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Orchestrating innovation ecosystems and digital technologies for dynamic capabilities development: the case of EdTech industry

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Abstract

Purpose – We investigate how digital technologies contribute to the development of dynamic capabilities for innovation ecosystem orchestration, focusing on the EdTech industry.

Design/methodology/approach – The study is based on eight case studies deepened through three rounds of (comprehensively 23) interviews. Empirical evidence has been enriched and validated through the triangulation of several secondary data.

Findings – We demonstrate that digital technologies play a crucial role in enhancing ecosystem-wide collaboration and information sharing, thereby facilitating the development of dynamic capabilities for innovation ecosystem orchestration. Moreover, we underscore the significance of digital skills in fully realizing the potential of digital solutions to foster collaboration and value creation within ecosystems.

Research limitations/implications – While insightful, findings are context-specific to the EdTech industry. Future research should explore broader industry applicability and delve into nuanced factors influencing digital skills and innovation ecosystem orchestration in varied contexts.

Practical implications – Strategic use of digital technologies enhances collaboration and value creation within ecosystems as well as empowering their competitiveness, entrepreneurial attitude and innovation.

Originality/value – The paper elucidates the pivotal role played by digital technologies in innovation ecosystem orchestration and dynamic capabilities' development, shedding light on how organizations should organize themselves to continuously adapt to an ever-changing competitive environment.

Keywords Digital technologies, Innovation ecosystems, Dynamic capabilities, Innovation, Entrepreneurship, Education technology (EdTech)

Paper type Research paper

1. Introduction

In today's rapidly evolving business landscape, the concept of ecosystems has emerged as a central paradigm, offering a diverse framework through which organizations can interact and create value (Adner, 2017; Jacobides *et al*., 2018; Scaringella and Radziwon, 2018; Shipilov and Gawer, 2020). The significance of ecosystems has been increasingly recognized across various fields, including management, innovation studies, and entrepreneurship (Cobben *et al*., 2022).

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Management scholars have identified several types of ecosystems (Jacobides *et al*., 2018; Cobben *et al*., 2022): business ecosystems (Moore, 1993), innovation ecosystems (Adner, 2006), entrepreneurial ecosystems (Isenberg, 2010), knowledge ecosystems (Van der Borgh *et al*., 2012), platform ecosystems (Gawer and Cusumano, 2014). This proliferation has led to various challenges in understanding the phenomenon and its applications. Cobben *et al*. (2022) stress the importance of systematically differentiating between ecosystem types to develop tailored strategies and frameworks.

This research investigates innovation ecosystems, which can be defined as *"the evolving set of actors, activities, artifacts, and relations that are important for the innovative performance of an actor or a population of actors"* (Granstrand and Holgersson, 2020). These kind of ecosystems are characterized by their emphasis on collaborative innovation, where multiple actors – including firms, research institutions, startups, and government agencies (Corvello *et al*., 2023; Zahra and Nambisan, 2012) – work together to develop and commercialize new technologies and solutions (Adner, 2017; Autio and Thomas, 2014; Nambisan and Sawhney, 2011).

Despite the extensive research on innovation ecosystems (Adner and Kapoor, 2010; Adner, 2017; Cobben *et al*., 2022), there remains a gap in fully understanding its formative phases and the specific role of digital solutions not only in shaping ecosystem development, but also in fostering the dynamic capabilities that are necessary to a proper ecosystem orchestration (Linde *et al*., 2021; Kindermann *et al*., 2022; Motamedimoghadam *et al*., 2024).

Digital technologies potentially play a pivotal role in enhancing ecosystem-wide collaboration (Jacobides *et al*., 2018; Warner and Wäger, 2019; Verhoef *et al*., 2021; Steiber and Alvarez, 2024). The widespread digitalization of innovation processes creates significant managerial opportunities and challenges, reshaping how firms manage innovation activities within ecosystems (Agostini *et al*., 2020). Recent literature also highlights how digitalization drives significant changes in ecosystem dynamics, enabling new logics of value creation and redistribution among the various participants (Wolfert *et al*., 2023). Nevertheless, as recently emphasized by Kindermann *et al*. (2022), there is still limited empirical understanding of how digital technologies actually shape the micro-foundations of ecosystem orchestration. Further, recent studies (Motamedimoghadam *et al*., 2024; Kowalski *et al*., 2024) call for a more integrated investigation into how digital tools influence the development of dynamic capabilities across different industries and organizational contexts.

Our research seeks to address these gaps by investigating the following research question: *How do organizations exploit digital technologies to dynamically orchestrate the innovation ecosystems in which they are embedded?* In order to answer this question, we analysed some organisations in the Education Technology (EdTech) industry. This industry represents a particularly relevant context for studying ecosystem orchestration, given its rapid transformation driven by digitalization, its critical role in shaping future workforce skills, and its heightened relevance during and after the COVID-19 outbreak (Shan and Wade, 2023). Moreover, the EdTech context exemplifies broader trends in digital transformation affecting knowledge-intensive industries, making our findings potentially generalizable beyond this specific sector.

Grounded in Eisenhardt's qualitative theory-building approach (Eisenhardt, 1989; Eisenhardt and Graebner, 2007), our study adopts a multi-case study design, drawing insights from eight EdTech organizations acting as orchestrators of the innovation ecosystem in which they are embedded. More specifically, and aligned with the dynamic capabilities' framework (Teece, 2007; Foss *et al*., 2023), in every case we focus on three pivotal phases charactering innovation ecosystem orchestration: sensing, seizing, and transforming.

In the sensing phase, organizations scan the market landscape, leveraging digital technologies to validate ideas and identify emerging opportunities. For instance, Warner and Wäger (2019) discuss how firms build dynamic capabilities for digital transformation

through continuous market sensing and strategic renewal. Similarly, Verhoef *et al*. (2021) highlight the role of digital technologies in enabling firms to sense and respond to market changes effectively. Through interviews, we gleaned insights into how EdTech organizations harness digital solutions to channel and confirm their vision, underscoring the generative nature (Fürstenau *et al*., 2023) of digital technologies in innovation ecosystem sensing (Linde *et al*., 2021). This market sensing process is further enhanced by open innovation strategies, such as peer innovation practices, which help organizations managing the balance between competition and collaboration in ecosystem contexts (Primario *et al*., 2024).

In the seizing phase, organizations translate validated ideas into viable business models, leveraging digital tools to streamline ecosystem validation, enlarge networks, and engage users effectively. Our findings highlight the convergent nature of digital solutions in facilitating ecosystem seizing, catalysing value proposition delivery and ecosystem expansion (Kindermann *et al*., 2022). Digital solutions can significantly accelerate this process, particularly when leveraged by academic entrepreneurs who commercialize research outcomes through technology-driven collaboration and networking initiatives (Rippa and Secundo, 2019).

Finally, in the transforming phase, organizations confront external market dynamism, necessitating continuous adaptation and renewal. Through interviews, we discerned how digital technologies play a pivotal role in enabling firms to navigate market changes and reinvent themselves to meet evolving customer needs (Linde *et al*., 2021; Kindermann *et al*., 2022; Motamedimoghadam *et al*., 2024). Organizations, especially those embedded in university-based entrepreneurial ecosystems, often utilize open innovation platforms such as Contamination Labs to foster continuous knowledge spillover, enabling rapid adaptation and transformation in response to changing market dynamics (Secundo *et al*., 2021). This aligns closely with our research context in the EdTech industry, where universities and research institutions represent key players within innovation ecosystems, continuously engaging in technology-driven transformation and adapting their strategies through similar collaborative and knowledge-sharing practices.

Leveraging insights from Teece (2018), our research underscores the transformative potential of digital solutions in facilitating ecosystem adaptation and competitive advantage renewal. More specifically, by delineating the strategic significance of digital solutions across ecosystem phases, our research provides practitioners and scholars with actionable insights to navigate the complexities of ecosystem-based value creation in the digital age.

The remainder of the paper is structured as follows: Section 2 outlines the theoretical background, Section 3 presents the research methodology, Section 4 discusses the empirical findings, Section 5 offers a comprehensive discussion and Section 6 concludes with theoretical and managerial implications, as well as future research directions.

2. Theoretical background

Our paper lies at the interplay of three streams of research: innovation ecosystems (Adner, 2006, 2017; Jacobides *et al*., 2018), digital technologies (Warner and Wäger, 2019; Verhoef *et al*., 2021; Iansiti and Nadella, 2022), and dynamic capabilities (Teece, 2007). This interplay is particularly relevant as it helps understanding how organizations can leverage dynamic capabilities to effectively orchestrate ecosystems and drive innovation through digital transformation (Warner and Wäger, 2019; Mele *et al*., 2023).

2.1 Orchestrating innovation ecosystem through digital technologies

Innovation ecosystems are particularly relevant for understanding the dynamic and collaborative nature of value creation in rapidly changing industries (Adner, 2006; Teece, 2007, 2018; Jacobides *et al*., 2018). Unlike business ecosystems, which revolve around a core

firm and its direct stakeholders, innovation ecosystems focus on collaborative innovation processes involving multiple actors, including firms, research institutions, and government agencies (Adner, 2017; Autio and Thomas, 2014). Within these ecosystems, startups often act as critical knowledge brokers, enhancing knowledge flows and fostering innovative collaborations with incumbent firms (Corvello *et al*., 2023; Zahra and Nambisan, 2012).

Digital technologies play a pivotal role in enhancing these collaborative processes by providing the necessary infrastructure for real-time communication, data sharing, and collaborative development (Beliaeva *et al*., 2020). In fact, digital technologies are not merely tools but essential enablers that drive the formation, operation, and evolution of innovation ecosystems (Teece, 2007, 2018; Kindermann *et al*., 2022). They provide the infrastructure that facilitate the intricate web of interactions within innovation ecosystems, enabling the integration of diverse capabilities and resources (Yoo *et al*., 2010). Recent empirical studies highlight that advanced digital technologies – such as artificial intelligence, big data analytics, and digital twins – reshape ecosystem interactions, innovation processes, managerial decision-making, and customer-centric value creation (Capurro *et al*., 2022; Nour and Arbussà, 2024; Steiber and Alvarez, 2024). Generativity, convergence, and combinatoriality are key characteristics of digital technologies that enhance ecosystem development.

Generativity refers to the capacity of digital solutions to foster novel experiences, organizational forms, and processes. This potential arises from the data-driven insights enabled by digital technologies, supporting continuous innovation and proactive adaptation to environmental shifts (Fürstenau *et al*., 2023).

Convergence emphasizes how digital technologies can integrate across different areas, enabling intelligent tools that support cross-sector collaboration and resource alignment (Yoo *et al*., 2010). This integration leads to growth and value creation (Yoo *et al*., 2012).

Combinatoriality underscores the modularity of digital technologies, enabling the recombination of various components to generate new solutions, foster innovation through collaborative synergies (Warner and Wäger, 2019) and, ultimately, leading to new and improved offerings within the ecosystem (Fürstenau *et al*., 2023).

While both Gomes *et al*. (2018) and Linde *et al*. (2021) have provided valuable insights into the structural dimensions of ecosystems, less attention has been devoted to the dynamic mechanisms through which digital technologies support continuous adaptation, collaboration and value co-creation. Recent studies (Idries *et al*., 2022; Haki *et al*., 2022; Kindermann *et al*., 2022; Kowalski *et al*., 2024) highlight that digital technologies are not only serve as enablers of ecosystem orchestration, but also act as critical drivers in the development of dynamic capabilities. However, these contributions primarily adopt a theoretical perspective, with limited empirical validation, leaving a gap in understanding how these dynamics unfold in practice. While the managerial implications of digitalizing innovation processes within ecosystems remain largely unexplored despite their strategic relevance (Agostini *et al*., 2020), existing literature has yet to establish a comprehensive framework for examining the mechanisms through which digital technologies influence dynamic capabilities. Furthermore, the interplay between digital technologies and ecosystem orchestration remains an underexplored area, particularly in contexts where digital transformation drives continuous organizational adaptation.

2.2 Orchestrating innovation ecosystem through dynamic capabilities

Dynamic capabilities are critical for the effective orchestration of innovation ecosystems (Teece, 2018; Linde *et al*., 2021). Teece (2007) defines dynamic capabilities as "*the firm's ability to integrate, build, and reconfigure internal and external competences to address rapidly changing environments*". These capabilities enable firms to shape and adapt to ecosystems, driving innovation and value creation (Teece, 2007, 2018). Dynamic capabilities are categorized into three main types: *sensing, seizing, and transforming*.

Sensing involves identifying and assessing opportunities and threats in the environment. Firms engage in extensive market research and innovation scouting to identify emerging

trends and unmet customer needs. This phase is critical for uncovering new opportunities that can be capitalized upon (Teece, 2007; Motamedimoghadam *et al*., 2024).

Seizing focuses on mobilizing resources to capture value from these opportunities, often through the development of new products, services, or business models based on insights gained during the sensing phase. Rapid prototyping and the launch of digital Minimum Viable Products (MVPs) are typical activities in this stage to quickly test and refine new concepts in the market (Haki *et al*., 2022). Additionally, open innovation practices mediate the link between dynamic capabilities and competitive performance by enhancing collaboration and knowledge flows, thus enabling firms to rapidly seize market opportunities (Pundziene *et al*., 2022).

Transforming refers to the continuous renewal and reconfiguration of assets and organizational structures to maintain competitiveness. This might involve reshaping the company's operational processes, reallocating resources, or even altering the organizational structure to better align with new strategic directions (Kowalski *et al*., 2024). Recent empirical evidence underscores the sequential interplay of dynamic capabilities, where effective sensing and seizing underpin transforming capabilities, ultimately enhancing innovation and organizational performance in emerging technology sectors (Zabel and O'Brien, 2024). Transforming capabilities ensure that firms remain agile and can adapt to ongoing changes in their environment (Teece, 2007; Kindermann *et al*., 2022; Motamedimoghadam *et al*., 2024).

While dynamic capabilities are often discussed at a strategic level, recent research (Kowalski *et al*., 2024) highlights the importance of their microfoundations – specific routines, managerial practices, and learning mechanisms that support their development. For example, sensing capabilities are grounded in data-driven decision-making practices, while seizing relies on cross-functional teams and agile methodologies. Transforming capabilities are supported by continuous learning cultures, flexible organizational structures, and dynamic resource reallocation mechanisms. Understanding these microfoundations is essential to grasp how firms operationalize dynamic capabilities within innovation ecosystems (Teece, 2018; Kowalski *et al*., 2024).

Studying dynamic capabilities within the context of innovation ecosystems and digital technologies is crucial because it reveals how firms can leverage these capabilities to navigate and thrive in interconnected and digitally-enabled environments (Helfat and Raubitschek, 2018). As networks of interconnected firms that co-evolve capabilities and roles, innovation ecosystems are often facilitated by digital platforms that enhance collaboration and innovation (Adner, 2017; Jacobides *et al*., 2018). Recently there has been a growing recognition of the importance of dynamic capabilities in ecosystem orchestration, as well as digital technologies (Kindermann *et al*., 2022). However, there are still gaps in understanding how these capabilities are developed and deployed within ecosystems, particularly the role of digital technologies in shaping these capabilities (Helfat and Raubitschek, 2018; Linde *et al*., 2021; Kindermann *et al*., 2022). The next section aims to reunite the state of the art of the three concepts (innovation ecosystems, dynamic capabilities, digital technologies), providing a more comprehensive and holistic view than the first two paragraphs, which aimed to shed light on the connections between innovation ecosystems and the other two concepts.

2.3 Integrating dynamic capabilities with innovation ecosystems and digital technologies

At the heart of innovation ecosystem orchestration lies the interplay between dynamic capabilities, ecosystems, and digital technologies (Adner, 2017; Jacobides *et al*., 2018; Teece, 2007). This triadic relationship is crucial in understanding how firms adapt to rapidly evolving environments, leveraging both internal competencies and external networks to create and capture value. Helfat and Raubitschek (2018) propose a theoretical framework that elucidates the role of dynamic capabilities in value generation and capture within ecosystems. They emphasize the need for further research to explore how organizations can develop and deploy dynamic capabilities to effectively navigate the complexities of ecosystems, particularly in

digitally-enabled environments. Digital technologies act as enablers, enhancing these capabilities by providing real-time data, fostering collaboration, and streamlining operations (Warner and Wäger, 2019; Fürstenau *et al*., 2023). These technologies not only support operational efficiency but also drive strategic flexibility, enabling firms to sense new opportunities, seize them through agile resource allocation, and transform their structures to maintain competitiveness (Linde *et al*., 2021; Kowalski *et al*., 2024; Motamedimoghadam *et al*., 2024).

Warner and Wäger (2019) propose a comprehensive framework that examines the interplay between dynamic capabilities and digital transformation. They argue that *"digital transformation is not only driven by technology but also by the organization's ability to build and leverage dynamic capabilities in a digital context"*. Their framework considers various factors influencing dynamic capabilities development, including external triggers (such as technological advancements and market changes), internal enablers (like organizational culture and leadership), and the critical role of digital solutions in reshaping business processes. They highlight that successful digital transformation requires organizations to continuously adapt their capabilities to effectively leverage digital technologies. This adaptation process is not linear but iterative, reflecting the dynamic nature of both technological evolution and ecosystem relationships (Cuel *et al*., 2024).

Although there are studies that have begun to explore the integration of dynamic capabilities, innovation ecosystems, and digital technologies, there is still significant room to understand the mechanisms and connections between these three concepts. Specifically, there is limited consensus on how firms can best organize partnerships and manage the complexities introduced by digital technologies (Linde *et al*., 2021). In parallel research streams, studies focusing on university-based entrepreneurial initiatives (Rippa and Secundo, 2019; Secundo *et al*., 2021) highlight how digital technologies can effectively support ecosystem orchestration and stimulate knowledge spillovers, indirectly fostering the development of dynamic capabilities. While our research targets firms operating in the EdTech industry rather than universities, insights from these parallel contexts offer valuable perspectives to better understand the role digital technologies may play in addressing ecosystem orchestration complexities.

Digital transformation is acknowledged as a driver of dynamic capabilities, but the detailed processes through which digital tools support the development and deployment of these capabilities remain underexplored (Warner and Wäger, 2019). Furthermore, Verhoef *et al*. (2021) emphasize the importance of understanding how digital technologies facilitate value creation and capture in ecosystems, noting that further research is needed to unpack these complex interactions. They argue that digital technologies not only alter firm-level processes but also reshape the broader ecosystem dynamics, influencing collaboration patterns, governance mechanism, and innovation pathways. This highlights the need for further research to unpack these complex interactions, particularly regarding the co-evolution of digital technologies and ecosystem structures.

In summary, while the literature has laid the groundwork for understanding the relationships between dynamic capabilities, ecosystems, and digital technologies, critical gaps remain in elucidating the integrative mechanisms that underpin ecosystem orchestration in the digital era. This paper aims to address these gaps by exploring how organizations leverage dynamic capabilities within digitally enabled ecosystems, contributing to both theoretical and practical advancements in the field.

3. Research methods

In order to deepen the pivotal role that digital technologies plays in the orchestration of innovation ecosystems, a qualitative research methodology is used based on a multiple case study (Yin, 2014). This approach is particularly suitable for analysing complex phenomena according from a holistic perspective (Flynn *et al*., 1990), to "*emphasize the rich and real*

context in which the phenomena occur (. . .) and provide a bridge between rich qualitative evidence and traditional deductive research" (Eisenhardt and Graebner, 2007). The qualitative approach is particularly justified in this study as it allows an in-depth exploration of the dynamic interactions within innovation ecosystems and the role of digital technologies in shaping these interactions.

Our primary aim is to understand how organizations orchestrate innovation ecosystems through the development of higher-order dynamic capabilities – sensing, seizing and transforming – and how digital technologies enable this process. The multiple case study design allows us to capture the complexity of these interactions in real-world contexts, providing a rich, comparative analysis.

To address the identified gaps, we conducted eight case studies focusing on both the internal dynamics – such as roles, hierarchies and processes – and the external interactions that occur during ecosystem formation phase. This dual focus enables a comprehensive understanding of how dynamic capabilities are activated within complex ecosystems, including the rationale behind ecosystem formation, how these ideas were tested in the marketplace to assess the feasibility of orchestration, the process of networking and feedback collection, and the transformations that organizations undergo.

Given the recognized importance of digital technologies in supporting ecosystem orchestration, this study also aims to address a gap in the literature how these technologies facilitate the development of dynamic capabilities. Specifically, we investigate the correlation between sensing, seizing, and transforming capabilities and the various natures of digital solutions, Furthermore, we explore whether this correlation can be considered unique.

To ensure data triangulation (Stake, 2013; Yin, 2017), we also made extensive use of secondary sources of evidence, such as online documentation and archival documents. While exploratory case studies do not allow for statistical generalization (Yin, 2003), the findings provide valuable insights that can inform future theoretical and empirical research on the creation and/or transformation of organizational models. Specifically, the results contribute to understanding how adaptive configurations can leverage ecosystem formation and the strategic use of digital technologies.

3.1 Case selection

The selection of the eight cases relied on the theoretical and purposeful sampling principles to guide our research in a way that best addressed the research problem (Eisenhardt, 1989; Eisenhardt and Graebner, 2007). An accurate choice of cases allows for limiting unrelated variations and to correctly defining the boundaries of validity of the generated theory, while the sampling method ensures selecting those cases most likely to provide the needed evidence (Eisenhardt, 1989). The case selection followed a theoretical sampling approach, aimed at identifying cases that could provide rich insights into the orchestration of innovation ecosystems within the EdTech sector. This approach allows for the investigation of diverse organizational contexts where ecosystem dynamics and digital technologies play a central role, enabling a deeper understanding of the phenomena under study.

Several important reasons led us to focus on the eight organizations analysed. First, they are all recognized as innovative entities due to their new methods of providing training and knowledge in the educational industry, organizing workshops, courses or developing new learning models. Second, the chosen organizations defined themselves or can be defined as an ecosystem. Third, they utilize new digital solutions to support value creation.

Cases were selected based on specific criteria to ensure diversity and analytical depth. These criteria include the maturity of the ecosystem (incumbents, scale-ups, and start-ups) and the degree of digital technology integration (ranging from basic digital tools to advanced platforms leveraging AI and data analytics). This selection strategy enhances the potential for cross-case comparison and allows us to capture the heterogeneity of ecosystem orchestration practices. The selection of cases was designed to explore how dynamic capabilities—sensing,

seizing, and transforming—are developed and deployed in diverse ecosystem contexts. This approach aligns with the theoretical framework, enabling the investigation of how digital technologies support ecosystem orchestration across different stages of organizational maturity.

The decision to study ecosystems was primarily driven by the fact that competition in markets has now shifted focus; we no longer speak of company-to-company competition, but rather competition between conglomerates. The EdTech sector is a particularly relevant context for studying ecosystem orchestration due to its rapid innovation pace and heavy reliance on digital technologies (Shan and Wade, 2023). The pandemic situation further accelerated the adoption of distance education, making it a hot topic internationally and leading to significant investments and funding in this sector.

Distance education is provided not only for schools and universities but also for companies, making corporate training an important focus of this research. The new digital solutions in EdTech represent a real change in how companies adopt training methods, addressing the increasing need for both specific skills and broader digital literacy and soft skills. These capabilities are crucial for fostering personal and professional growth, ultimately contributing to corporate growth. Lastly, in accordance with the principle of engaged scholarship (Van de Ven, 2007), we chose the eight cases based on the authors' connections and/or identified secondary sources with the aim of better preparing for the interviews, digging deeper into understanding their organizational characteristics, and achieving more effective data triangulation.

This purposive sampling strategy was instrumental in ensuring both the depth and breadth of empirical insights. By selecting cases with varying degrees of ecosystem complexity and digital maturity, we were able to identify patterns and divergences that contribute to a more nuanced understanding of how dynamic capabilities are orchestrated in different contexts.

For sampling purposes, the scope was narrowed down based on the years of activity of each organization to have a view of different stages of the ecosystem life cycle, from initial orchestration steps to evaluations of possible transformations and changes. According to this, three main clusters were identified.

(1) *Incumbent:* more structured entities that have been operating in the sector for years and have adapted to changes over time.

(2) *Scale-up:* entities that have existed for a few years but have experienced significant growth in a short period.

(3) *Start-up:* entities that have been standing for a short time, therefore very young.

Moreover, for most of the entities considered, we investigate not only the organizational side, but also the key ecosystem actors, including stakeholders such as partners, customers, and technology providers who actively contribute to value creation and ecosystem dynamics.

This research design allowed us to adhere to the maximum variation sampling principle, which suggests including extreme cases to obtain variations on dimensions of interest (Patton, 2005; Agostini *et al*., 2015).

In accordance with the criteria mentioned above, the choice fell on the following cases (Table 1).

Case A is an applied research centre that studies the impacts of digital transformation on the way we live and work. They provide data that helps to understand digital opportunities across sectors, matching supply and demands, and highlighting emerging trends. Its research contributes to understanding how data-driven insights support decision-making processes within ecosystems.

Case B is an applied research centre that creates knowledge around smart working and develop models, methodologies and data that help organisations adopt new ways of

Table 1. Summary of cases

Case	Founding year	Specific sector	Cluster
A	1999	Research	Incumbent
B	2012	Research	Incumbent
C	1992	Innovation	Incumbent
D	2021	HR	Scale-up
E	2020	Innovation	Scale-up
F	2015	HR	Scale-up
G	2023	HR	Start-up
H	2023	Research	Start-up

Source(s): Authors' own creation

working. It plays a role in fostering collaboration between organizations, offering tools that enhance ecosystem-wide learning and adaptation.

Case C is a students' association that operate as an umbrella for several other students' associations. It organizes networking activities, supports administrative and management activities, and provides training to enhance service offerings. Its coordination activities illustrate how informal networks can act as catalysts for ecosystem development.

Case D is an organization that organize training for HR professionals, helping them develop new skills and mindsets to accelerate organizational transformation and corporate growth. Its focus on people transformation highlights how human capital development supports the dynamic capabilities required for ecosystem orchestration.

Case E is a community of start-ups, big companies, academic research, venture capitalists, aimed at sharing and fostering digital business models. It facilitates knowledge exchange and partnerships, offering insights into the mechanisms of ecosystem orchestration.

Case F is an organization that offers self-coaching through a digital platform, collaborating with HR departments as part of corporate learning and wellness programs. It demonstrates how digital tools can enhance individual capabilities while supporting organizational learning within ecosystems.

Case G is an inclusive professional community that supports training and professional development, creating valuable connections and content that foster growth opportunities within the EdTech & HRTech sectors. Its activities show how professional communities contribute to ecosystem resilience through continuous learning.

Case H is an applied research centre that study the EdTech industry in Italy, analysing the landscape of digital solutions and innovative content for education and corporate training. It acts as a knowledge hub, providing strategic insights that inform both public and private stakeholders within the ecosystem.

Table 1 details the general characteristics of the selected cases.

3.2 Data collection

The data collection process took place between October 2022 and June 2023, relying on multiple sources and three main rounds of semi-structured interviews. This iterative, multi-phase data collection process allowed us to capture both stable elements and evolving dynamics within the selected ecosystems, providing a comprehensive view of organizational transformations over time. Multiple sources of evidence allowed limiting potential biases and gathering stronger insights (Eisenhardt, 1989; Eisenhardt and Graebner, 2007), as well as

exploiting the synergistic effects of data triangulation (Eisenhardt, 1989; Stake, 2013; Yin, 2017).

All interviews followed a common protocol, but many initial questions were adapted or added to maximize the insights from each interview. The interview protocol was structured around key themes derived from the literature on dynamic capabilities (Teece, 2007), innovation ecosystems (Adner, 2017), and digital transformation (Warner and Wäger, 2019). The questions were continuously refined based on organization materials reviewed in advance and new concepts discovered in previous interviews. This iterative process facilitated continuous learning from past interviews, adjusting the research protocol accordingly to the emerging insights.

The unit of analysis focused on organizations acting as central orchestrators within their ecosystems, while data were collected from key individuals (founders, executives, partners) to capture diverse perspectives on ecosystem orchestration. Based on the EdTech list drawn up by HolonIQ, we identified organizations that assumed a central role within their respective ecosystems, focusing on those responsible for key orchestration activities. The choice fell on.

(1) High-level employees within the organizational structure, such as founders or senior executives, who were directly involved in the creation and orchestration of the ecosystem. Their strategic roles provided valuable insights into decision-making processes and capability development.

(2) Actors or partners actively participating in the ecosystem, offering complementary perspectives on ecosystem functioning, value co-creation mechanisms, and the dynamics of inter-organizational relationships. The identification of additional interviewees followed a snowball sampling technique, guided by recommendations from initial key informants to ensure relevance and depth of insights.

All questions aimed to enhance the "representativeness and consistency" of our evidence (Corbin and Strauss, 1990). Interviews began with informants to briefly describing their roles and the organization's characteristics in terms of vision, structure and set of values and culture. Then, open questions allowed interviewees to "speak first", providing more authentic and reliable information (Flick, 2009). This open-ended approach encouraged participants to reflect on their experiences, revealing emergent themes that might not have been captured through more structured methods.

Specific questions followed, drawn from research problems and literature review variables, but we emphasized the interviewees' perspective to generate new findings and avoid bias. Each interview lasted at least one hour, conducted using online tools (Microsoft Teams, Google Meet, Zoom), recorded, and transcribed verbatim.

To ensure data reliability and mitigate potential researcher bias, we applied methodological triangulation, combining insights from interviews with secondary sources such as organizational reports, strategic documents, and publicly available information. This approach allowed us to validate key findings by cross-referencing multiple data points, thereby enhancing the robustness of the analysis.

The first two authors independently cross-checked the findings, coded key themes, and compared their initial interpretations (Bourgeois and Eisenhardt, 1988). The third author critically reviewed these observations, providing an external perspective to validate the analytical process. This approach allowed maintaining a high-level perspective (Gioia *et al.*, 2013).

Potential information bias was managed by ensuring anonymity (Eisenhardt, 1989) and considering diverse informants' perspective and roles (Ozcan and Eisenhardt, 2009).

Interviews were enriched with secondary data (company websites and online articles), useful for: (1) preparing interviews; (2) extrapolating additional empirical data; (3) triangulating with interview data for research validity. The three rounds of interviews uncovered points needing further investigation or understanding, allowing updates and

assessing changes over two/three month intervals. This iterative process not only deepened our understanding of ecosystem dynamics but also enabled us to track how organizations adapted over time in response to external and internal shifts. Table 2 below depicts the number of conducted interviews and the roles of key informants.

3.3 Data analysis

To analyse the rich body of data collected, we adopted the grounded-theory approach (Glaser and Strauss, 1967; Strauss and Corbin, 1998). According to the recommendations for multiple case study theory building, within- and cross-case analyses were performed (Eisenhardt, 1989; Eisenhardt and Graebner, 2007). We started by individually analysing the primary data and triangulated these with secondary sources (Jick, 1979). This triangulation process strengthened the validity of our findings by enabling cross-verification of information from different sources. Then, adopting an inductive approach (Saldaña, 2013) and the Gioia *et al*. (2013) methodology, we coded the various interview. The systematic approach suggested by Gioia *et al.* (2013) allowed us to examine transcripts line by line, developing new concepts while maintaining qualitative rigour in conducting and presenting our findings. This method ensured a structured transition from raw data to theoretical insights, fostering both transparency and analytical depth.

In the first order analysis, the most promising concepts were extracted, and interviewees' sentences were not modified to adhere faithfully to the original terms. This phase focused on identifying informant-centric concepts, preserving the authenticity of participants' voice. Initially, the number of quotes seemed high and unmanageable, but it is important to get lost at this stage to ensure all promising themes are considered (Gioia, 2004). After that, a second order analysis (cross-case) was conducted by replication logic across cases, grouping together sentences with similar meanings. Each group was labelled, retaining the original terms if possible. During this phase, we shifted from descriptive coding to interpretative analysis, identifying theoretical patterns and relationships among the emerging themes. Here, we started treating ourselves as knowledgeable agents, making connections between interviewees and theoretical levels, understanding the theoretical implications of themes emerging from the interviews (Gioia *et al*., 2013). As suggested by Gioia *et al*. (2013), if all the researchers did not

Table 2. Data sources

Case	Primary data
A	1 interview with the co-founder and Scientific Director
	2 interviews with a senior member and Director
B	1 joint session with the co-founder and Director and a senior researcher
	1 interview with the co-founder and Director
	1 interview with the Senior Researcher
C	2 interviews with the President – Executive board
	1 interview with a Partner development Leader
D	1 joint session with the co-founder & CEO and the Head of Product
	1 interview with the co-founder & CEO
	1 interview with the Head of Product
E	2 interviews with the CEO & Founder
	1 interview with an external collaborator expert
F	1 joint session with the co-founder & CEO and the Head of Research and Innovation
	1 joint session with the Head of Research and Innovation and a Senior analyst
G	1 joint session with the co-founders (President and Vice President)
	1 interview with the President
	1 interview with the Vice President
H	2 joint sessions with the co-founder and Director and a senior researcher
	1 interview with the co-founder and Director

Source(s): Authors' own creation

completely agree, we revised the analysis until consensus was reached, defining aggregate dimensions to reduce the number of categories to a more manageable number. This iterative process of discussion and refinement among the research team enhanced the reliability of the coding process and ensured that divergent interpretations were critically evaluated before reaching final conclusions.

During this process, particular attention was paid to both concepts related to the existing literature and novel themes emerging from the interviews. We actively engaged in cycling between empirical data, emerging theoretical constructs, and relevant academic literature, as recommended by Gilbert (2005), to refine construct definitions, abstraction levels, and theoretical relationships. This iterative back-and-forth process enabled us to continuously validate emerging insights against both empirical evidence and existing theoretical frameworks, strengthening the robustness of our theoretical contributions.

4. Findings

Research revealed that digital technologies significantly enhance the dynamic capabilities of ecosystems, particularly in phases of sensing, seizing, and transforming. Findings are reported in the upcoming three paragraphs, following the dynamic capabilities tripartition by Teece (2007): the behaviours, practices, and main actions of the organizations under analysis in the different phases of the formation, development and orchestration of an ecosystem were analysed and studied, and a proposition was constructed for each phase of the dynamic capabilities (sensing, seizing and transforming).

4.1 Innovation ecosystem sensing

The sensing phase is closely related to the creation process of the ecosystem, where the opportunity and idea for the creation of a business are initially identified. It often starts from an intuition based on experience or the perception of a market need, later validated with data and technologies, particularly the internet (Teece, 2007; Adner, 2017). Digital technologies play a pivotal role in enhancing ecosystem sensing through their generative nature, enabling organizations to detect emerging trends, identify unmet customer needs, and anticipate technological shifts with greater precision (Teece, 2018; Iansiti and Lakhani, 2020).

According to Teece (2018), dynamic capabilities, particularly sensing, are deeply intertwined with firms' abilities to interpret external signals and anticipate market changes. Digital tools, such as big data analytics, real-time monitoring systems, and AI-driven insights, allow organizations to process large datasets, identify weak signals, and generate actionable insights that would otherwise remain unnoticed (Iansiti and Lakhani, 2020). For example, in Case A, one of the founders had an idea due to frustration with the lack of representative data on digital transformation, leading to the creation of an organization based on this insight and further market research. One of the directors of Case A said, *"The idea came from one of the founders, who was frustrated that when searching for data on digital transformation, which has always been his passion, he only found international and geographically scattered data that was not representative."* The co-founder of Case A added, *"The organization was born as a gestation phase towards the second half of the 1990–2000 decade, for the first years from the idea of my co-founder, in his dialogue with a colleague confirmed by their research on national and international markets, thanks to the internet."*

Similarly, in Case H, the idea stemmed from studying the EdTech market to identify future trends and provide insights to solution providers and users (See Table 3). This aligns with the concept of digital sensing mechanisms, where technologies such as predictive analytics and machine learning algorithms support the early identification of market trends and evolving customer demands (Warner and Wäger, 2019).

Digital technologies play a crucial role in enhancing these processes by enabling real-time communication, data sharing, and collaborative development. Specifically, digital tools

Table 3. Other relevant quotes, aggregated themes, proposition

Quotes	Aggregated themes	Proposition
"The idea came from studying the EdTech market, also by comparing it with the international market, to identify what the future trends of the market might be, also to give insights to solution providers and users on how the market would evolve over the next two to three years." (Case H)	Digital Research and Market Validation	Proposition 1: Digital technologies enhance innovation ecosystem sensing through their generative nature
"Our organization is a social impact company in the education technology sector that was founded in 2015 and was born from an idea that was then translated into a book called MaM the acronym stands for Mom as a Master, written by the founder. The book, and thus the platform, explains and exploits the transversal skills, emotional intelligence, leadership, organization, innovation that women develop during motherhood and in their role as mothers." (Case F)	Experience-Driven Insight supported by Digital tools	
"I am an industrial engineering and I have been working a lot of years in the automotive industry, I wanted to build something to help others, but I didn't have the exact idea of how to do it. At that point, I started doing advisory and business angels for several startups in Spain from IoT platform, SaaS companies, and so on. I had in mind to build a platform, a digital business model, so with one of the company I made and the co-founder of it who is passionate of platform, coming back from one training we did, we say 'why don't we lead by the example and try to build the cup of knowledge as a platform' because we suffer a bit to learn about that: about which is the correct source, there are a lot of newsletters, reports, knowledge that is not digitalized, so we wanted to build a place where if you are building this kind of business model, you can go and talk to people, have resources and so on. So, everything was born." (Case E)	Creation of Digital Communities and Network	
"We work at a systemic level, and we are not the arm of any company, but from our inception, from our conception we had in our head that we were working at an ecosystem level . . . Right from the start we had the idea of working at a higher level, of aggregating the offer in particular . . . Our value proposition is created to offer occasions for discussion between supply and demand in a pre-competitive, non-commercial sector with the aim of improving the offer to improve supply competitive advantage and to allow demand to communicate and fulfill its needs." (Case A)	Creation of Digital Communities and Network	

(*continued*)

Table 3. Continued

Quotes	Aggregated themes	Proposition
"We started as an experiment in July with the launch of a digital MVP, i.e. the launch of a virtual platform. By September we had eighty members, so we decided to continue with the initiative." (Case G)	Experimentation through digital MVP	Proposition 2. Digital technologies streamline innovation ecosystem seizing through their convergent nature
"At the beginning we attracted them through LinkedIn, we contacted them by explaining what I was going to launch, we started like that. It was a word of mouth then. It was hard because I was coming from automotive, I was not in that sector and I didn't write a book, so I didn't have followers on LinkedIn, but we built it and we are building. Thanks to social media we could be efficient and faster to increase our awareness. Social media and LinkedIn were useful for the first contact to attract. I am a phygital person, I do every week an online event, and it is how I can keep in touch with my community members: India, Brazil, US, Europe, we are international, so for every day I prefer this online." (Case E)	Collection of feedback and data trial-and-error process	
"For the search of partners let's say that screening is there, and it is mainly on LinkedIn, or on the various sites or even on the network." (Case C)	Social media for User Attractionand Networking	
"We are a technology platform, and this favours the accessibility of our content. We also exploit the various LinkedIn channels to attract partners." (Case F)	Social media for User Attractionand Networking	
"People write a lot within the platform, and these are then the data that become key elements for the research that we do within the research team. We use artificial intelligence for research purposes so for example: people while learning write, or rather while writing they learn, these reflections that they jot down during the course that we offer, in addition to being analyzed by us as a research team in manual mode therefore with qualitative and quantitative techniques, we have trained an artificial intelligence model to give us back data that are indicators of effectiveness. " (Case F)	Feedback Collection due to Continuous Network Interaction	Proposition 3. Digital technologies extend innovation ecosystem transformation through their combinatorial nature
"Now we want more specific verticals on the area of the most advanced technologies to provide examples that can be a stimulus for companies on the one hand, and for possible consumers on the other, and therefore one of the possible themes that emerged during the Pollev is that of the metaverse, of the use of augmented reality, so that these technologies can be applied at several levels." (Case H)	Continuous Market and Desk Research	

Source(s): Authors' own creation

facilitate collaborative sensing by allowing organizations to collect and analyse large volumes of real-time data from diverse sources, enhancing the detection of emerging trends and weak signals in the environment (Warner and Wäger, 2019). This capability is critical in complex ecosystems where rapid changes require continuous environmental scanning and proactive identification of opportunities (Helfat and Raubitschek, 2018).

For instance, in Case B, virtual communication and research interactions led to the realization of a broader theme beyond simple web-calls, culminating in a focus on smart working. The director of Case B said, *"There was a specific unit about unified communication and collaboration, (i.e. integrated audio-video communication systems) and we had people that we involved in research and invited to events. Thanks to these interactions, facilitated by the possibility of virtual communication, and research, mainly on the internet, we realized that it was interesting to delve into the topic of technology, but in reality, this was a piece that served to explore an even bigger change that opened up a whole series of possibilities that had an impact on the way people worked: the smart working."*

In Case F, personal experiences validated by scientific research and digital technologies led to the creation of a digital training platform. Case F's co-founder & CEO shared, *"I was a manager in a large company, and the two times I became a mother, motherhood was seen as a problem from my company, when instead I realized that with motherhood I was improving a number of skills, so I wondered why, the same company that sent me for crisis management training, and for practice I used a simulator, didn't realize (the company) that I had crisis management practice with my daughter, on a daily basis, at high relevance, and with continuous feedback. Thanks to scientific research that confirmed this and the study of the EdTech market, I realized how this need was missing and how there was a need for a method of life-based learning."* The head of Research and Innovation added, *"The starting point is this: an idea that translates into a book, and in turn into a company that then materializes into a digital platform; a digital training platform that is primarily aimed at organizations."*

This pattern is also seen in Case E, where professional experience combined with digital platform creation fostered new business opportunities. An external collaborator expert of Case E added, *"It is a community built around the theme of platforms, of the net, founded a couple of years ago. The founder founded the community with the idea of creating a sort of community of interest in Europe, to pool knowledge, content, ideas and visions, on a relevant topic that is quite marginal in our society."*

Observation of the environment and market research facilitated by digital technologies also contribute to idea generation and validation. In Case D, observing market needs led to the creation of a platform for HR professionals to navigate digital transformation. The co-founder & CEO of Case D explained, *"The idea came about by looking at a need and looking at what decade we live in, the decade of the 10s was the one of digital transformation, in the early 20s with Covid we saw that digital transformation was far from complete, and that what had not worked in the previous decade was that it was understood, by digital transformation, something simply related to technology. Whereas digital transformation works when people are put at the center of the transformation process, and then technology becomes something useful to improve people's work. So, for me the 20s are the years of people transformation, and that's where the idea of helping the HR function and therefore companies in general to make this transformation came from."*

Case G similarly emerged from market observation and community interactions, leading to the establishment of a no-profit association. Case G's president shared, *"We just observed and listened, seeing what the members within our startup community were doing, and so instead of keeping the information restricted to just that network, we opened it up to others as well, creating a no-profit association"*.

Moreover, the role of these dynamics in the sensing phase should not be underestimated. Organizations with superior digital sensing capabilities can leverage data asymmetries to influence ecosystem trajectories, shaping how opportunities are identified and pursued (Adner, 2017; Jacobides *et al*., 2018). This strategic control over information flows can affect

competitive positioning and decisions within the ecosystem. The asymmetry can create dependencies among smaller actors of the ecosystem (Jacobides *et al*., 2018).

The importance of acting at an ecosystemic level for competitive advantage and survival is evident across the cases (Jacobides *et al*., 2018). For instance, Case F highlights the necessity of forming alliances and participating in ecosystems to grow and offer comprehensive services. Case F's co-founder & CEO explained, *"We have a series of partnerships in place, a series of allies with whom we are building a value chain of which we are just a piece. Looking ahead this is the only real existing way to grow, because as long as you are the only one offering a whole service it will always be a limited service, because you are a single innovative start-up, and you don't have broad shoulders. So, the idea of alliances and putting yourself within a supply chain, within an ecosystem is interesting and is necessarily the way of the future, and partly already of the present."*

This systemic approach is also evident in Case A, where collaborative research and value creation through ecosystem orchestration were fundamental from inception. Case A's Scientific Director said, *"The approach of doing research while remaining attached to reality was a fundamental starting point, coupled with the fact that there was a core of reference for conducting research, shared between the academy and several actors from the outside world. The initial founding group was made up of professors who by their very nature had a predisposition for applied and collaborative research with the business world and the outside world, so we already had several opportunities for confrontation with the outside world."*

In summary, digital technologies enhance innovation ecosystem sensing through their generative nature, facilitating idea generation, market validation, and the formation of collaborative networks (Yoo, *et al*., 2010, 2012; Fürstenau *et al*., 2023; Teece, 2018; Iansiti and Lakhani, 2020). These technologies support collaborative sensing, reduce information asymmetries, and foster early identification of opportunities through enhanced data-driven insights (Warner and Wäger, 2019). These aspects are crucial in validating the initial idea for ecosystem formation more effectively and quickly.

Proposition 1. Digital technologies enhance innovation ecosystem sensing through their generative nature.

4.2 Innovation ecosystem seizing

Once the direction and opportunity for an ecosystem are clear, developing seizing capabilities is essential to implement the idea into a successful business model. This phase involves creating a structure to support the value proposition, validating the business model, forming networks, attracting users, and managing customer relationships (Teece, 2007, 2018). Digital technologies streamline these processes through their convergent nature, enabling rapid feedback collection, dynamic resource allocation and efficient business model testing (Warner and Wäger, 2019; Iansiti and Lakhani, 2020). This convergence allows organizations to combine internal and external information, enhancing their ability to seize new opportunities efficiently (Haki *et al*., 2022). For example, Case D launched a digital MVP to quickly gather feedback and validate market interest, leading to a substantial number of initial members. Case D's co-founder & CEO said, *"We started with the club, doing an experiment, an MVP, we sensed that there was a need for continuous training, a new mindset for HR, so we launched the club, in a very short period of time (from when we thought and decided to launch it, to the actual launch, it was less than two months) and in less than three months we came to see that there was a concrete interest with 320 members initially in the club who showed us that we were on the right track, so we could continue."*

Similarly, Case G started with a digital MVP, quickly attracting members and validating the initiative (See Table 3). In Case E, Q&A sessions and surveys facilitated by digital platforms helped refine the business model based on user feedback. Case E's CEO & Founder explained, *"There was a Q&A section, and then we started asking users, then we had early members. We built a digital MVP and we started validating which was the best proposal, because at the*

beginning we had experts as a service like consulting, but we realized that during pitch people didn't know who is the writer of platform revolution, so we realized that it was better to have a place where to post content, create questions and answers and then asking to the people what is the best that was helping, we realized that posting the Q&A and the calendar that aggregates all events regarding the topic were most valuable propositions, and then we started to do The Network Talk, an interview and then there is a debate, where all the members have touch points every week and then you give the opportunity to talk to somebody that is doing the same as you, or you want to learn from."

Field experimentation and market research, supported by digital technologies, are critical for seizing opportunities. In fact, digital technologies such as cloud computing, data analytics, and automation tools enable organizations in rapid prototyping, real-time performance tracking, and adaptive learning cycles, thus enhancing their seizing capabilities (Teece, 2018; Idries *et al*., 2022). Case H conducted virtual workshops and research to gauge market interest and gather data. Senior researcher of Case H explained, *"The first workshop (supported to create engagement by the use of Pollev, surveys, and interactive games) was attended by those who wanted to, upon prior contact from us, and we explained the goals and why the initiative and topic was important. Participants were working in this area so when they responded to our call to action it was immediate to understand why. Following this kick-off workshop, we sent emails back to participants and other businesses that we were going to intercept, and we gave ourselves two three months to define the participation community, collect all the sign-ups, and then we started with the research and the various workshops where we presented the results with respect to the topic we decided to cover."*

In Case A, feasibility verification and partner attraction were significantly enhanced by digital tools, enabling efficient data collection and analysis. Director of Case A shared, *"Digital technologies come into play when there is a need to do the feasibility verification part of activating a new business unit, because for example we use automation solutions that allow us to retrieve key addresses using the LinkedIn service, which easily retrieves you the email addresses of people to contact to hear and identify the technical feasibility of starting a new business unit."*

Social media and digital channels play a vital role in user attraction and networking. Digital technologies – such as tools for real-time communication, project management, etc. – support collaboration among ecosystem actors. Furthermore, there can be tools for data sharing that foster coordination, reduce transaction costs, and improve the speed and quality of decision-making processes (Warner and Wäger, 2019). This collaborative advantage is critical when managing complex networks of stakeholders with diverse interests, as digital tools enable resource curation and foster ecosystem diversification (Haki *et al*., 2022). Case E utilized LinkedIn and social media to increase visibility and attract partners. An external collaborator expert of Case E said, *"Everything is enabled by digital technologies that, however, become standard technology, we talk about social media, so it is a necessary condition not sufficient but also a condition accessible by anyone. In the beginning, the founder strengthened the network mainly on LinkedIn increasing her visibility and that of her project, moving then to the proprietary platform."*

Case C similarly relied on LinkedIn to build a sustained network and engage partners. President of Case C said, *"We contact companies via LinkedIn, and over the years we have created a sustained network. Basically, the active sales channel is LinkedIn, but we also have passive channels, and many companies write in because we have been able to create some visibility over time."*

Additionally, power dynamics and resource dependencies emerge as critical factors during the seizing phase. Organizations with advanced dynamic capabilities often gain strategic advantages by controlling key data flows and influencing decision-making process within the ecosystem (Adner, 2017; Jacobides *et al*., 2018). Such control mechanism can shape competitive dynamics and impact the distribution of value across ecosystem participants (Idries *et al*., 2022). Overall, digital technologies streamline ecosystem seizing through their

convergent nature, by accelerating the validation process, improving feedback collection, and facilitating the efficient formation of networks and partnerships. These tools enhance the value proposition and streamline the go-to-market process, showcasing the convergent nature of digital technologies in this phase (Yoo, *et al*., 2010, 2012; Teece, 2018; Iansiti and Lakhani, 2020; Idries *et al*., 2022; Haki *et al*., 2022).

Proposition 2. Digital technologies streamline innovation ecosystem seizing through their convergent nature.

4.3 Innovation ecosystem transforming

Once a business is created, it must continuously adapt to external market dynamics and evolving customer needs. Transforming dynamic capabilities enable ecosystems to navigate these changes by renewing their structures and value propositions (Teece, 2007, 2018). Digital technologies, with their combinatorial nature, play a pivotal role in this phase by facilitating continuous feedback collection, market research, and the combination of information to generate new insights and opportunities (Yoo, *et al*., 2010, 2012; Fürstenau *et al*., 2023). This combinatorial nature reflects the ability of digital technologies to integrate diverse data streams, enabling knowledge recombination that supports continuous strategic renewal (Mele *et al*., 2023). For example, in Case A, digital solutions streamline internal coordination, enrich the value proposition, and provide real-time data to make informed decisions. Director of Case A explained, *"Today we use digital solutions to simplify all the organisational and administrative processes related to the management of our events. Then there are digital solutions that allow us to make informed awareness and decisions: yesterday I organised a conference, and thanks to the Power BI solution we have, we know daily how many people are registered for the conference, and it allows us to make comparisons with the same conference the year before, so that we can understand whether ad hoc actions are needed to boost the number of registered participants. Then there are a number of solutions that facilitate internal coordination, for example a CRM hub spot that is integrated with our emails, and that automates processes."*

Similarly, in Case F, the use of digital platforms and artificial intelligence facilitates continuous research and feedback collection, supporting ongoing transformation. Cases B and H demonstrate how digital technologies enable the identification of new trends and opportunities, ensuring that ecosystems remain relevant and competitive (See Table 3). Director of Case B said, *"The proposal as it was born continues to evolve, in fact compared to the first editions we have included a series of other activities, other interlocutors, broadened the focus no longer only on large companies but also small and medium-sized ones, as well as the Public Administration. So, in fact the organization always has the same objective but changes depending on the stimuli: what comes from partners, from the outside world and what we read in the literature. So, the proposal kind of adjusts and continues to evolve over time."*

In Case D, continuous interaction with ecosystem members and the use of digital surveys and newsletters helps anticipate market needs and adapt offerings accordingly. Co-founder & CEO of Case D shared, *"We have an extra piece because we are constantly observing what is happening within companies, collecting mainly best practices and we do this with our newsletter, which has 14,000 HR every week. So, we collect best practices from all the Italian companies and we do it with our observatories on the future of work, going on doing continuous surveys: we have done a survey on smart working in Italy, on corporate wellbeing, we have already done two and we are preparing a third one on the future of work trends of the year, another one done on the world of HR, and we will continue to do research in this sense. All this allows us to go and understand what the needs of the market are, and to be able to anticipate them and, above all, to satisfy them"*.

Moreover, digital technologies facilitate dynamic learning mechanisms, enabling organizations to continuously monitor performance, experiment with new approaches, and adjust strategies based on data-driven insights (Teece, 2018; Warner and Wäger, 2019). This

continuous learning capability is central to dynamic capabilities, supporting resilience and strategic agility in fast-changing environments (Mele *et al*., 2023; Kowalski *et al*., 2024).

Power dynamics also play a crucial role in the transforming phase. Organizations that control critical data infrastructures or possess advanced analytical capabilities can influence strategic decisions within the ecosystem, shaping value creation and distribution (Adner, 2017; Jacobides *et al*., 2018). These dynamics may create dependencies among ecosystem actors, reinforcing the strategic positioning of dominant players while challenging smaller organizations to adapt through collaboration and innovation.

Digital platforms and communities also facilitate the combination of information and data, leading to new insights and innovations. In Case E, the platform community helps stay updated on trends and generate new content based on user interactions. Case E's CEO & Founder explained, *"The best way to transform and be updated is through the platform community. Reports and feedback help us to discover new trends and opportunities. The community helps us to be dynamic."*

In summary, digital technologies extend innovation ecosystem transformation through their combinatorial nature, enabling continuous feedback collection, market research, the combination of information to generate new insights and strategic reconfiguration of resources to support adaptability and resilience (Yoo, *et al*., 2010, 2012; Fürstenau *et al*., 2023). These technologies are essential for sustaining competitiveness and navigating dynamic environments through data-driven decision-making and continuous learning.

Proposition 3. Digital technologies extend innovation ecosystem transformation through their combinatorial nature.

In Table 3 below, other quotes that gave rise to three propositions. In addition, we illustrate the aggregate theme (2nd order of coding).

(1) Proposition 1 has the following aggregated themes: Digital Research and Market Validation, Experience-Driven Insight supported by Digital tools, Creation of Digital Communities and Network.

(2) Proposition 2: Experimentation through digital MVP, Collection of feedback and data trial-and-error process, Social media for User Attraction and Networking.

(3) Proposition 3: Feedback Collection due to Continuous Network Interaction, Continuous Market and Desk research, Digital Combination of Information and Data to provide Insights. The latter is not represented in the Table, but quotes in this regard can be identified in the present section 4.3.

5. Discussion

Our research aimed to explore the intricate dynamics of orchestrating innovation ecosystems, specifically how digital technologies enhance the development of dynamic capabilities in the phases of sensing, seizing, and transforming. This exploration builds on established literature in the fields of dynamic capabilities and ecosystem theory, integrating insights from both seminal studies (Teece, 2007; Adner, 2006) and contemporary research on digital transformation (Warner and Wäger, 2019). Findings offer new insights into how digital technologies contribute to the orchestration of innovation ecosystems, highlighting their role not just as enablers of operational efficiency but as strategic tools for fostering dynamic capabilities across different stages of ecosystem evolution.

5.1 Macro-phenomenon: organizational competence for orchestrating innovation ecosystems for dynamic capabilities development

The basis for our analysis concerns the macro-theme of ecosystems, seen as a new way of representing the competitive environment, with new types of complementarities and new

forms of organising economic activities. Various actors and companies, through collaborative arrangements, combine their individual offers into a single solution that aims at satisfying the customer. The advantage of this approach lies in the fact that the value generated through collaboration exceeds the value that could be created individually, as it exploits internal synergies and complementarities of resources and competences. In accordance with Jacobides *et al.* (2018), the innovation ecosystem concept captures the interdependencies between firms that co-create value, enabling customers to benefit from integrated solutions that no single firm could deliver independently.

Past literature has analysed the different forms of ecosystems, highlighting the role of the system-level architect or orchestrator (Gulati *et al*., 2012; Adner and Kapoor, 2010; Dhanasai and Parkhe, 2006; Iansiti and Levien, 2004; Moore, 1993). The orchestrator plays a pivotal role, coordinating everyone's efforts across the ecosystem to create an effective organizational structure. This role is characterized by a systemic vision that enables the management of relationships among diverse actors, setting standards, defining governance structures, and establishing interfaces that foster alignment (Gulati *et al*., 2012). However, the literature predominantly focuses on the role of the orchestrator without thoroughly examining, as we have attempted in this study, the processes through which dynamic capabilities are developed to enable the creation and management of ecosystems in practice.

In fact, as Teece (2007) highlights (and as our findings corroborate), dynamic capabilities encompass a firm's ability not only to adapt to changes within an ecosystem but also to actively shape the ecosystem itself. This involves orchestrating resources, configuring value networks, and influencing the broader competitive environment.

Our study confirms the evidence of Adner (2006), who posits that the ecosystem orchestrators recognize the potential of collaborative systems where individual firm offerings are integrated to deliver superior value to end customers. What our case studies add, however, is the observation that this systemic perspective often emerges from the earliest stages of firm creation. Firms strategically position themselves as ecosystem architects from inception, embedding ecosystem thinking into their foundational strategies. This proactive approach reflects an awareness that competitive advantage increasingly depends on the ability to orchestrate complex networks of partners, rather than solely on internal firm capabilities (Adner, 2017; Jacobides *et al*., 2018). It is fully aware that the competitive arena is shifting more towards this ecosystem-oriented model (Adner, 2017), to the extent that new firms may struggle to survive if they do not embed themselves within – or actively build – ecosystems that enable alignment, interaction, and realization of their value proposition. Moreover, the role of power dynamics within ecosystems emerges as a critical factor influencing orchestrators' effectiveness. Organizations with greater control over key resources, data flows, or technological standards can shape ecosystem trajectories, reinforcing their strategic positioning while creating dependencies among smaller actors (Adner, 2017; Jacobides *et al*., 2018). This asymmetry highlights the importance of not only managing relationships but also navigating competitive tensions and potential conflicts of interest within the ecosystem.

Recent studies have emphasized the role of digital technologies in enabling ecosystem orchestration. (Steiber and Alvarez, 2024) highlight how artificial intelligence-based tools enhance collaboration, coordination, and organizational governance within ecosystems. Similarly, (Wolfert *et al*., 2023) illustrate how digital platforms structure interactions within agri-food ecosystems, demonstrating the broader applicability of these technologies beyond traditional sectors. Furthermore, (Primario *et al*., 2024) emphasize how open innovation strategies, facilitated by digital platforms, contribute to balancing competition and collaboration within innovation ecosystems.

Our research builds upon these contributions by examining how digital technologies support ecosystem orchestration within the EdTech industry, a context characterized by rapid innovation cycles and high technological intensity. While previous studies have highlighted the strategic importance of AI-driven tools and platforms (Steiber and Alvarez, 2024; Wolfert *et al*., 2023), our findings reveal how digital technologies act not only as coordination

mechanisms but also as strategic assets that enable the continuous development of dynamic capabilities. Unlike prior works that focus primarily on established ecosystems, we explore how digital technologies are leveraged from the early stages of ecosystem formation, contributing to both structural alignment and dynamic adaptability. This broader focus allows us to capture how digital technologies contribute to ecosystem orchestration across different phases of dynamic capability development, from sensing opportunities to transforming organizational structures.

While existing literature emphasizes the structural and strategic dimensions of ecosystem orchestration, it often overlooks the dynamic, capability-based processes that underpin effective orchestration.

Our research fills this gap by demonstrating that ecosystem orchestration is not merely about establishing governance structures but also about continuously developing and renewing dynamic capabilities. These capabilities – rooted in sensing opportunities, seizing them through resource mobilization, and transforming organizational processes – are fundamental to sustaining ecosystem health and competitive advantage (Teece, 2007, 2018).

In order to answer these questions, the evidence described in the previous chapter led to the building of a framework that starts from a macro view, as seen in Figure 1, in which we consider the organisational skills that an orchestrator needs to have from the early stages of foundation and orchestration. These realities, through the figures of the founders and CEOs, have changed their approach in that they are aware of the value that can be created jointly. However, it is necessary to break down this macro-theme to understand which organisational skills need to be developed to effectively orchestrate an ecosystem.

5.2 Micro-foundational level: phase of dynamic capabilities development and role of digital technologies

To answer the identified research question, the formation and orchestration of innovation ecosystems were analysed from a more detailed perspective. While the macro-level view highlights the orchestrator's strategic role, the micro-foundational level focuses on the development of dynamic capabilities that underpin ecosystem orchestration. By disaggregating dynamic capabilities into the phases of sensing, seizing, and transforming (Teece, 2007, 2018), we provide a granular understanding of how these capabilities emerge and evolve within ecosystems.

Through the application of a method of reductionism to constitutive phases, oriented towards the detailed definition of the individual components of the system for the understanding of the overall system concept (Honderich, 1995), this study breaks down the macro perspective – relating to the development of organizational competences – into its micro-foundational elements. Specifically, we identify how dynamic capabilities are not static competencies but are continuously shaped through iterative processes that involve strategic learning, resource reconfiguration, and knowledge integration (Foss *et al.*, 2023; Teece, 2018).

As illustrated in Figure 2, this process allowed us to advance the conceptual framework and highlight the distinct roles digital technologies play in different phases of dynamic capability development.

Our findings demonstrate that digital technologies are not just enabling tools but act as critical catalysts in the orchestration process, with their influence varying across the sensing, seizing, and transforming phases.

Recent research emphasizes the importance of micro-foundations in the development of dynamic capabilities within digital ecosystems. Kowalski *et al.* (2024) identify specific micro-

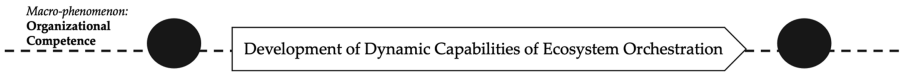

Figure 1. Macro-level of the framework. Source: Authors' own creation

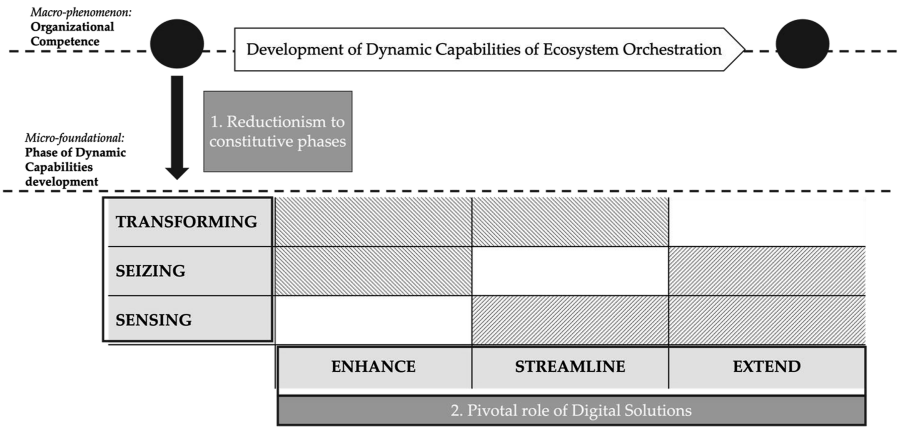

Figure 2. Micro-foundational level of the framework, phase of dynamic capabilities. Source: Authors' own creation

foundations such as "Digital Sensing" and "Digital Analytics Innovation Management" as critical enablers of organizational adaptability. Their findings indicate that digital sensing and data analytics are essential to capturing emerging trends and integrating knowledge within ecosystems. While Kowalski *et al*. (2024) emphasize the relevance of data-driven practices, our findings extend this perspective by demonstrating how digital technologies support not only knowledge integration but also the orchestration of relationships among diverse actors, facilitating alignment and value co-creation across the ecosystem. Similarly, Pundziene *et al*. (2022) highlight that open innovation practices mediated by digital platforms can enhance dynamic capabilities by facilitating knowledge exchange and collaborative innovation. Specifically, their findings suggest that platforms act as integrative mechanisms, enabling firms to mobilize resources, share knowledge, and accelerate innovation processes through collaborative networks. This structural role of platforms is particularly relevant for the seizing phase, where rapid prototyping and iterative feedback loops are essential for capturing value.

Although Pundziene *et al*. (2022) emphasize the critical function of digital platforms in supporting open innovation, our study demonstrates that that digital technologies contribute to dynamic capabilities not only through platforms but through a wider spectrum of tools. Specifically, AI-driven analytics, cloud infrastructures, and collaborative technologies collectively enhance dynamic capabilities across all phases of ecosystem orchestration. This finding is consistent with Helfat and Raubitschek (2018), who emphasize the structural role of platforms but do not account for the broader digital tools that orchestrators leverage to navigate complex ecosystems. By demonstrating how these tools facilitate alignment, value co-creation, and strategic flexibility, our study provides a more comprehensive understanding of the mechanisms through which digital technologies shape ecosystem dynamics.

5.2.1 Role of digital technologies in each phase. In the sensing phase, digital technologies – such as big data analytics and AI-driven platforms – facilitate environmental scanning, trend analysis, and the identification of emerging opportunities. This aligns with the literature emphasizing the generative nature of digital technologies, which fosters continuous innovation through the dynamic recombination of information (Fürstenau *et al*., 2023; Yoo *et al*., 2010). In our cases, the ability to rapidly identify emerging trends was supported by tools that enabled real-time market monitoring and advanced data processing, confirming how digital technologies enhance the firm's opportunity recognition capabilities.

In the seizing phase, they streamline the resource mobilization process, enabling rapid prototyping, real-time feedback loops, and effective ecosystem coordination. This is

particularly evident in the development of agile resource orchestration capabilities, where digital tools facilitate experimentation, quick iterations, and adaptive responses to market feedback. For example, Case D's ability to launch a digital MVP and quickly validate its business model illustrates how digital technologies accelerate the trial-and-error process, reducing time-to-market and supporting strategic decision-making (Warner and Wäger, 2019). This finding complements Warner and Wäger's (2019) model by showing how specific digital capabilities—like rapid prototyping and data-driven decision-making—are crucial for capturing value in dynamic environments.

In the transforming phase, digital technologies support continuous learning, adaptive change, and the reconfiguration of organizational structures to sustain long-term competitiveness. Here, the key dynamic capability is strategic adaptability, enabled by advanced data analytics, cloud platforms, and collaborative tools that allow organizations to pivot their strategies based on real-time insights. Our cases demonstrate how firms leverage digital technologies not only to optimize current operations but also to drive organizational renewal and ecosystem-wide transformation (Teece, 2018; Mele *et al*., 2023).

The literature widely acknowledges the strategic importance of digitalization, and thus the use of digital solutions in organisational and managerial settings, in fostering competitive advantage, both for established firms and new ventures (Eller *et al*., 2020; Fitzgerald *et al*., 2014; Hess *et al*., 2016; Liu *et al*., 2011). Warner and Wäger (2019) argue that *"digital transformation is an ongoing process of using new digital technologies in everyday organisational life to develop dynamic capabilities"* and create a model that identifies nine digital dynamic capabilities enabling a connection between these two constructs. Motamedimoghadam *et al*. (2024) identify four key clusters of digital innovation capabilities – sensing, analytic-driven, digital platform, and orchestration – that enhance firms' adaptability.

While their study focuses on firm-level innovation, our research extends this framework to ecosystem orchestration, showing how digital sensing, platforms, and orchestration co-evolve to shape industry-wide transformation. Moreover, our research highlights that the role of digital technologies extends beyond operational efficiency to encompass strategic orchestration functions. Digital technologies act as enablers of ecosystem-wide coordination, reducing information asymmetries, fostering real-time communication, and enabling the integration of diverse actors across geographical and organizational boundaries. While the literature often focuses on the transformative potential of platform-based ecosystems (Helfat and Raubitschek, 2018; Teece, 2018), our findings suggest that digital technologies – beyond platforms – are instrumental in shaping the micro-foundations of dynamic capabilities. This includes enhancing sensing through data analytics, facilitating seizing through agile resource management, and enabling transforming through continuous learning mechanisms.

Although this study focuses on the EdTech sector, the mechanisms identified are likely transferable to other industries undergoing digital transformation. The EdTech industry provides a fertile ground for studying these dynamics due to its rapid pace of innovation, high reliance on digital tools, and the presence of diverse ecosystem actors, ranging from startups to established ecosystems. Nevertheless, the principles observed – such as the role of digital technologies in dynamic capability development – can be generalized to industries where ecosystem orchestration and digital technologies are equally pivotal, including.

(1) *Healthcare*, where digital platforms facilitate telemedicine, AI-driven diagnostics, and patient data management, requiring continuous sensing, seizing, and transforming capabilities;

(2) *Fintech*, where blockchain, digital payment systems, and AI-powered risk assessment tools demand real-time adaptability and strategic ecosystem coordination;

(3) *Advanced manufacturing*, where IoT-enabled production, real-time analytics, and digital twins drive continuous innovation and operational transformation.

Each of these sectors faces similar challenges in orchestrating ecosystems, leveraging digital tools for innovation, and developing dynamic capabilities to sustain competitive advantage. Thus, while our findings emerge from the EdTech industry, they provide a broader theoretical framework applicable to any industry navigating rapid technological change.

In sum, our findings emphasize that digital technologies are not mere operational enablers but strategic assets that shape the micro-foundations of dynamic capabilities. Their differentiated roles across sensing, seizing, and transforming phases underscore the complex, multifaceted nature of digital technologies in ecosystem orchestration.

5.3 Specific nature of digital technologies

Having established the pivotal role that digital technologies in the development of dynamic capabilities that underpin ecosystem orchestration, it is essential important to understand the key characteristics that make these technologies effective for ecosystem development. Digital technologies, as highlighted by Yoo *et al.* (2010, 2012), foster innovation through their generative, convergent and combinatorial nature. Our analysis, as depicted in Figure 3, reveals a clear correlation between these distinctive characteristics and their role in shaping key higher-order dynamic capabilities (sensing, seizing, transforming) involved in the orchestration of the innovation ecosystems.

This contribution advances the discussion on the nature of digital technologies beyond what has been discussed in prior literature (Fürstenau *et al*., 2023; Yoo, *et al*., 2010, 2012), emphasizing their applicability in the context of innovation ecosystems. Specifically, we demonstrate how these characteristics are not merely technological attributes but strategic enablers of ecosystem orchestration, influencing how firms create, capture, and sustain value within innovation ecosystems.

5.3.1 Generative nature and sensing. The generative nature of digital technologies, as discussed by Fürstenau *et al*. (2023), can be viewed from both a product perspective and in terms of enhancing social interactions. Our research confirms how digital technologies facilitate, validate and channel the intuition of orchestrators, supporting the early stages of opportunity recognition and ecosystem creation. For instance, in Case A and Case H, digital tools such as internet research and virtual communication channels enabled organizations to identify market gaps and validate their initial intuitions, thereby enhancing the dynamic capability of sensing (Adner, 2017; Helfat and Raubitschek, 2018) and developing a new business model.

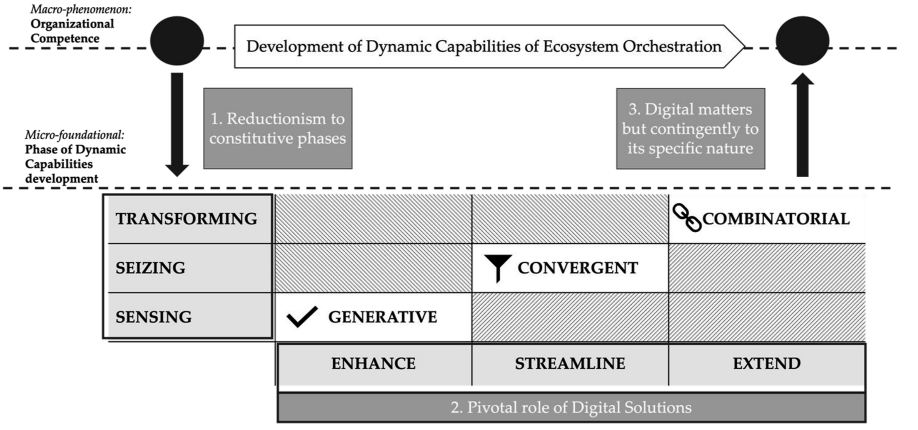

Figure 3. Theoretical Framework, development of dynamic capabilities of ecosystem orchestration and the role of digital solutions. Source: Authors' own creation

Digital solutions that were previously seen as fixed and unchangeable have proven to be dynamic, fundamentally transforming the organizational functioning of companies (Yoo, *et al*., 2010, 2012). These solutions facilitate interactions through platforms that highlight need and strategic direction within the competitive environment. They act as validators of the idea, especially for the creation of ecosystems, by enabling the formation of a network through platforms that implement a systemic vision from the outset, increasing the uncoordinated user base (Fürstenau *et al*., 2023). For example, in Case A, the frustration over the lack of reliable data on digital transformation led to the creation of an entirely new ecosystem, supported by online data sources and digital market analysis tools.

However, Fürstenau (2023) emphasises that the generative nature does not guarantee unlimited expansion. The boundaried of generativity are often determined by the orchestrator based on the desired level and degree of ecosystem growth, as well as the types of members to be included.

The introduction of new tools or functionalities to existing products alter roles, functions and control mechanism within the ecosystem (Yoo, *et al*., 2010, 2012), creating new dynamics for value generation. The connections generated through these technologies bring together supply and demand, supporting constructive dialogues on value creation and reinforcing systemic insights through continuous digital interactions.

A particularly relevant aspect concerns the volume of data generated by digital technologies (Yoo, *et al*., 2010, 2012), which is then transmitted and analysed to form the basis for idea generation and innovation validation. In the sensing phase, this data flow plays a crucial role in confirming the strategic directions identified by ecosystem founders. Thus, the generative nature of digital technologies is crucial for effectively and rapidly validating ideas during the ecosystem formation phase. However, this feature is particularly beneficial in the sensing phase. In subsequent phases, such as seizing, the large volume of generated information may slow down the processes of business model testing and market validation. The extensive evaluation and analysis of disparate data could hinder the agile decision-making required during the seizing phase, where focus and speed are critical for success.

5.3.2 Convergent nature and seizing. The convergent nature of digital technologies refers to their ability to integrate previously distinct systems, processes, and data sources, enabling organizations to create unified environments where collaboration, decision-making, and resource mobilization are streamlined (Yoo *et al*., 2010, 2012). In the context of innovation ecosystem orchestration, this convergence plays a critical role in the seizing phase, where firms must rapidly transform identified opportunities into concrete business models and value propositions (Teece, 2007, 2018).

Convergence facilitates the dynamic capability of opportunity capture, allowing orchestrators to gather and synthesize feedback from diverse ecosystem actors, coordinate resource allocation efficiently, and accelerate time-to-market. By reducing information silos and fostering seamless collaboration between stakeholders, digital technologies enhance firms' agility in responding to evolving market conditions (Warner and Wäger, 2019).

For example, in Case D, the orchestrator leveraged a digital MVP (Minimum Viable Product) to quickly test market interest and attract initial members. The digital MVP served as a convergence point for feedback from various ecosystem participants, enabling the organization to iterate on its value proposition based on real-time user input. As noted by the co-founder of Case D, the ability to move from concept to launch in under two months—and validate the initiative with over 300 engaged members shortly after—demonstrates the speed and adaptability enabled by digital convergence. This rapid feedback loop exemplifies how digital technologies facilitate trial-and-error learning within compressed timeframes, enhancing strategic responsiveness.

Similarly, in Case E, digital technologies supported Q&A sessions, surveys, and interactive workshops, enabling continuous feedback loops from the ecosystem's early adopters. These tools provided critical insights into user needs and fostered collaborative spaces where stakeholders co-created solutions. The integration of communication channels, data collection

tools, and user engagement platforms allowed the orchestrator to refine service offerings dynamically, optimizing the business model in response to emerging trends.

In Case G, digital MVPs served as experimental platforms for new initiatives, allowing the organization to pivot quickly based on stakeholder feedback. The ability to integrate data from diverse actors—ranging from partners to end-users—reduced the risks typically associated with innovation. This highlights how convergence enhances strategic flexibility, enabling firms to adapt swiftly to new opportunities while minimizing the costs of failed experiments.

Moreover, the network effects enabled by convergent digital technologies amplify their impact. As more actors join the ecosystem, the value of the network increases exponentially due to the enhanced flow of information, ideas, and resources. This dynamic is evident in Case C, where tools like LinkedIn were strategically utilized to build a robust network of partners and clients. The integration of professional networking, content dissemination, and direct engagement channels allowed the orchestrator to expand the ecosystem's reach and influence rapidly. As more participants interacted within the digital environment, the ecosystem's value proposition became more compelling, attracting even more stakeholders in a self-reinforcing cycle of growth.

However, the convergent nature of digital technologies must be managed carefully. While convergence enhances efficiency and accelerates the seizing process, over-reliance on convergent structures can lead to rigidity. Organizations may become overly dependent on established networks, tools, or processes, limiting their ability to explore novel opportunities or adapt to disruptive changes. This risk of path dependency can constrain long-term innovation, as firms may inadvertently prioritize incremental improvements over transformative shifts. To mitigate this, orchestrators should adopt dynamic reconfiguration mechanisms, such as modular system architectures, diversified collaboration models, and periodic ecosystem reviews to ensure continuous adaptability.

In summary, the convergent nature of digital technologies plays a pivotal role in the seizing phase of ecosystem orchestration by enabling efficient resource coordination, rapid market validation, and the amplification of network effects. However, to sustain long-term competitiveness, organizations must remain vigilant against the potential downsides of over-convergence, ensuring that their ecosystems retain the adaptability needed for continuous growth and renewal.

5.3.3 Combinatorial nature and transforming. The combinatorial nature of digital technologies refers to their ability to enable the dynamic recombination of existing resources, knowledge, and capabilities, allowing firms to reconfigure their value-creation processes and sustain competitive advantage within ecosystems (Teece, 2007; Yoo *et al*., 2010, 2012). In the transforming phase of dynamic capability development, this characteristic plays a pivotal role by facilitating ongoing renewal, knowledge integration, and ecosystem-wide adaptability (Teece, 2018; Fürstenau *et al*., 2023).

Combinatorial digital technologies allow orchestrators to aggregate and synthesize insights from multiple sources, integrating diverse perspectives and enabling real-time adjustments to strategies and business models. This flexibility is particularly valuable in innovation ecosystems, where new value propositions emerge through iterative interactions between stakeholders, digital infrastructures, and evolving market needs (Fürstenau *et al*., 2023). For example, in Case A, digital technologies played a key role in continuously refining the organization's offerings through data-driven decision-making and strategic adaptation. By leveraging advanced analytics and real-time data flows, the orchestrator could identify shifting market demands and adjust its services accordingly, ensuring sustained ecosystem relevance. Similarly, in Case F, the use of digital tools enabled the organization to integrate insights from research, user feedback, and AI-driven analytics to refine its value proposition dynamically. The ability to rapidly test, learn, and iterate illustrates how the combinatorial nature of digital technologies fosters continuous renewal.

Moreover, AI-powered tools and collaborative digital solutions enable organizations to combine knowledge across ecosystem actors, leading to the co-creation of new services and

business models. In Case E, for instance, digital solutions facilitated continuous learning within the ecosystem, allowing members to generate insights from prior interactions, adapt to emerging challenges, and collectively drive innovation. This ongoing recombination of expertise, facilitated by cloud-based collaboration tools and interactive digital environments, highlights the strategic role of digital technologies in ensuring that ecosystems remain dynamic and competitive.

The modularity of digital solutions further amplifies their combinatorial potential, as organizations can selectively integrate new capabilities, experiment with different configurations, and scale innovations with minimal friction (Yoo *et al*., 2010, 2012). This modularity also mitigates risks associated with technological lock-in, ensuring that ecosystems can evolve dynamically without becoming overly reliant on specific tools or configurations. Unlike in the sensing and seizing phases, where digital tools support opportunity recognition and rapid market entry, the transforming phase requires ongoing reconfiguration and adaptation to sustain competitive advantage.

However, while the combinatorial nature of digital technologies enhances ecosystem adaptability, it also introduces complexity management challenges. Without deliberate orchestration mechanisms, the unstructured recombination of data, insights, and digital assets can lead to inefficiencies, misalignment between actors, or strategic drift (Teece, 2018). This risk arises particularly when multiple ecosystem stakeholders pursue parallel but uncoordinated initiatives, creating fragmentation rather than convergence toward shared value creation. Organizations must balance the exploration of new opportunities with the need for coherence and strategic alignment, ensuring that digital-enabled transformations contribute to long-term ecosystem health rather than creating fragmented or unsustainable shifts.

The combinatorial nature of digital technologies plays a fundamental role in the transforming phase of ecosystem orchestration by enabling continuous learning, strategic adaptation, and the dynamic recombination of capabilities. However, effective governance structures are needed to ensure that this combinatorial potential translates into sustainable and strategically aligned transformations. By leveraging digital tools to orchestrate structured knowledge integration and ecosystem-wide innovation, firms can extend their competitive advantage while ensuring long-term ecosystem resilience.

6. Conclusion

Today's competitive environment is increasingly characterized by collaborative organizational forms, where firms coalesce into innovation ecosystems to co-create and capture value. The digitalization of business processes has further accelerated this shift, making ecosystem orchestration a critical capability for firms operating in dynamic markets (Adner, 2006, 2017; Jacobides *et al*., 2018). Digital technologies play a pivotal role in this transformation, providing firms with the tools needed to identify opportunities, mobilize resources, and continuously adapt their strategies (Singh and Hess, 2017; Warner and Wäger, 2019; Yoo, *et al*., 2010, 2012).

This study contributes to the advancing literature on innovation ecosystems, dynamic capabilities, and digital transformation, integrating insights from both classical and recent research (Adner, 2006; Adner, 2017; Adner and Kapoor, 2010; Felin and Foss, 2023; Foss *et al*., 2023; Helfat, 2007; Helfat and Raubitschek, 2018; Jacobides *et al*., 2018; Linde *et al*., 2021; Kowalski *et al*., 2024, etc.) Additionally, we also build on recent advancements in digital transformation studies, particularly those that examine the intersection of digital technologies and dynamic capabilities (Idries *et al*., 2022; Haki *et al*., 2022; Mele *et al*., 2023; Kowalski *et al*., 2024).

By examining multiple EdTech cases, this study develops a nuanced framework for understanding how digital technologies enhance dynamic capabilities in ecosystem orchestration across the sensing, seizing, and transforming phases. Our findings offer both

theoretical insights and managerial guidance for firms navigating digital transformation within innovation ecosystems.

6.1 Theoretical implications

This study provides several theoretical contributions to the literature on innovation ecosystems, dynamic capabilities, and digital technologies. It extends the understanding of how digital technologies enhance dynamic capabilities in ecosystem orchestration, distinguishing their roles in the sensing, seizing, and transforming phases (Teece, 2007, 2018). Prior research has explored the role of digital transformation at the firm level (Warner and Wäger, 2019; Linde *et al*., 2021; Motamedimoghadam *et al*., 2024; Kowalski *et al*., 2024), emphasizing how dynamic capabilities enable firms to enhance internal processes, optimize resource allocation, and develop data-driven innovation strategies. However, while these studies focus on firm-specific transformation strategies, our research shifts the focus to the orchestration of innovation ecosystems, demonstrating how digital technologies extend beyond intra-organizational processes to shape inter-organizational dynamics and ecosystem-level orchestration. Specifically, we contribute to the debate on how firms leverage digital technologies not only for internal capability development but also to coordinate, align, and sustain multi-actor innovation networks.

Generative digital technologies such as AI-driven analytics and real-time data processing support sensing, enabling firms to detect weak signals and anticipate shifts in ecosystem dynamics (Fürstenau *et al*., 2023; Idries *et al*., 2022). Convergent digital technologies, including digital MVPs and integrated communication platforms, accelerate seizing, allowing firms to iterate, refine, and scale new value propositions (Warner and Wäger, 2019; Haki *et al*., 2022). Combinatorial digital technologies, such as modular AI solutions and cloud-based collaboration tools, facilitate transforming, fostering continuous renewal and strategic adaptability (Mele *et al*., 2023; Kowalski *et al*., 2024).

This study also refines Yoo *et al*.'s (2010, 2012) conceptualization of digital generativity, convergence, and combinatoriality, demonstrating how these characteristics must align with specific phases of dynamic capability development. Our findings suggest that a misalignment between technology type and ecosystem phase can hinder orchestration. For instance, excessive reliance on generative technologies in the seizing phase may lead to information overload, slowing decision-making. This insight refines previous research by emphasizing the importance of phase-specific deployment of digital tools (Fürstenau *et al*., 2023).

Furthermore, our study reinforces that successful ecosystem orchestrators strategically position themselves from inception, actively shaping, coordinating, and aligning value co-creation processes (Adner, 2006; Jacobides *et al*., 2018). This finding extends prior research by highlighting digital technologies as key enablers of early-stage ecosystem formation and long-term governance. Additionally, our insights on the role of digital technologies in power asymmetries contribute to discussions on ecosystem strategy and governance (Haki *et al*., 2022).

By situating our work within the broader discourse across academia and practice, we address recent calls for research emphasizing the importance of understanding how digital technologies shape dynamic capabilities across diverse contexts (e.g. Kowalski *et al*., 2024; Pundziene *et al*., 2022). Recent studies have increasingly explored how digital technologies enhance innovation ecosystems in various sectors – such as the agri-food industry (Wolfert *et al*., 2023) and advanced manufacturing (Nour and Arbussà, 2024). While Kowalski *et al*. (2024) emphasize the role of data-driven analytics and Pundziene *et al*. (2022) highlight the importance of digital platforms in supporting open innovation, our research provides an integrative framework that acknowledges the interdependence of generative, convergent, and combinatorial digital technologies. By illustrating how these technological characteristics collectively contribute to ecosystem orchestration, our study extends existing frameworks by offering a holistic approach that is applicable across multiple domains.

Through this broader perspective, we advance theoretical discussions on digital ecosystems, dynamic capabilities, and innovation orchestration, while also providing practical insights for managers seeking to leverage digital infrastructures to sustain ecosystem evolution.

6.2 Managerial implications

This study provides actionable insights for managers seeking to orchestrate innovation ecosystems effectively using digital technologies. It clarifies the specific roles of digital tools in dynamic capability development and offers guidance on ecosystem management strategies.

The findings emphasize that organizations must leverage digital technologies strategically to enhance sensing capabilities, ensuring that market trends, weak signals, and emerging needs are identified efficiently. AI-driven analytics, for instance, can support decision-makers in navigating complexity by distilling actionable insights from vast amounts of data. However, managers must ensure that data collection is targeted and relevant, avoiding excessive information overload that could hinder effective decision-making.

During the seizing phase, managers should focus on deploying digital MVPs, interactive feedback mechanisms, and social engagement platforms to refine business models rapidly. Digital platforms facilitate collaborative experimentation, allowing firms to quickly validate market fit, co-create solutions with partners, and adjust strategies based on user feedback. The case examples illustrate how organizations that leveraged digital solutions to orchestrate iterative learning cycles significantly reduced time-to-market and improved ecosystem coordination.

In the transforming phase, managers must develop modular digital infrastructures that support continuous reconfiguration of capabilities. Cloud-based collaboration tools, AI-driven analytics, and flexible digital governance mechanisms enable firms to sustain ecosystem-wide adaptability, ensuring that partners remain aligned despite evolving market dynamics.

Beyond these phases, this study highlights the importance of managing power asymmetries in innovation ecosystems. As discussed in previous sections, dominant players often control critical digital infrastructures, data flows, and decision-making protocols, shaping ecosystem evolution in ways that may disadvantage smaller actors. To mitigate these risks, managers should implement transparent governance frameworks, decentralized decision-making processes (e.g. blockchain-based governance), and flexible participation models that ensure inclusivity while preserving innovation incentives.

Furthermore, the increasing reliance on digital technologies for ecosystem orchestration has broader societal implications, particularly in shaping public perceptions of innovation and transformation in education. The adoption of AI-driven learning platforms, real-time data-driven decision-making, and collaborative digital tools not only enhances operational efficiency but also influences how stakeholders – students, educators, and policymakers – view the legitimacy, effectiveness, and accessibility of digitally enabled education ecosystems. These dynamics highlight the responsibility of organizations to balance technological advancement with governance structures that promote inclusivity, trust, and fair value distribution within the ecosystem.

This study provides systematic guidance for managers and policymakers, particularly regarding the societal implications of digital innovation in education. Organizations that balance digital integration with adaptive governance structures will be better positioned to sustain competitive advantage and navigate the complexities of innovation ecosystems.

6.3 Limitations and future research recommendations

While this study provides valuable insights into the orchestration of innovation ecosystems, several limitations suggest avenues for future research.

A key limitation is sectoral focus. The study focuses on the EdTech industry, which represents an ecosystem with high digital adoption, strong interdependencies, and diverse stakeholders. To narrow the scope, we chose a representative sector, EdTech, which is one of the most evolving sectors at the moment (Shan and Wade, 2023). However, the findings are likely transferable to other sectors undergoing digital transformation, such as healthcare, fintech, and advanced manufacturing, where digital orchestration plays a similarly critical role. Future research should explore how industry-specific dynamics influence digital ecosystem strategies, providing comparative insights across multiple contexts.

Another limitation is the qualitative nature of the study, which provides rich insights but limits generalizability. Future research should incorporate quantitative validation to measure the impact of digital technologies on ecosystem agility, dynamic capability performance, and network resilience. Survey-based studies, longitudinal analyses, and econometric modelling could provide a more precise understanding of causal relationships between digital orchestration mechanisms and ecosystem outcomes. For instance, Capurro *et al*. (2022) demonstrate how Big Data analytics can enhance firms' dynamic capabilities by providing deeper insights into the intersections between digital and physical worlds. Incorporating such analytical tools into quantitative studies could reveal more granular mechanisms of ecosystem orchestration.

Additionally, emerging technologies such as blockchain, AI, and IoT are likely to reshape digital ecosystem orchestration in ways that extend beyond the findings of this study. Future research should explore how AI enhances sensing through predictive analytics, how blockchain improves governance through decentralized trust mechanisms, and how IoT expands ecosystem integration by enabling real-time data-driven decision-making. Zabel and O'Brien (2024) emphasize the importance of understanding how sensing, seizing, and transforming capabilities evolve in highly uncertain environments, particularly in emerging technology markets. Investigating these dynamic capabilities across various technological contexts could provide deeper insights into their transformative potential and reveal new micro-foundations for digital ecosystem orchestration.

Finally, future studies could examine how successful ecosystems evolve over time, identifying best practices for long-term sustainability and resilience. Conducting in-depth longitudinal case studies of mature ecosystems could uncover governance models, digital strategies, and capability configurations that contribute to ecosystem longevity and competitiveness. Investigating how generative, convergent, and combinatorial technologies interact over time to enhance ecosystem resilience could provide valuable contributions to the literature on dynamic capabilities and innovation ecosystems.

By addressing these research directions, in line with recent calls for comprehensive frameworks that account for technological, strategic, and governance aspects of ecosystem orchestration (Kowalski *et al*., 2024; Primario *et al*., 2024; Steiber and Alvarez, 2024; Pundziene *et al*., 2022; Agostini *et al*., 2020), scholars can advance theoretical models and provide empirical insights into the next frontier of digital ecosystem orchestration.

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