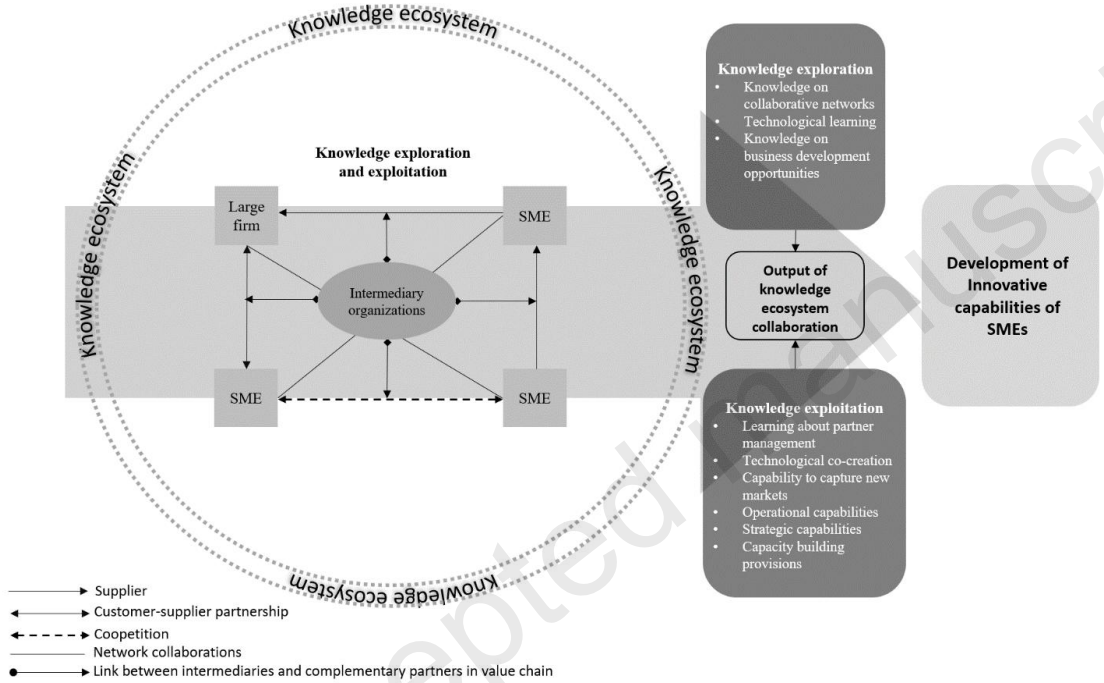


Figure 2. Knowledge ecosystem collaborations and the innovative capabilities of SMEs

## 6. CONCLUSIONS

This study aimed to examine the collaborations within knowledge ecosystems that support SMEs in exploring and exploiting knowledge to enhance their innovative capabilities. Empirical data was collected through 33 semi-structured interviews and two focus groups with multiple stakeholders (18 SMEs, 1 large firm, and 14 intermediary firms) from a knowledge ecosystem in the Ostrobothnia region of Finland. The study made several significant theoretical contributions and provided critical managerial implications, as detailed in the following sections.

### 6.1 Theoretical contributions

This study contributed to the current knowledge ecosystem [10], [11], [12], [13] and innovative capabilities literature [21], [22], [23], [24], [25] by explaining how collaborations within

knowledge ecosystems enhance SMEs' innovative capabilities. It demonstrated that capability development results from combining knowledge exploration and exploitation within knowledge ecosystems. The novelty of this lies in identifying the synergetic effects of collaborations between heterogeneous complementary actors and intermediary firms, outlining each collaboration phase's contribution to SMEs' innovative capabilities. Compared to non-ecosystem collaborations, ecosystem collaborations develop various innovative capabilities, including collaborative, technological, business creation, and innovation process capabilities. Aligned with the knowledge-based view [29], [30], the study's findings prove that successful exploration and exploitation of external knowledge improves firms' innovative capabilities. Specifically, SMEs jointly explore and co-create new knowledge to improve their ability to understand, contextualize, and utilize it for the development of innovative solutions. This process increases their collaborative, technological, and market development capabilities, while innovation process capabilities are developed through network-based collaborations to exploit future business opportunities.

Within knowledge ecosystems, actors' roles co-evolve throughout the collaboration process. While previous studies have highlighted keystone actors (i.e., intermediary firms) as knowledge brokers and facilitators [10], [12], [14], this study identifies their new extended role as 'enablers of capacity building provisions.' In this role, intermediaries design and execute specialized activities to build the capacities of diverse actors to exploit explored knowledge. This extended role is critical for the knowledge ecosystem's functioning and value creation for two reasons. First, it enhances actors' capabilities through co-creation projects addressing specific challenges and, second, it broadens the ecosystem's scope from knowledge creation to knowledge utilization, ensuring successful absorption of collaboration outcomes and effective resource use. This research also contributes to the current discourse on the scope of knowledge ecosystems, emphasizing that

they can be purposefully built and facilitated to exploit knowledge and solve actor-specific problems. Ecosystem partners co-evolve their roles and capabilities during collaboration, with keystone actors minimizing the gap between knowledge and business ecosystems. Despite technological advancements allowing for remote communication, spatial proximity remains crucial as most SMEs benefit from in-person and, more specifically, experiential learning [11], [46].

In summary, our study makes significant contributions to both practice and the engineering management literature by addressing a critical research gap concerning the role of knowledge ecosystems in fostering SMEs' innovation capabilities. Practically, it highlights how collaborative interactions within ecosystems enable SMEs to overcome resource constraints and enhance their innovation capabilities through knowledge exploration and exploitation. By demonstrating the synergetic effects of collaborations between heterogeneous actors, such as SMEs, large firms, and intermediary organizations, the study provides actionable insights for SMEs to engage effectively in co-creation processes, access broader knowledge networks, and integrate external knowledge into their innovation strategies. These findings are particularly relevant for managers seeking to navigate complex ecosystem collaborations.

In terms of contributions to engineering management literature, the study extends prior research by [78], [79], [80], and [81] on knowledge-based collaborations and technological innovation. It advances the understanding of knowledge ecosystems by emphasizing not only the role of exploration but also the often-overlooked mechanisms of knowledge exploitation. By broadening the scope of existing studies, this research provides an integrative framework linking knowledge ecosystem collaborations with the development of innovation capabilities, offering a valuable theoretical and empirical contribution to the field of engineering management.

## 6.2 Managerial implications

This study offers several important implications for managers of SMEs with results serving as guiding principles for managers engaged in various types of ecosystem collaborations. SMEs must recognize the importance of knowledge-based collaborative ties within an ecosystem. They can categorize such collaborations into core partners and supporting intermediary firms, as these two types of firms have distinct goals and objectives within the knowledge ecosystem. Since SMEs' internal innovations and capabilities are determined by the number of heterogeneous complementary actors, their diversity, and their activities within an ecosystem, such layered and coordinated network interactions are only considered rules of thumb to help them expand their organizational boundaries toward the bigger picture, i.e., the knowledge ecosystem, and access to wider networks and innovative ideas. Co-creation within an ecosystem can support SMEs in securing multiple benefits, such as developing their technological solutions and innovation processing capabilities, knowledge repositories of actors, processes, and funding opportunities, and capturing new markets and customers. Consequently, SMEs can realize the necessary tangible and intangible resources for their quest for innovation and prepare themselves to address the challenges of being small while enhancing their significance in an ecosystem.

In addition, intermediary firms play a crucial role in supporting and connecting SMEs with relevant actors in the ecosystem. They extend their traditional roles by mobilizing resources and ensuring effective knowledge exchange to develop capacity-building provisions for knowledge exploitation. SMEs benefit from these extended roles by joining networks through joint activities, exploring and exploiting new knowledge to develop innovative solutions. This enables SMEs to identify available support functions, addressing both operational and strategic challenges.

6.3 Limitations and Future Research

Interpretation of the study's results must be considered within certain limitations that provide avenues for future research. The empirical setting of this study focused on SMEs within the knowledge ecosystem, which potentially differs from ecosystems where research institutions play a more dominant role. Consequently, future research could examine the orchestrating roles of universities and research institutes in managing ecosystems, particularly in their engagement with SMEs. Conducted within a regional knowledge ecosystem, this study's findings may not be fully generalizable to other types of ecosystems, such as innovation, business, and entrepreneurial ecosystems, limiting their external validity. Therefore, researchers are encouraged to validate the results of this study in other types of regional knowledge ecosystems. In addition, as this exploratory analysis included both manufacturing and service SMEs, future studies could examine these sectors separately to compare their characteristics and activities from an open innovation perspective, providing a more thorough understanding of how different types of SME engage in such collaborations. Investigating the diverse roles of large firms within a knowledge ecosystem, especially given SMEs' traditional role as suppliers, would also be intriguing. Similarly, exploring how innovation intermediaries influence interdependent actors, in terms of transaction costs and resource complementarity, could provide important insights for SME managers. Lastly, adopting a quantitative approach to examine various levels of analysis offers an interesting avenue for future research, enabling scholars to assess the impact of interactions at different scales.

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## References

[1] L. Turulja and N. Bajgoric, "Innovation, firms' performance and environmental turbulence: is there a moderator or mediator?," *Eur. J. Innov. Manag.*, vol. 22, no. 1, pp. 213–232, Jun. 2018, doi: 10.1108/EJIM-03-2018-0064.

[2] L. Mei, T. Zhang, and J. Chen, "Exploring the effects of inter-firm linkages on SMEs' open innovation from an ecosystem perspective: An empirical study of Chinese manufacturing SMEs," *Technol. Forecast. Soc. Change*, vol. 144, pp. 118–128, Jul. 2019, doi: 10.1016/j.techfore.2019.04.010.

[3] A. Radziwon and M. Bogers, "Open innovation in SMEs: Exploring inter-organizational relationships in an ecosystem," *Technol. Forecast. Soc. Change*, vol. 146, pp. 573–587, Sep. 2019, doi: 10.1016/j.techfore.2018.04.021.

[4] N. Zahoor and O. Al-Tabbaa, "Inter-organizational collaboration and SMEs' innovation: A systematic review and future research directions," *Scand. J. Manag.*, vol. 36, no. 2, p. 101109, Jun. 2020, doi: 10.1016/j.scaman.2020.101109.

[5] I. Deschamps, M. G. Macedo, and C. Eve-Levesque, "University-SME collaboration and open innovation: Intellectual-property management tools and the roles of intermediaries," *Technol. Innov. Manag. Rev.*, vol. 2013, no. 3, Art. no. 3, 2013, doi: 10.22215/timreview/668.

[6] G. Acheampong and R. E. Hinson, "Benefitting from alter resources: network diffusion and SME survival," *J. Small Bus. Entrep.*, vol. 31, no. 2, pp. 141–158, Mar. 2019, doi: 10.1080/08276331.2018.1462620.

[7] G. Corral de Zubielqui, N. Lindsay, W. Lindsay, and J. Jones, "Knowledge quality, innovation and firm performance: a study of knowledge transfer in SMEs," *Small Bus. Econ.*, vol. 53, no. 1, pp. 145–164, Jun. 2019, doi: 10.1007/s11187-018-0046-0.

[8] D. Cobben, W. Ooms, N. Roijakkers, and A. Radziwon, "Ecosystem types: A systematic review on boundaries and goals," *J. Bus. Res.*, vol. 142, pp. 138–164, Mar. 2022, doi: 10.1016/j.jbusres.2021.12.046.

[9] K. Shahzad and J. Takala, "Understanding the Impact of Entrepreneurial Ecosystem Interactions on Innovative Capabilities: Toward a Conceptual Framework," in *Trust and Digital Business*, Routledge, 2022.

[10] M. van der Borgh, M. Cloodt, and A. G. L. Romme, "Value creation by knowledge-based ecosystems: evidence from a field study," *RD Manag.*, vol. 42, no. 2, pp. 150–169, 2012, doi: 10.1111/j.1467-9310.2011.00673.x.

[11] B. Clarysse, M. Wright, J. Bruneel, and A. Mahajan, "Creating value in ecosystems: Crossing the chasm between knowledge and business ecosystems," *Res. Policy*, vol. 43, no. 7, pp. 1164–1176, Sep. 2014, doi: 10.1016/j.respol.2014.04.014.

[12] K. Valkokari, "Business, innovation, and knowledge ecosystems: How they differ and how to survive and thrive within them," *Technol. Innov. Manag. Rev.*, vol. 5, no. 8, 2015.

[13] K. Järvi, A. Almpanopoulou, and P. Ritala, "Organization of knowledge ecosystems: Prefigurative and partial forms," *Res. Policy*, vol. 47, no. 8, pp. 1523–1537, Oct. 2018, doi: 10.1016/j.respol.2018.05.007.

[14] J. Howells, “Intermediation and the role of intermediaries in innovation,” *Res. Policy*, vol. 35, no. 5, pp. 715–728, Jun. 2006, doi: 10.1016/j.respol.2006.03.005.
[15] P. Kivimaa, W. Boon, S. Hyysalo, and L. Klerkx, “Towards a typology of intermediaries in sustainability transitions: A systematic review and a research agenda,” *Res. Policy*, vol. 48, no. 4, pp. 1062–1075, May 2019, doi: 10.1016/j.respol.2018.10.006.
[16] G. Reischauer, W. H. Güttel, and E. Schüssler, “Aligning the design of intermediary organisations with the ecosystem,” *Ind. Innov.*, vol. 28, no. 5, pp. 594–619, May 2021, doi: 10.1080/13662716.2021.1879737.
[17] K. Randhawa, R. Wilden, and M. A. Akaka, “Innovation intermediaries as collaborators in shaping service ecosystems: The importance of dynamic capabilities,” *Ind. Mark. Manag.*, vol. 103, pp. 183–197, May 2022, doi: 10.1016/j.indmarman.2022.03.016.
[18] T. Abbate, F. Cesaroni, and A. Presenza, “Knowledge transfer from universities to low- and medium-technology industries: evidence from Italian winemakers,” *J. Technol. Transf.*, vol. 46, no. 4, pp. 989–1016, 2021.
[19] R. Hernández-Chea, M. Mahdad, T. T. Minh, and C. N. Hjortsø, “Moving beyond intermediation: How intermediary organizations shape collaboration dynamics in entrepreneurial ecosystems,” *Technovation*, vol. 108, p. 102332, Dec. 2021, doi: 10.1016/j.technovation.2021.102332.
[20] M. Saunila, “Innovation capability in SMEs: A systematic review of the literature,” *J. Innov. Knowl.*, vol. 5, no. 4, pp. 260–265, Oct. 2020, doi: 10.1016/j.jik.2019.11.002.
[21] S. Doh and B. Kim, “Government support for SME innovations in the regional industries: The case of government financial support program in South Korea,” *Res. Policy*, vol. 43, no. 9, pp. 1557–1569, Nov. 2014, doi: 10.1016/j.respol.2014.05.001.
[22] P. van Hemert, P. Nijkamp, and E. Masurel, “From innovation to commercialization through networks and agglomerations: analysis of sources of innovation, innovation capabilities and performance of Dutch SMEs,” *Ann. Reg. Sci.*, vol. 50, no. 2, pp. 425–452, Apr. 2013, doi: 10.1007/s00168-012-0509-1.
[23] B. Weber and S. Heidenreich, “When and with whom to cooperate? Investigating effects of cooperation stage and type on innovation capabilities and success,” *Long Range Plann.*, vol. 51, no. 2, pp. 334–350, Apr. 2018, doi: 10.1016/j.lrp.2017.07.003.
[24] E. Szeto, “Innovation capacity: working towards a mechanism for improving innovation within an inter-organizational network,” *TQM Mag.*, vol. 12, no. 2, pp. 149–158, Jan. 2000, doi: 10.1108/09544780010318415.
[25] A. Mendoza-Silva, “Innovation capability: a systematic literature review,” *Eur. J. Innov. Manag.*, vol. 24, no. 3, pp. 707–734, Jun. 2020, doi: 10.1108/EJIM-09-2019-0263.
[26] B. Lawson and D. Samson, “Developing innovation capability in organisations: a dynamic capabilities approach,” *Int. J. Innov. Manag.*, vol. 05, no. 03, pp. 377–400, Sep. 2001, doi: 10.1142/S1363919601000427.
[27] A. Smith, M. Fressoli, D. Abrol, E. Arond, and A. Ely, *Grassroots Innovation Movements*. Taylor & Francis, 2017. doi: 10.4324/9781315697888.
[28] M. De Silva and F. Rossi, “The effect of firms’ relational capabilities on knowledge acquisition and co-creation with universities,” *Technol. Forecast. Soc. Change*, vol. 133, pp. 72–84, Aug. 2018, doi: 10.1016/j.techfore.2018.03.004.
[29] G. Martín-de Castro, P. López-Sáez, and M. Delgado-Verde, “Towards a knowledge-based view of firm innovation. Theory and empirical research,” *J. Knowl. Manag.*, vol. 15, no. 6, pp. 871–874, Jan. 2011, doi: 10.1108/13673271111179253.
[30] R. M. Grant, “Toward a knowledge-based theory of the firm,” *Strateg. Manag. J.*, vol. 17, no. S2, pp. 109–122, 1996, doi: 10.1002/smj.4250171110.
[31] N. Sammerl, B. W. Wirtz, and O. Schilke, “Innovationsfähigkeit von Unternehmen,” *Betriebswirtschaft*, vol. 68, no. 2, p. 131, 2008.

[32] M. Subramaniam and M. A. Youndt, "The Influence of Intellectual Capital on the Types of Innovative Capabilities," *Acad. Manage. J.*, vol. 48, no. 3, pp. 450–463, Jun. 2005, doi: 10.5465/amj.2005.17407911.
[33] J. Frishammar, M. Kurkkio, L. Abrahamsson, and U. Lichtenthaler, "Antecedents and Consequences of Firms' Process Innovation Capability: A Literature Review and a Conceptual Framework," *IEEE Trans. Eng. Manag.*, vol. 59, no. 4, pp. 519–529, Nov. 2012, doi: 10.1109/TEM.2012.2187660.
[34] A. Carmeli, R. Gelbard, and R. Reiter-Palmon, "Leadership, Creative Problem-Solving Capacity, and Creative Performance: The Importance of Knowledge Sharing," *Hum. Resour. Manage.*, vol. 52, no. 1, pp. 95–121, 2013, doi: 10.1002/hrm.21514.
[35] J. Yao, A. Crupi, A. Di Minin, and X. Zhang, "Knowledge sharing and technological innovation capabilities of Chinese software SMEs," *J. Knowl. Manag.*, vol. 24, no. 3, pp. 607–634, May 2020, doi: 10.1108/JKM-08-2019-0445.
[36] O. A. E. Sawy, I. Eriksson, A. Raven, and S. Carlsson, "Understanding shared knowledge creation spaces around business processes: precursors to process innovation implementation," *Int. J. Technol. Manag.*, vol. 22, no. 1–3, pp. 149–173, Jan. 2001, doi: 10.1504/IJTM.2001.002959.
[37] K. B. Whittington, J. Owen-Smith, and W. W. Powell, "Networks, Propinquity, and Innovation in Knowledge-intensive Industries," *Adm. Sci. Q.*, vol. 54, no. 1, pp. 90–122, Mar. 2009, doi: 10.2189/asqu.2009.54.1.90.
[38] T. Stuart and O. Sorenson, "The geography of opportunity: spatial heterogeneity in founding rates and the performance of biotechnology firms," *Res. Policy*, vol. 32, no. 2, pp. 229–253, Feb. 2003, doi: 10.1016/S0048-7333(02)00098-7.
[39] S. Tallman, M. Jenkins, N. Henry, and S. Pinch, "Knowledge, Clusters, and Competitive Advantage," *Acad. Manage. Rev.*, vol. 29, no. 2, pp. 258–271, Apr. 2004, doi: 10.5465/amr.2004.12736089.
[40] J. Singh, "Collaborative Networks as Determinants of Knowledge Diffusion Patterns," *Manag. Sci.*, vol. 51, no. 5, pp. 756–770, May 2005, doi: 10.1287/mnsc.1040.0349.
[41] C. Phelps, R. Heidl, and A. Wadhwa, "Knowledge, Networks, and Knowledge Networks: A Review and Research Agenda," *J. Manag.*, vol. 38, no. 4, pp. 1115–1166, Jul. 2012, doi: 10.1177/0149206311432640.
[42] U. R. Hülsheger, N. Anderson, and J. F. Salgado, "Team-level predictors of innovation at work: A comprehensive meta-analysis spanning three decades of research," *J. Appl. Psychol.*, vol. 94, no. 5, pp. 1128–1145, 2009, doi: 10.1037/a0015978.
[43] A. Messeni Petruzzelli, "Proximity and knowledge gatekeepers: the case of the Polytechnic University of Turin," *J. Knowl. Manag.*, vol. 12, no. 5, pp. 34–51, Jan. 2008, doi: 10.1108/13673270810902920.
[44] A. Messeni Petruzzelli, V. Albino, and N. Carbonara, "Technology districts: proximity and knowledge access," *J. Knowl. Manag.*, vol. 11, no. 5, pp. 98–114, Jan. 2007, doi: 10.1108/13673270710819834.
[45] A. M. Petruzzelli, "The impact of technological relatedness, prior ties, and geographical distance on university–industry collaborations: A joint-patent analysis," *Technovation*, vol. 31, no. 7, pp. 309–319, Jul. 2011, doi: 10.1016/j.technovation.2011.01.008.
[46] A. Capaldo and A. M. Petruzzelli, "Partner Geographic and Organizational Proximity and the Innovative Performance of Knowledge-Creating Alliances," *Eur. Manag. Rev.*, vol. 11, no. 1, pp. 63–84, 2014, doi: 10.1111/emre.12024.
[47] L. Scaringella and A. Radziwon, "Innovation, entrepreneurial, knowledge, and business ecosystems: Old wine in new bottles?," *Technol. Forecast. Soc. Change*, vol. 136, pp. 59–87, Nov. 2018, doi: 10.1016/j.techfore.2017.09.023.
[48] K. M. Eisenhardt and D. C. Galunic, "Coevolving At Last, a Way to Make Synergies Work," *Harv. Bus. Rev.*, vol. 78, no. 1, pp. 91–91, Jan. 2000.

[49] L. Ardito, A. Ferraris, A. Messeni Petruzzelli, S. Bresciani, and M. Del Giudice, "The role of universities in the knowledge management of smart city projects," *Technol. Forecast. Soc. Change*, vol. 142, pp. 312–321, May 2019, doi: 10.1016/j.techfore.2018.07.030.
[50] G. Elia, A. Lerro, G. Passiante, and G. Schiuma, "An Intellectual Capital perspective for Business Model Innovation in technology-intensive industries: empirical evidences from Italian spin-offs," *Knowl. Manag. Res. Pract.*, vol. 15, no. 2, pp. 155–168, May 2017, doi: 10.1057/s41275-017-0052-z.
[51] M. Iansiti and R. Levien, "Strategy as ecology," *Harv. Bus. Rev.*, vol. 82, no. 3, pp. 68–78, 126, Mar. 2004.
[52] G. Becattini, "The Marshallian industrial district as a socio-economic notion," *Rev. Déconomie Ind.*, no. 157, Art. no. 157, Mar. 2017, doi: 10.4000/rei.6507.
[53] M. H. Best, *THE New Competition: Institutions of Industrial Restructuring*. Harvard University Press, 1990. Accessed: Nov. 21, 2024.
[54] J. F. Moore, *The death of competition : leadership and strategy in the age of business ecosystems*. Wiley, 1996. Accessed: Nov. 22, 2024.
[55] C. Boari, F. X. Molina-Morales, and L. Martínez-Cháfer, "Direct and Interactive Effects of Brokerage Roles on Innovation in Clustered Firms," *Growth Change*, vol. 48, no. 3, pp. 336–358, 2017, doi: 10.1111/grow.12170.
[56] K. Randhawa, R. Wilden, and S. Gudergan, "Open Service Innovation: The Role of Intermediary Capabilities," *J. Prod. Innov. Manag.*, vol. 35, no. 5, pp. 808–838, 2018, doi: 10.1111/jpim.12460.
[57] K. M. Eisenhardt, "Building Theories from Case Study Research," *Acad. Manage. Rev.*, vol. 14, no. 4, pp. 532–550, Oct. 1989, doi: 10.5465/amr.1989.4308385.
[58] M. E. Graebner, J. A. Martin, and P. T. Roundy, "Qualitative data: Cooking without a recipe," *Strateg. Organ.*, vol. 10, no. 3, pp. 276–284, Aug. 2012, doi: 10.1177/1476127012452821.
[59] M. A. Phillips and P. Ritala, "A complex adaptive systems agenda for ecosystem research methodology," *Technol. Forecast. Soc. Change*, vol. 148, p. 119739, Nov. 2019, doi: 10.1016/j.techfore.2019.119739.
[60] M. Garri, "Coopetition, value co-creation, and knowledge-enhancement in the UK alpaca industry: A multi-level mechanism," *Eur. Manag. J.*, vol. 39, no. 5, pp. 545–557, Oct. 2021, doi: 10.1016/j.emj.2020.11.001.
[61] P. Capolupo, A. M. Petruzzelli, and L. Ardito, "A knowledge-based perspective on transgenerational entrepreneurship: unveiling knowledge dynamics across generations in family firms," *J. Knowl. Manag.*, vol. 28, no. 5, pp. 1444–1467, Dec. 2023, doi: 10.1108/JKM-05-2023-0451.
[62] M. C. Annosi, E. Mattarelli, D. Dentoni, and A. Messeni Petruzzelli, "The micro-foundations of ambidexterity for corporate social performance: A study on sustainability managers' response to conflicting goals," *Long Range Plann.*, vol. 57, no. 1, p. 102412, Feb. 2024, doi: 10.1016/j.lrp.2023.102412.
[63] G. Guest, A. Bunce, and L. Johnson, "How Many Interviews Are Enough?: An Experiment with Data Saturation and Variability," *Field Methods*, vol. 18, no. 1, pp. 59–82, Feb. 2006, doi: 10.1177/1525822X05279903.
[64] D. A. Gioia, K. G. Corley, and A. L. Hamilton, "Seeking Qualitative Rigor in Inductive Research: Notes on the Gioia Methodology," *Organ. Res. Methods*, vol. 16, no. 1, pp. 15–31, Jan. 2013, doi: 10.1177/1094428112452151.
[65] M. A. Islam and F. M. F. Aldaihani, "Justification for adopting qualitative research method, research approaches, sampling strategy, sample size, interview method, saturation, and data analysis," *J. Int. Bus. Manag.*, vol. 5, no. 1, pp. 01–11, 2022.
[66] V. Braun and V. Clarke, "Using thematic analysis in psychology," *Qual. Res. Psychol.*, vol. 3, no. 2, pp. 77–101, Jan. 2006, doi: 10.1191/1478088706qp063oa.

[67] I. Mancuso, A. M. Petruzzelli, and U. Panniello, "Value creation in data-centric B2B platforms: A model based on multiple case studies," *Ind. Mark. Manag.*, vol. 119, pp. 1–14, May 2024, doi: 10.1016/j.indmarman.2024.04.001.
[68] J. Jones and G. Corral de Zubielqui, "Doing well by doing good: A study of university-industry interactions, innovationess and firm performance in sustainability-oriented Australian SMEs," *Technol. Forecast. Soc. Change*, vol. 123, pp. 262–270, Oct. 2017, doi: 10.1016/j.techfore.2016.07.036.
[69] N. Carter, D. Bryant-Lukosius, A. DiCenso, J. Blythe, and A. J. Neville, "The use of triangulation in qualitative research," *Oncol. Nurs. Forum*, vol. 41, no. 5, pp. 545–547, Sep. 2014, doi: 10.1188/14.ONF.545-547.
[70] R. K. Yin, *Case study research: Design and methods*, vol. 5. Sage, 2009. Accessed: Nov. 21, 2024.
[71] K. Rong, J. Wu, Y. Shi, and L. Guo, "Nurturing business ecosystems for growth in a foreign market: Incubating, identifying and integrating stakeholders," *J. Int. Manag.*, vol. 21, no. 4, pp. 293–308, Dec. 2015, doi: 10.1016/j.intman.2015.07.004.
[72] C. Blanka and V. Traunmüller, "Blind date? Intermediaries as matchmakers on the way to start-up-industry coopetition," *Ind. Mark. Manag.*, vol. 90, pp. 1–13, 2020, doi: 10.1016/j.indmarman.2020.05.031.
[73] R. Ricci, D. Battaglia, and P. Neirotti, "External knowledge search, opportunity recognition and industry 4.0 adoption in SMEs," *Int. J. Prod. Econ.*, vol. 240, p. 108234, Oct. 2021, doi: 10.1016/j.ijpe.2021.108234.
[74] L. Cannavacciuolo, G. Ferraro, C. Ponsiglione, S. Primario, and I. Quinto, "Technological innovation-enabling industry 4.0 paradigm: A systematic literature review," *Technovation*, vol. 124, p. 102733, Jun. 2023, doi: 10.1016/j.technovation.2023.102733.
[75] S. Andersson and J. Sundermeier, "Firms' use of organizational, personal, and intermediary networks to gain access to resources for internationalization," *Thunderbird Int. Bus. Rev.*, vol. 61, no. 4, pp. 609–621, 2019, doi: 10.1002/tie.22043.
[76] P. Ritala and P. Hurmelinna-Laukkanen, "What's in it for me? Creating and appropriating value in innovation-related coopetition," *Technovation*, vol. 29, no. 12, pp. 819–828, Dec. 2009, doi: 10.1016/j.technovation.2009.07.002.
[77] G. Cainelli, "Spatial Agglomeration, Technological Innovations, and Firm Productivity: Evidence from Italian Industrial Districts," *Growth Change*, vol. 39, no. 3, pp. 414–435, 2008, doi: 10.1111/j.1468-2257.2008.00432.x.
[78] M. Cuvero, M. L. Granados, A. Pilkington, and R. D. Evans, "The Effects of Knowledge Spillovers and Accelerator Programs on the Product Innovation of High-Tech Start-Ups: A Multiple Case Study," *IEEE Trans. Eng. Manag.*, vol. 69, no. 4, pp. 1682–1695, Aug. 2022, doi: 10.1109/TEM.2019.2923250.
[79] H. Choi and H. Zo, "Network Closure Versus Structural Hole: The Role of Knowledge Spillover Networks in National Innovation Performance," *IEEE Trans. Eng. Manag.*, vol. 69, no. 4, pp. 1011–1021, Aug. 2022, doi: 10.1109/TEM.2020.2972347.
[80] W. Zhang, Y. Jiang, and W. Zhang, "Capabilities for Collaborative Innovation of Technological Alliance: A Knowledge-Based View," *IEEE Trans. Eng. Manag.*, vol. 68, no. 6, pp. 1734–1744, Dec. 2021, doi: 10.1109/TEM.2019.2936678.
[81] C. Battistella and E. Pessot, "Nurturing Social Innovation Capabilities in Businesses Through Open Innovation," *IEEE Trans. Eng. Manag.*, vol. 71, pp. 8388–8401, 2024, doi: 10.1109/TEM.2024.3391859.

Appendix 1a – Description of interviewees from core value chain actors

| Interviews | Participant position | Experience (years) | Sector | Products/services | Gender |
|---|---|---|---|---|---|
| **SMEs** | | | | | |
| 1 | CEO (CEO1) | 30 | Services | Building maintenance | Female |
| 2 | CEO (CEO2) | 14 | Services | Distributors | Male |
| 3 | CEO (CEO3) | 5 | Services | Information Technology | Male |
| 4 | Head of Business Intelligence (HBI) | 4 | Manufacturers | Energy and District heating solutions | Male |
| 5 | Head of Business Development (HBD) | 4 | Manufacturers | Light manufacturers | Male |
| 6 | Automation Engineer (AE) | 2 | Manufacturers | Moveable power plants | Male |
| 7 | CEO (CEO4) | 5 | Services | Information Technology | Male |
| 8 | CEO (CEO5) | 11 | Services | Games, software, and user-experience | Male |
| 9 | Software Engineer (SE) | 1 | Services | Educational consultancy | Male |
| 10 | Project Manager (PM1) | 4 | Services | Educational consultancy | Male |
| 11 | CEO (CEO6) | 3 | Services | Marketing consultancy | Female |
| 12 | Communication Manager (CM) | 21 | Manufacturers | Waste Process Plant | Female |
| 13 | Group manager (GM) | 8 | Services | Wind Power Consulting | Male |
| 14 | CEO (CEO7) | 12 | Services | Research and consultancy in B2B | Female |
| 15 | Managing Director (MD) | 9 | Manufacturing | Metal supply | Male |
| 16 | Chief Technology Officer (CTO) | 15 | Services | Information Technology and consultation | Male |
| 17 | CEO (CEO8) | 5 | Services | Peer-to-peer service platform | Male |
| 18 | CEO (CEO9) | 12 | Services | IT services and consulting | Male |
| **Large firm** | | | | | |
| 19 | Operations Center Manager (OCM) | 11 | Manufacturing | Energy production and distribution | Male |

Appendix 1b – Description of interviewees from intermediary organizations

| Interviews | Participant position | Experience (years) | Firm's agenda | Gender | Types |
|---|---|---|---|---|---|
| 1 | CEO (CEO10) | 4 | Provides support activities to SMEs and large firms in the digitalization and internationalization process. | Male | Private |
| 2 | Manager Development (MDV) | 3 | Technology center that facilitates collaboration between ecosystem actors. | Male | Public-private |
| 3 | Project Manager (PM2) | 2 | Technology center that facilitates collaboration between ecosystem actors. | Male | Public-private |
| 4 | Incubator Manager (IM) | 3 | Provides an incubator for SME development in the region. | Male | Public |

| | | | | | |
|---|---|---|---|---|---|
| 5 | Project Manager (PM3) | 10 | Promotes, initiates, and facilitates various activities, projects, and collaborations for developing innovations in the region. | Male | Public |
| 6 | Executive Director (ED) | 8 | Promotes SMEs and entrepreneurs in the region. | Female | Private |
| 7 | Development and Business Manager (DBM) | 5 | Policy making, structural planning, and support for business development. | Male | Public |
| 8 | Senior Specialist (SS1) | 1 | Innovation and commercialization. | Male | Public |
| 9 | Senior Specialist (SS2) | 1 | Innovation and commercialization. | Male | Public |
| 10 | Senior Specialist (SS3) | 1 | Innovation and commercialization. | Female | Public |
| 11 | Director 1 | 8 | Provides an incubator for SME development in the region. | Female | Public |
| 12 | Director 2 | 14 | Education and research. | Male | Public |
| 13 | R&D Manager | 13 | Education and research. | Female | Public |
| 14 | Dean | 2 | Education and research. | Male | Public |