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Dynamic Capacities and Value Creation in Digital Innovation Ecosystems: An Empirical Study of European EDIHs

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Abstract: The Digital Europe Programme is a new EU initiative to fund the development of digital innovation ecosystems known as European Digital Innovation Hubs (EDIHs). The European Commission sees these hubs as key actors in increasing the digitalisation of SMEs and promoting competitiveness.

This study examines the value creation and dynamic capabilities of EDIH ecosystems by mapping 31 ecosystems. The aim is to understand the formation of the ecosystem's value network and its key drivers. We will discuss with EDIH the ongoing efforts to develop dynamic capabilities for value creation. Our results reveal the most significant value creation areas in the EDIH ecosystem and identify five levels of multidimensional value-creating practices. We propose to link dynamic capacities and value creation in Europe's digital innovation ecosystems.

Keywords: Digital Innovation Ecosystem; European Digital Innovation Hubs; Digital Capabilities; Value Creation, Co-Creation Value Creation, Innovation Management.

1 Introduction

The European Commission selected 151 European Digital Innovation Hubs (EDIHs)[1] for its Digital Europe program[2], underscoring the significance of digital innovation ecosystems. These networks, rich in innovative actors and resources, encourage innovation and value creation.[3,4] Interest in these ecosystems has surged, with researchers applying Service-Dominant Logic (SDL) to examine value co-creation in digital transformation.[5] SDL posits that service value maximizes when businesses and digital

technologies align with ecosystem service goals. Despite this interest, studies on how digital transformation facilitates value creation within and for companies are limited.[6] Value in ecosystems like EDIHs emerges through cooperation, integration mechanisms, information-sharing clusters, and innovation. The ecosystem concept, likened to biological systems, illustrates the complex interactions among innovation stakeholders. However, the role of EDIHs in value creation, dynamic capabilities, interoperability, and productivity, especially in emerging markets, remains underexplored. Innovation ecosystems have permeated strategy, innovation, and business discussions, offering diverse definitions and contexts. These ecosystems, extending beyond mere platforms, are complex networks that promote innovation and strategic growth. Management literature has delved into business ecosystems' nature, innovation mechanisms, and their competitive advantage. Digital ecosystems, characterized by decentralization, adaptability, and self-organization, have merged with business ecosystems to form digital business ecosystems (DBEs). However, relying solely on business ecosystems may not suffice for manufacturing success, highlighting the necessity of integrating with digital ecosystems. DBEs are analyzed for their network, value co-creation, collaboration, data management, and strategy. Yet, the specific contributions of DBEs to EDIH networks in nascent markets lack thorough examination.

This article aims to bridge this gap, focusing on the evolution of digital innovation ecosystems, particularly EDIHs. It investigates the objectives, dynamic capabilities, and value network creation within these ecosystems and their benefits and value creation for SMEs in the manufacturing sector. The study employs a multi-method approach, combining surveys, interviews, and literature reviews, and analyses data through content analysis.

Research questions include:

What are the objectives, dynamic capabilities, and value network creation of digital innovation ecosystems (EDIHs)?

What are the key benefits, dynamic capabilities, and value creation of European digital innovation ecosystems (EDIHs) for SMEs in the manufacturing sector?

The findings contribute to both theoretical and empirical discussions on ecosystem management, offering directions for future research. The article concludes by highlighting its advancements in the field.

2 Literature review

2.1 Value Creation in Digital Innovation Ecosystems

A Digital Innovation Ecosystem is a dynamic network of interdependent entities that collaborate to innovate digital solutions, differing from natural ecosystems which involve biological and environmental interactions[7]. The process of value creation frequently reaps the benefits of collaboration and co-creation among organizations[8], and contemporary

research has particularly emphasized the potential value derived from collaboration between public and private organizations.[9]

This concept evolves from Moore's (1993) business ecosystem idea, with digital platforms playing a crucial role[10]. These platforms enable organizations to efficiently provide sophisticated services at an unprecedented scale.[11] Their use has surged recently, with companies like Apple, Microsoft, and Amazon leading the way[12]. Concurrently, numerous manufacturers grapple with leveraging digital platforms[13]. Cheng et al. (2020) proposes that within digital innovation ecosystems, digital platforms can facilitate collaboration across the value chain in areas such as product development, joint manufacturing, operation, and maintenance[14] Actors within the digital innovation ecosystem engage in value sharing through digital value networks[15]. It raises questions about the creators of value and the distribution of this value, contingent on the interaction among the actors in the digital innovation ecosystem. This is not necessarily dictated or favored by the system's initiator.

Within digital innovation ecosystems, the principal attributes encompass: 1) size/density, which refers to the count of actors within the ecosystem, 2) vitality, denoting the quantity of actors entering or exiting the ecosystem, 3) diversity, indicating the variances within and among groups of actors, 4) structure, describing the organization of actors along with their relationships and activities, and 5) resilience, a measure of the ecosystem's ability to withstand changes.[16] Constituents encompass infrastructure, regulation, capital, data, knowledge, innovations, interface between actors, platform solutions[17], corporations, consumers, suppliers, regulators[18], entrepreneurs, employees, investors, mentors, universities, and an entrepreneurial culture[19].

Digital innovation ecosystems, encompassing diverse entities like universities and private R&D labs, are heterogeneous systems supplementing existing networks. Despite their independence, these actors contribute to the ecosystem's upkeep and assist others in their endeavors. European Digital Hubs, overseen by a coordinator, aim to enhance the digital capacity of the SME sector[17]. Resilience in these ecosystems is crucial to ensure their ability to support vital infrastructure during crises and adapt to (geo)political shifts and natural disasters[20].

2.2 Digital Servization value Co-Creation Framework for EDIH Services

The European Commission promotes European Digital Innovation Hubs (EDIHs) to foster an ecosystem providing diverse expertise to SMEs and startups. Each EDIH collaborates with regional partners to amalgamate expertise, identify needs, and join a

network of EDIHs, forming a pan-European innovation ecosystem[21,22,23]. Innovation ecosystems focus on value creation[24], harnessing the expertise of knowledge producers and value collectors. Universities traditionally provide expert knowledge to leading companies, but inverse roles suggest companies should contribute exploitation-related knowledge[24]. Dedehayir et al. (2017) and (2018) delineate four principal roles within innovation ecosystems: leadership, direct value creation, support for value creation, and roles within the entrepreneurial ecosystem. Comprehensive collaboration offers a value proposition for end-users[25,26]. Value co-creation encompasses processes and activities that bolster resource integration and incorporate diverse actor roles in the digital innovation ecosystem[27,28]. Each actor engages in value co-creation by amalgamating their individual experiences[28], heteronomous resources[27], and other attributes shaping the usable value of the ecosystem's context of use[29].

Figure 1 shows the theoretical framework that serves as a roadmap for exploring digital innovation ecosystems and dynamic capacities that facilitate value co-creation in digital innovation ecosystem services. This framework highlights the basic elements of the services of the digital innovation ecosystem that precede value co-creation and involve different actors in manufacturing, taking into account the use of the services of the European Digital Innovation Hubs and the impact of digitalisation. While the framework does not claim to be comprehensive, it provides an initial platform to understand the research field of dynamic capacities and value co-creation through digital innovation ecosystems. We provide a concise overview of certain characteristics of network actors described in our framework, which are expected to play a key role in value co-creation in the digital innovation ecosystem.

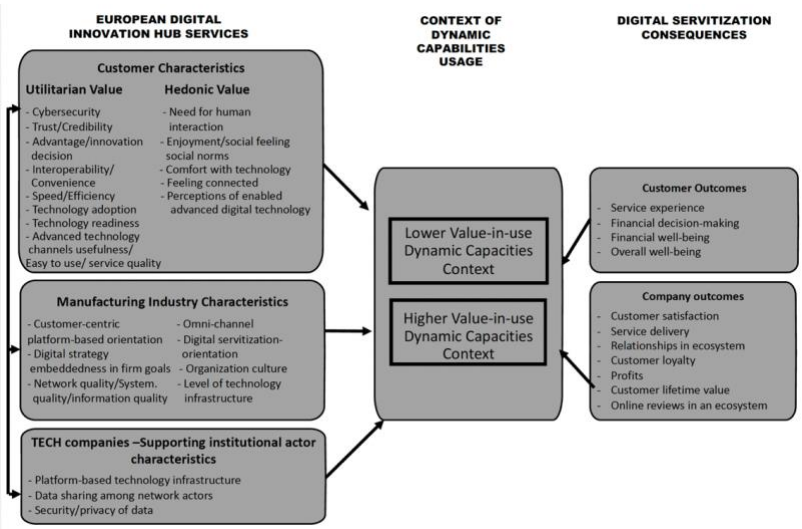

Figure 1 Multi-Actor dynamic capabilities by value co-creation framework for EDIH services (Extended to Manser Payne, Dahl & Perltier 2021 framework[30]).

Our framework highlights network actors' roles in value co-creation in digital innovation ecosystems. Customer capabilities, integral to Service-Dominant (SD) logic, are crucial for resource integration and value determination[31,8]. Evaluating customer experiences involves emotional, cognitive, and normative elements[32]. The evolving digital economy presents opportunities for multidimensional value-creating practices[33]. We categorize customer characteristics by their potential to generate utilitarian or hedonic value[34].

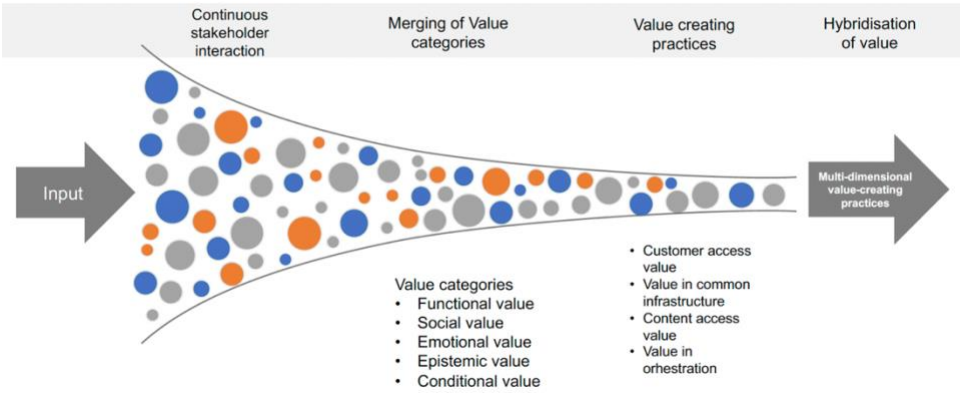

Figure 2 Framework of value creation and the multi-dimensional of value-creating practices in European digital innovation hubs (ecosystem). (According Suseno et al. 2018)[33].

Attributes of the Customers

Customer capabilities are key to pooling resources and determining use value according to SD logic[35,8]. In addition to demographic characteristics, customer evaluations of service experiences may include emotional, cognitive, and normative elements[36]. The emerging concept of value in the digital economy (Kumar and Reinartz, 2016) highlights the possibility of practices that create value in multiple dimensions in the context of digital innovation[37]. Empirical studies are needed to examine value creation practices that arise from stakeholder interactions. We continue to classify consumer characteristics based on how they can deliver either utilitarian or hedonic value.

Utilitarian value

Utilitarian value relates to customer satisfaction from service innovations addressing financial or economic tasks[38]. Disruptive innovation literature explores customer expectations of benefits from innovation adoption[39]. Digital channels' comparative advantages include convenience, trust, and information efficiency. Self-service technology enhances comparative advantages like speed and accuracy. Convenience is a multidimensional structure encompassing access, transaction, and possession[40]. Customers assess ecosystem services' usefulness based on their dependence on digital data exchange[38]. Trust and security concerns may affect customers' readiness to use

digital services[41]. Technology readiness, dynamic abilities, and digital orientation help understand customer engagement with technologies [40].

Hedonic value

Hedonic value encapsulates the emotional satisfaction a customer derives from service transition[42]. It considers the customer's perception of value associated with the affective aspect of innovation. Human engagement is crucial in co-generating value within the ecosystem [8,43].

Current research on value generation within ecosystems faces limitations. The process of value generation through stakeholder engagement and specific practices is unclear. There's a lack of empirical studies evaluating value categories. This research investigates value generation through novel practices facilitated by European Digital Innovation Hubs and the amalgamation of value categories within digital innovation ecosystems.

Our model (Figure 2) links stakeholder interactions, value-generating practices, and value categories, offering a new perspective on value creation. Stakeholders create value and foster innovative practices in the digital innovation ecosystem, leading to a convergence of value categories. We argue that these practices are complex and interconnected, supporting the concept of value hybridization[44,33]. These value categories merge into a digital innovation ecosystem.

2.3 Dynamic Capabilities in Value Creation of Digital Innovation Ecosystems

Dynamic capabilities, rooted in a corporate resource-based perspective, address challenges in unstable environments by integrating, developing, and reorganizing skills [45]. This enables innovation and competitive advantages, integrating business models and strategies. Digital transformation capabilities, seen as microfoundations, improve digital maturity[46]. Dynamic capabilities are classified into identification, opportunity exploitation, and threat management[47]. The digital shift, driven by digitalization, decentralization, sustainability, democratization, and deregulation, promotes co-creation in European Digital Innovation Hubs[48].

European Digital Innovation Hubs are transitioning towards sustainable, decentralized, digitized, and platform-centric business models[49]. Dynamic capabilities play a crucial role in resource renewal throughout the life cycle of digital innovation ecosystems[50,51]. Scholars have used dynamic capability frameworks to understand ecosystem organization, emphasizing the importance of environmental scanning, innovation, value integration, and cooperative arrangements[50]. This paper extends this research by examining the capabilities associated with the organizational roles of ecosystems[51].

3 Research Design

This study is a qualitative case study focusing on the network of European Digital Innovation Hubs (EDIHs). The European Commission has selected 151 DIHs, of which 31 have responded to this case study. This empirical study uses the case study method. The case study method facilitates a comprehensive and in-depth understanding of real-world cases and can cover both single and multiple cases. Empirical data, which can be either qualitative or quantitative, can be collected, for example, through interviews, direct observation, participant observation, documentation, archival resources, and physical artifacts[67]. Case studies can provide a description, formulate a theory, or test a theory. When the goal of a case study is to form a theory, grounded theory methods and techniques are an appropriate approach to conducting research[52].

3.1 Data collection

Our data comes from a comprehensive survey conducted in late 2022, involving 31 representatives from the European Digital Innovation Hubs (EDIH), supplemented by an analysis of the EDIH's website and services. The survey aimed to understand ecosystem value and dynamic capabilities by exploring managers' and coordinators' perceptions of their ecosystem[53]. The survey, which consisted of both multiple choice and open-ended questions, lasted about 15-20 minutes. The study used multiple choice questions to explore key technologies in the EDIH ecosystem and the primary sector they serve. The questionnaire consisted of a total of 27 open-ended questions and 5 multiple-choice questions. It covered the digital capabilities of the EDIH, the services provided, and the structure of the EDIH ecosystem. The survey, which included both multiple choice and open-ended questions, focused on the key technology area, the European Digital Innovation Hub, digital capacities, and the services provided by EDIH. It also delved into the EDIH ecosystem, its structure, unique aspects, societal values, organisational roles, and long-term goals. Respondents were asked to reflect on the significant development of EDIH up to 2030 and beyond, and provide a brief description of their EDIH network.

3.2 Data analysis

In this research, content analysis was selected as the method for data analysis and was implemented in three stages: pinpointing and categorizing stakeholders within the framework of European Digital Innovation Hubs, recognizing practices that involve the identified stakeholders, and evaluating the integration of various value categories into the recognized practices[54]. To elaborate, content analysis was employed in three stages: (1) pinpointing and categorizing stakeholders within the context of European Digital Innovation Hubs (ecosystems), (2) recognizing practices that involve the identified stakeholders, and (3) evaluating the integration of the different value categories, as identified in existing literature, into the recognized practices.

In the second stage, the dataset was revisited to identify practices involving ecosystem leaders. This inductive identification yielded ten unique practices based on repeated activity cycles. An additional coding iteration highlighted how these practices were manifested among EDIH managers. The analysis explored informants' perceptions of the EDIH ecosystem, their dynamic capabilities, and how value categories were incorporated into practices in digital innovation ecosystems.[55] The data was classified into five categories: "Customer Use Value", "Common Infrastructure Value", "Modularity Value", "Content Use Value", and "Orchestration Value".

Using Gioia et al's (2012) analysis, we categorized data into five groups to facilitate meaningful analysis, covering the EDIH ecosystem, observed network, and dynamic capabilities results[56]. This process helped answer research questions about the objectives, dynamic capabilities, and value creation of the Digital Innovation Ecosystems (EDIH) and the main benefits of European digital innovation ecosystems for manufacturing SMEs. We explored how value categories were incorporated into identified practices in digital innovation ecosystems, guided by categories of values identified in existing literature: External vs. Internal Value and Self-Centered vs. Other Oriented Value[57] External vs. internal value and self-centered vs. other-oriented value[58] Functional, social, and emotional value and Experiential and utilitarian value[59]. These value categories were applied to each identified policy to determine identifiable value categories.

4 Results

4.1 Value Network of EDIH ecosystem

We studied the values of business-to-business networks in the 31 European Digital Innovation Hubs of EDIH coordination units. We have asked how they build social and community values in their EDIH projects. To understand who controls EDIH networks, we must first thoroughly explore the evolving path of creating and capturing value. We were able to identify multidimensional value-creating practices together with five value levels. First, Table 1 shows multidimensional value-creating practices and illustrative data examples at five value levels.

Table 1 Multi-dimensional value-creating practices in EDIH works.

Multi-Dimensional value creating practices	Data example	Number of Mention
Customer access value	"Experience gathered from 3 years services from National Competence Centres aiming at digitalizing SMEs in the manufacturing ecosystem"	**5**
Value in common infrastructure	"The added value is the DIGI-SI online shop, DIGI-SI Academy, Virtual agent, supported by Live agents and Digital emergency hotline". "Cooperation with clusters, building cross border virtual platforms (Austria-Slovakia, Czech republic - Slovakia etc.)"	**3**
Value in Modularity	"Range of activities aimed at mobilisation of the innovation ecosystem concerning wider outreach, promotion and awareness on offered services and activities, to support networking and reaching out to the target groups, where necessary to access to testing facilities, financing and investment, and further EU collaboration/digital capacities"	**3**
Content access value	"International accelerator programs and hackathon formats" "Affordable services and training in cybersecurity area"	**10**
Value in orchestration	" Our experience can be especially useful to those EDIHs who aim at the development of their territories by supporting the innovation of SMEs. Our added value is linked to the significant experience we have gained in offering integrated and complete innovation services to SMEs". "More than 5 year experience in DIH orchestration - all EDIH partners are DIHS for 5+ years"	**7**
Total	**EDIH sees mostly multidimensional value-creating practices in the value of orchestration, which means that survey participants rated collaborative activities like projects, joint services, and internationalization as the most valuable in the work of EDIH's ecosystems**.	**28**

Customer Access Value focuses on being the customer's gatekeeper. The most economic value is created at the network's periphery, where highly customized connections that deliver value to customers are made.[15] EXPANDI EDIH has described how they have been building services for customers for the past three years based on experience gathered from National Competence Centers aimed at digitalizing SMEs in the manufacturing ecosystem. Customer access value can be viewed as a regional, national, and international process in which EDIH attempts to engage customers' access to its services.

Value in Common Infrastructure refers to the combination and utilization of infrastructure elements as utilities[15]. EDIH has described the value in common infrastructure, particularly in its focus area of the circular economy. ATTRACT DIH will provide three main contributions to environmental sustainability and European Green Deal goals: delivering customized recommendations for SMEs and public entities, promoting solutions that mitigate climate change, and supporting the transition to a circular economy through AI. AI can help boost the transition to a circular economy in several areas of application, including product, component, and material design; optimizing circular business models; optimizing circular economy infrastructure; and providing an assessment tool for responsible and sustainable innovation (ATTRACT DIH candidate of EDIH 2022).

Value in Modularity allows for the reorganization of hardware, software, organizational capabilities, and business processes into well-defined, standalone modules that can be quickly and seamlessly combined with other modules. Value is created by developing modules that can be integrated into as many different value chains as possible. Companies and individuals aim to spread their dynamic talents widely rather than keeping them as their own funds.[15] EDIH brings modularity values by allowing dynamic capabilities and business processes to be connected by modules and developing as many different value chains as possible. ATTRACT DIH ecosystem describes the added value of combining main competence centers in AI and HPC in Portugal to provide specialized services to organizations (ATTRACT DIH candidate of EDIH 2022).

Content Access Value refers to the gradual mastery of content as a content gatekeeper, which is a critical success factor for achieving and maintaining long-term competitive positions.[15] The use value of content in the EDIH ecosystem starts from the long-term construction of the ecosystem and focuses on their own long-term built area of expertise. Greece HealthHub EDIH describes their strong commitment to social and community values and their 17 years of experience in the health field. Content access value is also created by digital service development, where digitalization is used as a tool for product creation (DIHCUBE).

Value in Orchestration refers to the ability to coordinate modules as modularization takes hold, which becomes the most valuable business skill.[15] Value creation is the result of a process that encourages creativity and diversity while EDIHs coordinate partners in the ecosystem to help SMEs become more skilled, innovative, and competitive. Oltenia Digital Innovation Hub describes their EDIH values and orchestration in their ecosystem as being correlated with national and regional policies and collaborating with the Local Administration to benefit from the results. (Oltenia DIH candidates of EDIH 2022) EDIH also considers orchestration to improve its work by developing collaborative projects and cooperating with other EDIHs with similar thematic interests to generate European added value for businesses.

Our study examines the dynamics of actors in European Digital Innovation Hubs (EDIHs), distinguishing between utilitarian and hedonic values in dynamic capacities. EDIHs play a crucial role in overcoming innovation barriers and promoting Europe's digital revolution. ARTES 5.0 EDIH exemplifies higher value-in-use dynamic capacities, promoting a business model focused on innovation and socially acceptable cost reduction (ARTES 5.0 EDIH candidates 2022). The results highlight utilitarian values such as energy-efficient construction. EDIH EBE addresses the construction sector's low digital maturity and aims to provide comprehensive support for SMEs and public sector organizations. A key hedonic value for EDIHs is building trust in service quality (EBE EDIH candidate 2022).

4.2 Dynamic Capabilities and Value Creation at EDIHs

Our study links dynamic capability development and value creation in European digital innovation ecosystems based on 31 EDIHs. Ecosystem innovation relies on adaptation to customer needs, technologies, and new entrants. Successful leaders develop dynamic capacities for ecosystem management. We propose a dynamic capability framework

(figure 3) for value creation, based on content analysis and empirical themes, illustrating the interdependence of capabilities[63].

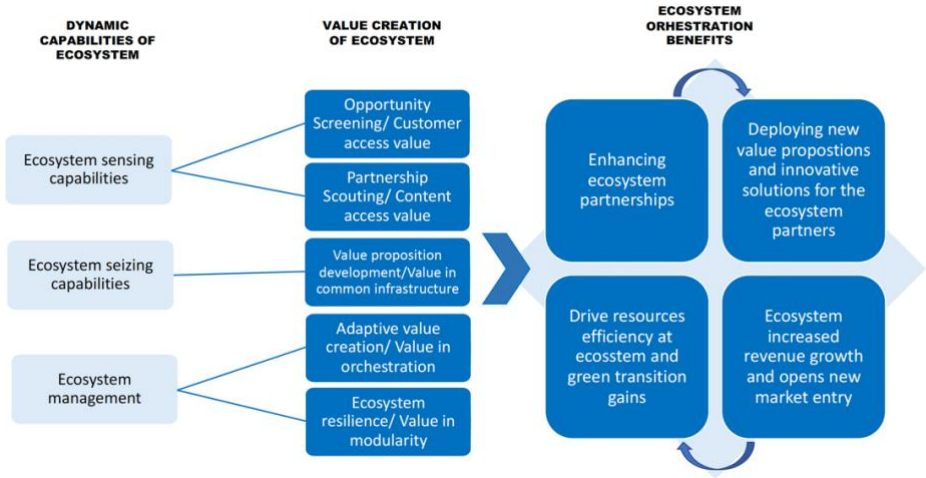

Figure 3 Dynamic Capabilities and Value Creation at European Digital Innovation ecosystem framework. (Extended for Linde et al. 2021 a dynamic ecosystem capability framework[50])

Three key properties within dynamic ecosystems are identification, understanding, and self-management. Identification enables firms to discover new business opportunities and potential collaborators. Understanding aids in seizing these opportunities by creating attractive value propositions. Self-management ensures ecosystem adaptability and resilience to changes. European Digital Innovation Hubs should lead in advanced digital capabilities, disseminate knowledge to SMEs, and help them enhance digital skills and integrate advanced technologies. These dynamic capabilities benefit the entire ecosystem, enabling leading organizations to manage the ecosystem under dynamic conditions[50].

The proposed dynamic capability framework suggests that the existence of these capabilities not only allows the ecosystem leader to manage relationships, but also leads to significant sustainability benefits[50]. When used simultaneously, the identification, understanding and management of capabilities contribute to sustainable ecosystem development and increase the benefits of EDIH's ecosystem innovations. A crucial aspect is understanding ecosystem value creation, such as ecosystem identification abilities for lead generation, opportunity screening, and value customer access value. At the same time, emphasis should be placed on partnership intelligence and raising awareness of the value of access to corporate content. Harnessing the strengths of the ecosystem leads to the formulation of value propositions that deliver value in shared infrastructure, such as EDIH testing facilities. Ecosystem management generates adaptive value by assessing the maturity of ecosystem resilience and understanding the value of modularity, especially how different EDIHs orchestrate their EDIHs and deliver values to their members.

Key results indicate that for an ecosystem’s long-term competitiveness and innovation, all three capabilities and their routines must be present and work together. These dynamic features provide four orchestration procedures: improving ecosystem connectivity,

implementing value propositions and creative solutions, aligning the ecosystem, and increasing revenue growth and market entry opportunities[50]. Findings from 31 European Digital Innovation Hubs (EDIHs) suggest that effective development and application of dynamic capabilities by an ecosystem leader can lead to profitability. This can be achieved by offering innovative solutions like advanced digital technologies and enhancing revenue through new business opportunities and markets. Thus, dynamic capabilities are fundamental for attaining and redefining the internal routines of the European digital innovation ecosystem, allowing it to adapt to the evolving EU market and enhancing global digital competitiveness.

5 Conclusions

Our research highlights the importance of stakeholder engagement in European Digital Innovation Hubs (EDIHs) for value creation[60]. We found EDIH practices to be cooperative, with stakeholders using interactive features to express their experiences and align with EDIH managers' preferences[61]. This research offers two notable theoretical contributions.

Firstly, our study addresses the limited understanding of value creation in digital innovation ecosystems[62]. We support the dynamic nature of these practices through an empirical assessment of 31 European DIHs [63]. This advances theory and practice in value creation, dynamic capabilities, and innovation management. [64]

Secondly, our research shows a convergence of value categories in digital innovation ecosystems, facilitated by value aggregation[65]. As a result, our research contributes to the relatively limited literature on value categories in digital innovation ecosystems and shows that differentiating between different value categories may no longer be possible. We found that European Digital Innovation Hubs have moved towards hybridisation or value aggregation[44], challenging the differentiation of value categories. However, we establish empirical connections with all dynamic abilities of value creation (sensory, contagion, and change/change phases)[66].

Empirical contribution shows that our study offers a comprehensive examination of 31 European Digital Innovation Hubs (EDIHs) ecosystems. This empirical investigation uncovers the most crucial areas of value creation within these ecosystems and delineates five tiers of multidimensional value-creating practices. This enriches our comprehension of the mechanisms of value creation in digital innovation ecosystems and the practices propelling this process.

Theoretical contribution presented in our research posits a connection between dynamic capabilities and value creation within Europe's digital innovation ecosystems. This theoretical revelation enhances our understanding of the development and application of dynamic capabilities for value creation in digital innovation ecosystems. It further underscores the role of EDIHs in augmenting the digitalisation of SMEs and fostering competitiveness, in alignment with the objectives of the Digital Europe Programme.

These contributions furnish invaluable insights for academics researching digital innovation ecosystems and practitioners engaged in the development and management of EDIHs. They also lay the groundwork for future research probing value creation in diverse contexts and international comparisons of various methods of deriving value from digital innovations.

Our insights on multidimensional value creation practices in European Digital Innovation Hubs (EDIHs) can guide corporations in assessing their value beyond commercial aspects. The dynamic capability of these practices enables corporations to evaluate how they can deliver value to stakeholders. The study's outcomes provide a new perspective on value creation, emphasizing the potential of diverse value categories. Future research could explore value creation in different contexts and compare methods of creating value from digital innovations. These findings are crucial for the development of European smart specialization strategies (S3) and excessive deficit procedures.

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