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PUBLIC POLICY FOR INNOVATION: EVALUATING DIGITAL INNOVATION HUBS IN ITALY

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INTRODUCTION

Context and Relevance of the Topic

The present research is situated within a broader historical transition marked by the widespread diffusion of digital technologies across all sectors of the economy. According to Carlota Perez's theory of techno-economic paradigms (2002), each major technological revolution—such as steam power, electricity, or information and communication technologies (ICTs)—unfolds in two distinct phases: an installation phase, led by speculative private investment and experimentation, and a deployment phase, where technologies become embedded into production structures, institutions, and society through guided diffusion. In the deployment phase, public policies play a central role in steering technological development toward socially beneficial outcomes. From this perspective, the current phase of digital transformation represents a turning point in which state intervention becomes essential not only to correct market failures, but also to enable widespread, inclusive adoption of digital technologies. Instruments such as EU cohesion funds and Digital Innovation Hubs exemplify this policy effort: they aim to reduce structural gaps, build capabilities within firms, and align innovation with broader economic and social objectives. This thesis adopts this structural perspective as a backdrop, situating the analysis of public support for innovation within the broader context of long-term technological and institutional co-evolution.

Research Objectives

In light of the above context, the primary objective of this thesis is to evaluate the real-world effectiveness of Digital Innovation Hubs (DIHs) as a policy instrument for supporting firm-level digital transformation and innovation. This entails examining not only the positive outcomes attributed to DIH interventions but also identifying any shortcomings or challenges in their implementation. Accordingly, the research addresses two main questions:

1. RQ1: *To what extent are Digital Innovation Hubs (DIHs) perceived as effective in supporting firms' digital transformation, innovation, and competitiveness?*
2. RQ2: *What are the main weaknesses, barriers, or limitations perceived by firms, experts, and implementing bodies in the functioning of DIHs?*

These questions reflect a dual focus on the benefits and limitations of DIHs. By investigating both aspects, the study aims to provide a balanced assessment of how well DIHs fulfill their intended role in the innovation ecosystem. To answer the research questions, the study adopts a mixed-methods approach with deliberate *triangulation* of perspectives and data sources. Quantitative evidence is gathered through a survey of firms (primarily SMEs) that have engaged with an EDIH/DIH, capturing measurable outcomes and perceptions. Complementing this, qualitative insights are obtained via semi-structured interviews with two other key stakeholder groups: innovation experts (policy analysts or domain specialists) and DIH implementing bodies (those responsible for running or overseeing the hubs). By combining these multiple viewpoints—firms, experts, and implementers—the research achieves data triangulation, which strengthens the validity of the findings. In essence, convergence and contrasts across these sources provide a more comprehensive and nuanced understanding of DIH effectiveness than any single source alone could offer. This multi-perspective design ensures that the conclusions drawn about DIHs are robust, credible, and reflective of the complex realities of their operation. The overall approach is exploratory and evaluative, leveraging both statistical trends and in-depth narratives to address the research objectives with rigor.

Structure of the Work

Following this introduction, the thesis is organized into four main chapters, plus a final conclusion section, as outlined below:

1. Chapter 1 – Theoretical Framework: This chapter establishes the conceptual foundations of the study. It reviews the literature on market failures and the rationale for public intervention in innovation, highlighting issues such as knowledge

externalities, financing gaps, and systemic barriers that justify state support. The chapter then introduces Digital Innovation Hubs in the context of these theories, explaining their purpose and function as policy tools designed to reduce innovation barriers (especially for SMEs) and to foster collaboration in the digital economy. By the end of Chapter 1, the reader is acquainted with the key concepts and the *innovation paradox* that motivates the need for instruments like DIHs, as well as the identified gaps in the literature that this thesis aims to fill.

2. Chapter 2 – Research Methodology: This chapter describes the research design and methods used to pursue the above objectives. It details the mixed-methods approach adopted, consisting of a quantitative survey of firms and qualitative interviews with experts and an implementing body representative. The chapter explains the rationale for using a convergent mixed-methods design and outlines how triangulation is implemented to integrate findings from different sources. Specific sections cover the development of the firm survey (questionnaire structure, sample characteristics, and administration process), the conduct of expert interviews and the DIH implementer interview (sampling strategy, interview protocols), and the procedures for data analysis. Additionally, Chapter 2 discusses measures taken to ensure methodological rigor (e.g. validity, reliability) and reflects on any limitations of the chosen approach. By laying out the research process transparently, this chapter provides the necessary context for interpreting the results in subsequent chapters.
3. Chapter 3 – Data Analysis: In this chapter, the empirical findings of the study are presented. It begins with a profile of the survey respondents (firms) to contextualize the quantitative results (e.g. firm sizes, sectors, extent of engagement with the DIH). The chapter then reports the quantitative results from the survey, including descriptive statistics of key Likert-scale items that measure perceived impacts of DIH services on various dimensions (such as improvements in digital skills, innovation outcomes, and competitiveness). Where insightful, basic cross-tabulations or comparisons across different types of firms are included to explore patterns (for instance, differences in perceived impact by firm size or sector). Following the survey results, the chapter delves into qualitative insights. It summarizes the main themes

and examples that emerged from open-ended survey questions and, importantly, from the interviews with experts and the DIH implementer. Through thematic analysis, the chapter identifies common perceptions of DIH effectiveness, as well as recurring concerns or weaknesses noted by participants. By combining the quantitative and qualitative findings, Chapter 3 directly addresses RQ1 and RQ2: it reveals areas where DIHs are widely seen as successful (answering RQ1) and delineates the key barriers or limitations that have been observed in practice (answering RQ2). Any convergences or divergences between the survey data and interview perspectives are highlighted as part of this integrated analysis.

4. Chapter 4 – Discussion and Conclusions: The final chapter interprets and discusses the findings in light of the theoretical framework and research questions. It synthesizes how the evidence from Chapter 3 answers the core questions of DIH effectiveness and limitations, evaluating the extent to which the results confirm or challenge expectations from the literature. Chapter 4 provides a critical discussion of what the findings imply for the role of DIHs in addressing innovation market failures and systemic challenges. It discusses tensions and trade-offsobserved (for example, the balance between breadth of services and depth of impact, or between rapid deployment and the need for capacity-building among firms). The chapter then outlines the implications for key stakeholders: policymakers (particularly in the context of EU cohesion policy and digitalization initiatives), participating firms (SMEs seeking to innovate), and the DIHs themselves (as implementers needing to refine their support strategies). In doing so, it offers practical considerations or recommendations for enhancing the effectiveness of DIHs and similar programs. Finally, the chapter reflects on the limitations of the study – such as sample size, scope, or generalizability – and suggests directions for future research. These concluding sections acknowledge the boundaries of the thesis's findings and propose how subsequent studies might build upon this work to further investigate and support digital innovation and public-private collaboration.

Overall, this structured approach ensures a logical flow: from theoretical motivations (why DIHs matter), to methodological execution (how the research is conducted), to empirical evidence (what was found), and finally to interpretation and broader significance (what it means for theory and practice). Together, the chapters provide a comprehensive examination of Digital Innovation Hubs as a bridge between European public policy and private sector innovation, shedding light on their achievements as well as the challenges that must be addressed to maximize their impact.

CHAPTER 1- THEORETICAL FRAMEWORK FOR PUBLIC INTERVENTION IN INNOVATION

1.1 The Innovation Paradox: Market Inefficiencies and the Case for Public Action

While innovation is often portrayed as the natural byproduct of competitive markets and entrepreneurial spirit, a closer inspection reveals a paradox: some of the most socially valuable innovations emerge not despite state intervention, but because of it.

The economics of innovation has long recognized several fundamental market failures that justify public intervention in the innovation process. Foremost among these is the public good nature of knowledge. Knowledge and innovative ideas are only partially excludable and non-rivalrous, once created, others can often benefit from them at little or no additional cost. As a result, private firms cannot fully appropriate the returns from their investment in R&D, leading to underinvestment relative to the socially optimal level (Arrow 1962).

In his seminal work, Arrow (1962) formalized this argument: a competitive market left on its own will provide a sub-optimal level of investment in inventive activities due to knowledge spillovers and the inability of innovators to capture the full social value of their innovations. Similarly, Nelson (1959) emphasized the "simple economics" of basic research, noting that private firms tend to underinvest in fundamental research because the benefits "spill over" to other firms and sectors and cannot be fully internalized. In short, because new knowledge generates positive externalities for the broader economy—benefits that the inventor cannot charge for—the market alone will under-supply innovative effort. This provides a classic market failure rationale for government support of R&D and innovation.

Another related market failure arises from information asymmetries in capital and technology markets. Innovative projects are often characterized by high uncertainty and intangible assets, making it difficult for external investors to assess their true potential. Inventors or entrepreneurs typically possess much better information about their idea than outside investors (banks, venture capitalists, etc.), which can lead to problems of adverse selection and credit rationing (Stiglitz and Weiss 1981). Indeed, financial economists have observed that R&D-intensive firms face greater hurdles in obtaining external finance, because lenders have trouble evaluating novel projects and fear financing "lemons" (bad projects) in the absence of good information (Stiglitz and Weiss 1981). The consequence is a "funding gap" for innovation: worthy R&D projects may go unfunded due to information problems in financial markets. As Stiglitz and others have noted, the combination of information asymmetry, moral hazard, and the inability to use knowledge assets as collateral makes R&D investments riskier and harder to finance than other types of investments (Stiglitz and Weiss 1981). This capital market failure reinforces the tendency toward underinvestment in innovation and provides a further rationale for public intervention—for example, through R&D tax credits, public venture funds, or guaranteed loans to innovative SMEs. Finally, the presence of knowledge externalities and information gaps often leads private firms to adopt a shorter time horizon than is socially optimal. Breakthrough innovations or basic research may require long development times and uncertain payoffs. However, private firms facing market pressures may discount these future benefits too heavily or avoid projects with long gestation periods (Dosi 1988). As one study succinctly puts it, market actors often apply a "short time horizon" in their investment decisions, contributing to underinvestment in knowledge creation (Dosi 1988). In contrast, the public sector can afford to take a longer-term view, investing in research areas or nascent technologies that may not yield immediate profit but have high social returns. Indeed, numerous empirical studies have found that the social rate of return on R&D (including spillover benefits to other firms and society at large) far exceeds the private rate of return that an investing firm can capture (Griliches 1992; Mansfield 1991). This gap between social and private returns underlies the economic justification for government funding of research and innovation. Classic studies by Griliches (1992), Mansfield (1991), and others documented substantial spillovers from R&D, lending

support to the idea that without public subsidies or policies, society would under-invest in innovative activity.

In summary, the presence of market failures, especially knowledge externalities and information asymmetries, forms the core theoretical justification for public intervention in innovation (Arrow 1962; Nelson 1959). The state can, in principle, correct or offset these failures by funding research, offering R&D incentives, protecting intellectual property rights (e.g. patents) to improve appropriability, and facilitating the dissemination of knowledge.

1.2 Uncertainty, Risk, and Underinvestment in Innovation

Innovation is not only prone to externalities; it is also an inherently uncertain and risky process. Unlike routine investment decisions, R&D projects often have unpredictable outcomes – the technological success, time to market, and eventual commercial payoff are all highly uncertain. This uncertainty has a profound impact on private investment behavior. In the presence of high risk, private firms may be reluctant to commit resources to innovation, especially if capital markets do not effectively share or mitigate that risk (Stiglitz and Weiss 1981; Arrow 1962). As Giovanni Dosi and colleagues have argued, innovation involves a trial-and-error search in which outcomes cannot be fully known in advance, and firms operate under conditions of substantive uncertainty rather than calculable risk (Dosi 1988). From a market perspective, this uncertainty can lead to underinvestment in R&D for at least two reasons. First, if firms are risk-averse or face financing constraints, they will tend to shy away from projects with highly uncertain returns, even if the expected value to society is large (Nelson 1959). Second, the option value of waiting can deter investment: firms may delay R&D investment until some uncertainty is resolved (for instance, until a technology shows clearer signs of commercial viability) (Arrow 1962). But what is rational for an individual firm – waiting or avoiding risk – can be suboptimal from society's standpoint, especially when many firms simultaneously hold back. The result is a systemic underinvestment in innovative activities absent public intervention.

Empirical evidence supports the view that risk and uncertainty dampen R&D investment. Studies find that R&D projects face greater difficulty attracting external finance, and firms

often rely on internal funds to pursue innovation, indicating that capital markets are imperfect for high-risk innovation finance (Stiglitz and Weiss 1981). One recent analysis of emerging-market firms confirms that due to problems like information asymmetry and agency issues, R&D investments are perceived as "riskier than other forms of investment", making it hard for firms to obtain external funds for innovation (Criscuolo et al. 2019).

In such cases, public funding or guarantees can play a critical role in sharing risk. For example, government grants or co-funding can encourage firms to undertake ambitious R&D projects that they would not attempt with private funding alone.

Another aspect of uncertainty is the long-time horizon and intangible nature of returns. Innovation often requires upfront costs now in exchange for uncertain benefits that may arrive years later. This intertemporal aspect, combined with uncertainty, can lead to underinvestment due to discounting of future gains. Private investors might apply high hurdle rates to R&D projects or simply prefer nearer-term investments (Griliches 1992).

The state, however, can justify intervention to take on these longer-term, uncertain investments on behalf of society. This is closely related to the notion of "strategic" public investment in innovation – governments funding basic research, nascent technologies, or infrastructure (such as digital networks or research labs) that lay the groundwork for future innovation, even when private actors are unwilling to do so (Freeman 1987; Lundvall 1992). As Nelson (1959) observed, basic scientific research is a prime example: it is fraught with uncertainty and unlikely to be pursued by firms to the socially desirable extent, thus warranting public support.

In summary, the inherent uncertainty and risk in innovation outcomes reinforce the case for public intervention, complementing the argument based on static market failures. Together, these factors explain why laissez-faire markets will not produce the socially optimal level of innovation, and why virtually all advanced economies employ an array of public policies to stimulate and support R&D.

1.3 Barriers to Innovation and the Role of State Incentives

Beyond the abstract market failures discussed above, firms, especially small and medium-sized enterprises (SMEs) do face numerous practical barriers to engaging in innovation. Understanding these barriers provides insight into the specific ways public intervention can help. One major category of barriers is financial: innovative projects often require significant investment, yet smaller firms may lack internal funds and find external financing difficult (Stiglitz and Weiss 1981). Indeed, evidence shows that financing problems disproportionately affect small and young firms with growth ambitions (European Investment Bank 2020). When firms cannot secure affordable capital for R&D or new technology adoption, their innovation activities will be stifled. State incentives such as R&D tax credits, innovation grants, or public loans are designed to alleviate these financial constraints, effectively lowering the cost of innovation to the firm and encouraging greater investment. By sharing costs or providing upfront funding, governments aim to overcome the financial barrier that would otherwise prevent many SMEs from innovating.

However, funding is not the only barrier. Equally important are organizational and capability barriers. Many SMEs lack dedicated R&D departments or specialized expertise in cutting-edge technologies. They may also face shortages of skilled workers, or managerial challenges in organizing innovation projects. Studies find that in certain SME segments—particularly traditional industries or "low-tech" sectors—a combination of internal skill gaps, organizational problems, and high market uncertainty form the most widespread barriers to innovation (Mohnen and Hall 2013; OECD 2021). Such firms often produce only incremental innovations and may not engage in formal R&D at all, instead relying on informal know-how and external sources of knowledge. For these businesses, simply providing funding may not be sufficient; non-financial support is crucial. This is where state intervention extends to policies like workforce training programs, innovation management assistance, and facilitation of knowledge transfer. For example, public programs might subsidize the hiring of skilled researchers or engineers by SMEs, or support consulting services to improve firms' innovation management practices. The logic is that by building absorptive capacity within

firms—enhancing their skills and organizational readiness—the state helps firms better utilize new technologies and ideas (Cohen and Levinthal 1990).

Another barrier lies in the access to knowledge and networks. Innovation often requires collaboration or at least awareness of new technological opportunities. SMEs, in particular, can be at a disadvantage in accessing the latest research, partnering with universities, or connecting with other firms for collaborative innovation. There can be coordination failures: even if multiple firms could benefit from working together or sharing knowledge, such collaboration may not emerge naturally due to transaction costs or lack of trust (Lundvall 1992). Public policy can intervene to broker connections and provide platforms for collaboration. Examples include government-sponsored research consortia, industry-university collaboration programs, innovation clusters, and digital platforms that connect innovators. By reducing the transaction costs and building networks, these interventions help firms overcome isolation and access external knowledge (European Commission 2024).

So we can affirm that the barriers to innovation are multi-faceted: spanning cost, risk, skills, organizational capability and networks. Correspondingly, effective innovation policy is broad-based. As one analysis of European SMEs concludes, innovation support must comprise both financial and non-financial measures, given the diverse obstacles different firms face (OECD 2021). Key policy measures include not only funding (e.g. subsidies, tax incentives) but also support for training and upskilling of staff, development of innovation management systems, and transfer of technical knowledge. These "building blocks that promote innovation" are aimed at tackling the root causes of innovation inertia in firms (Criscuolo et al. 2019). For instance, training programs and skill development address the human capital barrier; advisory services in innovation management address organizational hurdles; and knowledge transfer initiatives (such as extension services or tech advisors) address informational barriers. Together, such state-led initiatives create an environment that encourages firms to innovate by mitigating many of the risks and costs, and by empowering firms with the capabilities needed to succeed.

The remainder of this chapter will delve into one particular policy mechanism that embodies several of these support dimensions: Digital Innovation Hubs, which have emerged as a policy tool to spur innovation, especially in the context of digital transformation of SMEs.

1.4 Digital Innovation Hubs: Reducing Barriers and Fostering Collaboration

In recent years, Digital Innovation Hubs (DIHs) have gained prominence as a policy instrument to bolster innovation, particularly targeting the needs of SMEs in the era of digitalization. A Digital Innovation Hub is generally a regional center or network that provides companies with access to technology testing, knowledge, and expertise, acting as a "one-stop-shop" for innovation support. The European Commission defines European DIHs as "one-stop shops supporting companies and public sector organisations to respond to digital challenges and become more competitive" (European Commission 2024). These hubs help firms improve their products, processes, and services using digital technologies by providing access to technical expertise and testing facilities – enabling firms to 'test before they invest' (European Investment Bank 2020)In other words, a small manufacturer can experiment with, say, an AI-based production optimization or a new industrial IoT setup at a hub's test center before committing to a full investment, thereby substantially reducing the risk of adopting new technology.Digital Innovation Hubs typically offer a suite of innovation services that directly tackle common barriers to innovation. These services often include: financing advice (guidance on funding opportunities, grants or investment readiness), training and skills development programs, mentorship on business models, and links to researchers or technology providers (OECD 2021). By bundling these services, DIHs address both financial and non-financial constraints. For instance, the training and skills development component helps overcome the human capital barrier by upskilling the SME's workforce in new digital tools. The financing advice component can guide firms to appropriate funding schemes or investors, mitigating financial constraints. The technical expertise and "test before invest" aspect directly lowers the technological uncertainty barrier – firms can validate the benefits of an innovation on a small scale, reducing uncertainty about returns before scaling it up (Criscuolo et al. 2019). Another critical role of DIHs is to foster collaboration and network-building. DIHs often connect multiple stakeholders: they may be consortia that include universities, R&D centers, industry associations, larger tech companies, and government agencies. This structure allows them to act as brokers between SMEs and sources of

innovation knowledge. An SME engaged with a hub can be linked to researchers who have expertise in a needed technology, or to other companies that might become partners in a supply chain or innovation ecosystem. In effect, the hub becomes a node in an innovation network, overcoming the isolation that many smaller firms experience. This collaborative aspect is particularly important in the context of digital innovation, where solutions like AI, cloud computing, or advanced robotics often require integration of knowledge from different fields and partners (Lundvall 1992). By stimulating such interactions, DIHs help generate spillovers and shared learning among local firms, thereby amplifying innovation outcomes (Freeman 1987; Dosi 1988). Digital Innovation Hubs are also designed to have a regional presence while being connected nationally and supra-nationally. The regional presence means a hub understands the needs of local industry and can provide hands-on support in the local language and context (OECD 2021). At the same time, in initiatives like the European network of DIHs, hubs are connected across borders to exchange best practices and specialized expertise (European Commission 2024). This multi-level network ensures that even firms in less-developed regions can tap into cutting-edge knowledge through their local hub, which can source know-how from the wider network. It reflects a systems approach to innovation policy: rather than seeing innovation as isolated efforts of individual firms, DIHs seek to create an ecosystem where various actors (firms, universities, service providers, government) interact synergistically. This approach echoes insights from the innovation systems literature (Freeman 1987; Lundvall 1992; Dosi 1988) that effective innovation often requires well-functioning systems of collaboration and knowledge flow, not just market transactions.

In sum, Digital Innovation Hubs serve as mechanisms to reduce persistent barriers to innovation. They lower information and adoption costs for new technologies, spread awareness of advanced techniques, build SME capabilities, and connect firms to larger innovation networks. Early evidence suggests that DIHs can indeed help SMEs overcome hurdles in digital transformation, increasing their innovation activities and competitiveness (Criscuolo et al. 2019). By providing a concrete, on-the-ground intervention, DIHs embody many of the theoretical rationales for public involvement in innovation: they correct market

failures (e.g. providing a public good in knowledge and experimentation facilities), address systemic failures (gaps in networks and capabilities), and reduce risk and uncertainty for firms embarking on new innovations.

1.5 Innovation Adoption and the Need for Organizational Change

While developing new technologies and processes is one side of innovation, an equally important side is the adoption and diffusion of those innovations within firms and across the economy. Economist Paul David famously illustrated this point with historical examples of general-purpose technologies. In his classic analysis of the adoption of electric motors in manufacturing, David observed that simply installing a new technology is not enough to reap its full benefits—firms must also adapt their organizational structures and processes (David 1990).

Initially, when factories in the late 19th century began to electrify (replacing steam engines with electric motors), many managers merely "overlaid one technical system upon a preexisting stratum," meaning they swapped the power source but left factory layouts and work processes unchanged (David 1990). The result was only marginal improvement. It was only after a reorganization—shifting from one large motor driving all machines via belts (the old system) to individual motors for each machine with flexible factory layouts—that productivity surged in the 1920s (David 1990). David's study, "The Dynamo and the Computer," draws a parallel between electrification and the late 20th-century adoption of computers, arguing that the productivity gains from computers were initially slow ("the productivity paradox") because businesses needed time to redesign workflows and train workers to fully harness the new technology (David 1990).

The lesson for modern innovation policy is that innovation is not automatic—its benefits depend on complementary changes and adoptions. Firms often require new business models, skills, and internal processes to make effective use of a novel technology. For example, adopting an AI-based system in a manufacturing firm might require retraining staff,

redesigning the production process, and changing management practices. If firms fail to make these changes, the innovation may have little impact on performance. This insight reinforces the importance of some types of public intervention: policies should not only focus on creating new technologies (the invention side), but also on facilitating the diffusion and uptake of those technologies. This can involve demonstration projects, pilot programs, or advisory services that help firms restructure and implement innovations (Cohen and Levinthal 1990; Lundvall 1992).

Indeed, Paul David and others have highlighted that the rate of diffusion of new technologies can lag unless there are efforts to reduce uncertainty and promote learning about the innovation's use in context (David 1990; Freeman 1987). Moreover, the need for adaptation underscores why collaboration and knowledge sharing (as facilitated by innovation hubs or networks) are vital. Firms often learn how to implement innovations by observing or consulting with peers and experts—a process of social learning. If left purely to market forces, such learning might be slow or uneven, especially if firms are protective of their know-how. Public or collective mechanisms (like industry associations or innovation hubs) can accelerate diffusion by spreading best practices (Lundvall 1992).

Paul David's work essentially reminds us that technological innovation and organizational innovation go hand in hand. Therefore, an effective innovation ecosystem requires attention to human and organizational factors, not just the technical invention itself.

For the purposes of this thesis, which focuses on public intervention and instruments like digital innovation hubs, David's insights imply that we should evaluate not only whether such interventions spur R&D or new tech development, but also whether they assist firms in absorbing and integrating innovations into their operations. Do policies help firms change their processes, adopt new business models, and build the needed skills? These questions are critical because the ultimate goal is improved economic performance and productivity, which only occurs when innovations are widely adopted and effectively used, not merely invented.

1.6 Research Contribution and Gaps

In conclusion, this chapter has built a theoretical foundation for why public intervention in innovation is often necessary and how it can be designed. We began by identifying classic market failures, knowledge externalities and information asymmetries—that lead to underinvestment in innovation absent public support (Arrow 1962; Nelson 1959; Stiglitz and Weiss 1981). We then incorporated insights about uncertainty and risk, which further justify state involvement to share risk and provide long-term investment where private actors may not (Dosi 1988; Freeman 1987).

We discussed practical barriers to innovation (financial, organizational, knowledge-based) that particularly affect SMEs, and surveyed how state incentives and programs attempt to lower these barriers—including newer instruments like Digital Innovation Hubs (Criscuolo et al. 2019; OECD 2021; European Commission 2024). We also examined the role of Digital Innovation Hubs as a policy tool, illustrating how they operationalize many of these theoretical rationales by providing expertise, networking, and risk-reduction for firms embarking on innovative projects (European Investment Bank 2020; Lundvall 1992). Finally, drawing on Paul David's perspective, we highlighted that true innovation progress requires successful adoption and diffusion, which often hinges on changes within firms and effective knowledge transfer (David 1990).

This theoretical framework sets the stage for the research to follow. The contribution of this thesis lies in evaluating whether and how public interventions—in particular, the state's support measures and Digital Innovation Hubs—can help overcome persistent innovation barriers identified in the literature. While prior studies have established the rationale for intervention and described various programs, there remains a gap in understanding the effectiveness and specific mechanisms of newer approaches like Digital Innovation Hubs in practice. By empirically examining their role—particularly in the context of SMEs' digital transformation—this thesis addresses a literature gap at the intersection of innovation policy and digitalization. In particular, it contributes to the still limited body of work that evaluates the effectiveness of European Digital Innovation Hubs (EDIHs) as policy instruments. This contribution is grounded in direct, data-based evidence and supported by a focused case study on selected Digital Innovation Hubs operating in Italy, offering concrete insights into their structure, services, and impact on firm-level innovation.

In doing so, the thesis aims to shed light on how public policy can better facilitate innovation in environments where market forces alone are insufficient, and how bridging the gap between technological opportunities and firm capabilities can unlock greater innovation-driven growth (Cohen and Levinthal 1990). This extends the theoretical discussions of market failure and systemic failure rationales into an updated analysis of contemporary innovation policy tools, thus contributing both to academic discourse and to practical policy considerations on fostering innovation.

Overall, Chapter 1 has provided the necessary conceptual underpinnings—drawing on Arrow, Nelson, Dosi, David, and other foundational thinkers—to justify why the public sector plays a critical role in the innovation ecosystem. The subsequent chapters will build on this foundation to explore the evolution of specific policies (in particular, within the European context) and to assess their impact on private sector innovation and investment. The goal is to advance our understanding of how targeted public interventions can stimulate innovation activity, crowd-in private investment, and ultimately drive economic development in line with the theoretical principles outlined here.

CHAPTER 2: RESEARCH METHODOLOGY

2.1 Research Objectives and Approach

This chapter builds upon the theoretical framework introduced in Chapter 1, which examined the role and functions of Digital Innovation Hubs (DIHs) within innovation ecosystems. The following sections outline the research approach used to assess DIH effectiveness and limitations from multiple stakeholder perspectives.The primary objective of this research is to evaluate the perceived effectiveness and weaknesses of Digital Innovation Hubs (DIHs) from multiple stakeholder perspectives. In particular, the study examines how firms (especially SMEs that have engaged with DIHs), innovation policy experts, and DIH implementing bodies view the impact and limitations of these hubs. By capturing insights from these different groups, the research aims to build a holistic understanding of DIH performance. This multi-perspective approach recognizes that the effectiveness of DIHs can be observed at different levels – from the on-the-ground results for firms, to the strategic policy viewpoint, to the operational execution – and that each may highlight distinct facets of success or challenge.

To achieve these objectives, the study adopts a mixed-methods research approach with triangulation. A combination of quantitative and qualitative methods was employed in order to gather both breadth and depth of data on DIH effectiveness. The rationale is that quantitative data (e.g. survey metrics) provide measurable indicators of outcomes and perceptions, while qualitative data (interviews and open-ended responses) provide context, nuance, and insight into why those outcomes occur. Triangulating multiple data sources and methods helps strengthen the validity of the findings by offsetting the biases or limitations inherent in any single method. In other words, convergence of evidence across different stakeholders and techniques increases confidence in the results. This approach follows the principle that combining quantitative and qualitative evidence yields a more robust evaluation: collecting both types of data and comparing them enables a more comprehensive understanding of the phenomenon under study. The triangulated design is intended to enhance the study's internal validity, as corroborating findings from firms, experts, and

implementers can reveal consistent patterns or meaningful discrepancies in how DIHs are perceived. By using multiple perspectives, the research mitigates the risk of one-dimensional or biased conclusions, thereby improving the reliability of the evaluation. In sum, the research approach is exploratory and evaluative, leveraging mixed methods to capture the rich, multifaceted nature of DIH effectiveness and to address the research objectives with greater rigor.

The research is guided by the following central question:

RQ1: To what extent are Digital Innovation Hubs (DIHs) perceived as effective in supporting firms' digital transformation, innovation, and competitiveness?

An additional question complements the central aim:

RQ2: What are the main weaknesses, barriers, or limitations perceived by firms, experts, and implementing bodies in the functioning of DIHs?

These questions were formulated on the basis of the key themes identified in the theoretical background, particularly the dual role of DIHs as both policy instruments and support structures for SME digitalization.

2.2 Research Design

The study utilizes a convergent mixed-methods research design in which a quantitative survey and qualitative interviews are conducted in parallel and their findings later integrated. This overall design strategy allows the strengths of one method to complement the weaknesses of the other. The quantitative component (survey of firms) offers broad coverage, providing numeric data on how a range of companies rate the impact of DIH services. The qualitative components (interviews with experts and a DIH operator) yield depth and detail, uncovering the reasoning, experiences, and examples behind those impacts. By combining these approaches, the design captures both breadth and depth of insights on DIHs. As the

National Institutes of Health and methodology scholars note, mixed-methods designs intentionally integrate quantitative and qualitative methods to draw on the strengths of each and offset the limitations of each approach, resulting in a more comprehensive understanding of the research problem. In practice, this means the statistical trends observed in the survey can be explained or contextualized by the narratives from interviews, and conversely, the interview findings can be supported (or questioned) by the broader survey evidence.

Triangulation is a core feature of the research design, used to merge insights across different sources and ensure robustness of conclusions. The design incorporates triangulation in two ways: (1) across data sources (stakeholder groups) and (2) across methods. First, by engaging multiple stakeholder groups (firms, policymakers, and DIH implementers), the study performs a form of data triangulation, examining the object of study (DIH effectiveness) from different angles. Each group provides complementary viewpoints – for example, firms report on direct outcomes and challenges, while experts can speak to policy-level effectiveness and DIH staff to operational issues. Second, the use of both a survey and interviews constitutes methodological triangulation, i.e. using multiple methods to study the same phenomenon. Methodological triangulation helps ensure the findings are not an artifact of one specific method: survey results can be cross-checked against interview insights and vice versa. Overall, this mixed-methods, triangulated design improves the credibility of the results. It enables complementary insights to emerge – quantitative data reveal what has been achieved or not, and qualitative data illuminate how and why – thereby capturing a fuller picture of DIHs' effectiveness than either method alone could provide. By integrating the findings during analysis (see Section 2.5), the design allows areas of convergence to reinforce each other and discrepancies to be investigated for deeper meaning. This careful integration of survey and interview evidence is aimed at producing a well-rounded evaluation of DIHs that reflects both measurable outcomes and lived experiences. This approach follows the framework of Creswell and Plano Clark (2017), who emphasize the value of combining quantitative and qualitative evidence for robust evaluation in mixed-methods research.

2.3 Data Collection

Data were collected from two primary sources: a structured survey of firms and semi-structured interviews with selected experts and two DIH implementing body representative. Each data collection method was tailored to the participant type and research questions, while aligning with the mixed-methods design. All data were collected over the course of the research project in 2025. Prior to data collection, participants were informed of the purpose of the study and how their data would be used. Participation was voluntary, and informed consent was obtained from all respondents. The survey was administered with assurances of confidentiality to encourage honest feedback, and interviewees consented to being recorded and (in the case of experts) identified by name and affiliation given their public roles. The following subsections detail the data collection procedures for each component.

2.3.1 Firm Survey

A structured questionnaire survey was developed to gather quantitative data on firms' experiences with and perceptions of Digital Innovation Hubs. The survey targeted approximately 50 firms, primarily small and medium-sized enterprises (SMEs), that had engaged with an European Digital Innovation Hub (EDIH) or similar DIH services. These firms were identified through DIH program participant lists and referrals. An email invitation with a survey link was sent to each, explaining the study and ensuring confidentiality of responses. Ultimately, 28 complete responses were received (a response rate of about 56%), which formed the basis for quantitative analysis. While the sample size is modest, it provides valuable indicative data on a range of firms. The respondents span various sectors (manufacturing, services, ICT, etc.) and sizes (micro, small, medium), ensuring some diversity in the firm sample.

Survey Structure: The questionnaire was divided into sections covering the firm's background and several key domains of DIH impact, following the research focus areas. Most questions were closed-ended for quantitative measurement, supplemented by a few optional open-ended questions for additional commentary. The sections and question types included:

- General Firm Information: Basic characteristics of the firm (size by number of employees, primary industry sector, and market scope). These questions used multiple-choice formats (e.g., selecting firm size range, sector category, and whether the firm operates domestically or internationally). This context helps later in analyzing results by subgroup (for instance, comparing responses of manufacturing vs. service firms, or micro vs. medium enterprises).
- Engagement with the DIH: Questions about the firm's involvement with the Digital Innovation Hub. For example, firms indicated which types of DIH services they had used (multiple selection from options such as "test before invest" technology trials, training and digital skills development, funding/investment support, networking ecosystem access"). They also reported the duration or intensity of their engagement (e.g., less than 6 months, 6–12 months, over 1 year, or only occasional participation in events). These questions establish the context of how the firm interacted with the DIH.
- Impact on Digital Skills: This section assessed whether the DIH had improved the firm's internal capabilities. A key question asked respondents to rate their agreement with the statement "The participation in the DIH has improved the digital skills of our company's personnel." on a Likert scale from 1 (Strongly Disagree) to 5 (Strongly Agree). An average or distribution of these Likert responses indicates the perceived effectiveness of the DIH in upskilling staff. Additionally, an optional open-ended question invited firms to describe any new digital competences their team acquired through DIH activities (for example, skills in AI, data analytics, cybersecurity, use of new software, etc.). This open question allowed respondents to elaborate on the types of skills gained, providing qualitative detail to enrich the numeric ratings.
- Impact on Innovation and Investment: Several survey items examined the DIH's impact on the firms' innovation outcomes and investment behavior. One Likert-scale item stated "We have developed new products or services thanks to the support received from the DIH.", measuring agreement on whether the DIH engagement directly facilitated innovation output (such as product development). Another item asked whether, as a result of DIH support, the firm increased its investments in certain

areas. Instead of a single scale, this was a multiple-choice question where firms could tick all applicable categories of investment that were expanded (for instance: investments in new equipment or technology infrastructure, in workforce training or organizational capabilities, etc.). This question captures which domains saw additional investment, reflecting DIH influence on the firm's resource allocation. Together, these questions address the perceived effectiveness of DIHs in spurring innovation and follow-on investments within firms.

- Impact on Competitiveness and Digital Transformation: This section continued with outcomes related to the firm's performance and digital transformation progress. Firms rated statements such as "We improved operational efficiency or productivity through the digital solutions implemented with the help of the DIH." and "We expanded our market share or entered new markets thanks to the support received from the DIH." on the 1–5 Likert agreement scale. These items probe whether DIH assistance translated into tangible competitive advantages, like efficiency gains or market growth. Positive responses here would indicate that the DIH's support had meaningful business impacts, not just intermediate outputs.
- Barriers and Weaknesses: Finally, the survey addressed the obstacles or challenges encountered during the collaboration with the DIH, to capture the weaknesses or limitations in the DIH experience. A multiple-selection question asked respondents to indicate which issues they faced (if any) while working with the DIH. Provided options included, for example: "The solutions offered were not fully appropriate for our company's needs, size, or sector," "We had difficulties in the practical implementation of the solutions, despite recognizing their potential utility," "There were organizational or bureaucratic complexities in managing the collaboration (e.g., slow response times, procedural hurdles, unclear support processes)," "No significant obstacles encountered," and an "Other (specify)" option with a free-text field. This allowed firms to report any misalignments or inefficiencies in DIH service delivery, or to note if the engagement was smooth. Additionally, an open-ended question invited a brief example of how DIH support improved the firm's competitiveness or performance (e.g. describing a successful project outcome).

Although optional, these qualitative responses provide illustrative evidence of DIH impact or highlight specific pain points.

The survey questions were primarily in the Italian language (as the participant firms are Italy-based), and responses were later translated to English for analysis where necessary. The use of mostly closed-ended, Likert and categorical questions enables quantitative analysis of the responses, while the included open-ended items give respondents the opportunity to voice insights or examples beyond the fixed choices. Data was collected via an online survey platform over a period of approximately four weeks. Regular follow-up reminders were sent to improve the response rate. All responses were recorded anonymously – no firm names were collected in the survey – to encourage candor especially when reporting any negative experiences or perceived shortcomings of the DIH.

2.3.2 Expert Interviews

To complement the firm-level data, the study conducted semi-structured interviews with two experts in the field of innovation policy and digital transformation. These individuals were selected through purposive sampling for their deep expertise and direct involvement in initiatives related to Digital Innovation Hubs:

- Dr. Raffaele Spallone (Ministry of Enterprises and Made in Italy – MIMIT): A senior official involved in innovation and industrial policy, providing a government perspective on the role and performance of DIHs. MIMIT (Ministero delle Imprese e del Made in Italy) is the Italian ministry overseeing economic development and innovation programs, including the support and funding of EDIHs. Dr. Spallone has been directly engaged in shaping or monitoring innovation support initiatives, making him well positioned to comment on DIH effectiveness from a policymaker's viewpoint.
- Dr. Gianpiero Ruggiero (National Research Council – CNR): A leading researcher and innovation strategist at the Consiglio Nazionale delle Ricerche, Italy's National Research Council. Dr. Ruggiero has significant expertise in innovation ecosystems

and technology transfer, and has interacted with DIHs or similar digital transformation programs from the research and policy advisory side. His perspective represents the research community and provides insight into how DIHs fit into broader innovation networks and where they succeed or fall short.

These experts bring high-level, informed perspectives on DIHs, and were chosen to gain insights into the perceived effectiveness of DIHs at a systemic level (beyond individual firms). The expert interviews were semi-structured, meaning that an interview guide of key topics and questions was prepared, but the conversation remained flexible to allow probing of interesting points in depth. The interview guide covered areas such as: the experts' views on the objectives of DIHs and whether those objectives are being met, the strengths of the DIH model in practice, any weaknesses or challenges they have observed (e.g., common implementation issues, gaps in services, engagement problems with SMEs), the impact of DIHs on firms' innovation capacity and regional innovation ecosystems, and suggestions for improvement or future policy directions for DIHs.

Each expert interview was conducted one-on-one via Google Meet video conferencing. The interviews were scheduled at a time convenient for the participants and lasted approximately 30 minutes on average. With the interviewees' consent, the sessions were audio-recorded to ensure accurate capture of their responses. During the interviews, the researcher asked open-ended questions following the guide, but also allowed the experts to elaborate freely and steer into relevant subtopics. For example, if an expert mentioned a particular challenge (like coordination between DIHs and other programs), follow-up questions would explore that further. This flexibility helped in uncovering detailed insights and examples. The tone of the interviews was conversational yet focused, encouraging experts to share candid assessments and draw on their professional experiences with DIHs or related initiatives. After each interview, the recording was transcribed verbatim (and translated to English) to create a text document for analysis. The experts agreed to be identified by name and institutional affiliation in this thesis, given their public roles and the non-sensitive nature of the information shared (which was professional opinion about a

policy instrument). This transparency adds credibility, as readers can recognize the authority of the sources.

2.3.3 Implementing Body Interview

In addition to policy experts, the research included interviews with representatives from DIH implementing bodies to gather the perspective of those who operate and deliver DIH services. Specifically, Ms. Debora Zrinscak of Artes 4.0 and Ms. Francesca Felline of CETMA were interviewed.

Artes 4.0 is one of Italy's prominent Competence Centers (and a designated European Digital Innovation Hub) focusing on advanced robotics and enabling technologies for Industry 4.0. Ms. Zrinscak serves as a senior project manager at Artes 4.0, involved in managing programs and partnerships. Her role gives her first-hand insight into how a DIH functions on the ground – the services offered, how firms engage with the hub, and what challenges occur in implementation.

CETMA (Center for Design, Material Technologies & Planning) is a Research and Technology Organization (RTO) based in Brindisi, operating for over 30 years in the fields of industrial research, product innovation, and advanced digital design. CETMA is the coordinating entity of CETMA-DIHSME, a European Digital Innovation Hub providing services to SMEs in areas such as digital prototyping, design for manufacturing, and materials technologies. Ms. Francesca Felline, who works as a Senior Researcher and Engineer at CETMA, has extensive experience in managing innovation projects and coordinating support activities for SMEs. Her position provides practical insight into the day-to-day operations of a regional DIH and the challenges and successes involved in delivering digital transformation support.

The interviews with both Ms. Zrinscak and Ms. Felline were semi-structured, using tailored guides. The questions for these interviews were oriented towards the operational and practical aspects of running a DIH. Key topics included: the range of services their DIHs provide to companies (e.g., technology testbeds, training, funding advice, etc.), how they measure or

perceive the effectiveness of these services (success stories, typical outcomes for client firms), common challenges faced in delivering support to SMEs (such as resource constraints, varying firm readiness, outreach and engagement difficulties, administrative hurdles), and their perspective on the strengths and weaknesses of the DIH model based on their experience. The discussion also touched on the relationship between the DIHs and the broader ecosystem (universities, industry partners, government funding) and how that influences effectiveness.

These interviews were conducted via video conference (Google Meet), each with a duration of around 30 minutes. They were recorded with permission and later transcribed. The insights offered by Ms. Zrinscak and Ms. Felline added the practitioner's viewpoint – effectively, insiders' assessments of how DIHs operate and where improvements might be needed. While the firm survey captures the customer experience and the experts provide the policy-level assessment, the DIH operators provide the service-provider perspective. Including these interviews is crucial for triangulation: they help explain certain findings from the firm survey (for instance, if firms report obstacles, the DIH implementers might shed light on why those obstacles occur). They also highlight internal challenges of DIHs that may not be visible to external observers. Both interviewees' responses were handled confidentially in terms of sensitive details, but they agreed that their names and DIH affiliations could be mentioned as part of the methodological description.

Overall, the data collection yielded three sets of data: (1) quantitative survey data from 28 firms, (2) qualitative transcripts from two expert interviews, and (3) qualitative transcripts from the DIH implementing body interviews. This mix of data provides a rich foundation for analysis. All interviews were conducted in Italian when necessary and translated, but the respondents often used English technical terms; the analysis was done on the English transcripts for consistency. The combination of survey and interview data ensures that the research can address the evaluation of DIHs from multiple vantage points, aligning with the study's objectives.

2.4 Data Analysis

Given the mixed-methods design, data analysis was carried out separately for the quantitative and qualitative datasets, followed by a convergence of findings in interpretation. This section describes the analysis procedures for each type of data.

2.4.1 Quantitative Data Analysis

The survey data from the 28 responding firms were compiled and analyzed using descriptive statistical techniques. Since the sample size is relatively small, the analysis focused on descriptive statistics rather than inferential statistical tests. Each survey question was analyzed to determine the distribution of responses and summarize the central tendencies:

- For Likert-scale items (rated 1 to 5), the responses were tabulated to see the frequency of each rating. The mean and median scores were calculated as overall indicators of agreement. For example, the average agreement score on statements like "DIH improved our digital skills" was computed to gauge overall perceived effectiveness in that area. Standard deviations were also noted to understand the variability in responses (i.e., whether firms had consensus or divergent views on each statement).
- For multiple-choice questions (such as those asking which types of investments were increased or which obstacles were encountered), frequency counts and percentages were calculated for each option. This reveals which outcomes or issues were most commonly experienced. be ~54% of the sample, highlighting a frequent impact area of the DIH.
- Basic cross-tabulations were performed to explore patterns or differences between subgroups of firms. Given the sample size, these cross-tabs were used in an exploratory manner (not for statistical significance testing, but for identifying possible trends). Examples include: comparing responses by firm size (do micro-enterprises report different levels of satisfaction or obstacles than medium-sized firms?), by sector (e.g., do manufacturing firms note more improvement in productivity than service firms?), or by length of engagement with the DIH (do firms engaged for over a year report greater benefits than those with short-term

engagement?). These cross-tab analyses help to identify if certain kinds of firms experienced DIH support differently, which can be useful for nuanced interpretation.

- The results were visualized in simple charts (bar graphs for frequency distributions of key questions, etc.) to aid interpretation, although detailed visualization is presented in the results chapter.

All quantitative analysis was conducted using Microsoft Excel and Python. Excel was used for data cleaning and initial tabulations, while Python was used to generate descriptive statistics tables and cross-tabs systematically. Given the limited sample, no advanced statistical modeling (like regression analysis) was attempted, as it would not be reliable. Instead, the analysis remained at the level of summarizing what proportion of firms experienced certain effects or challenges and highlighting prominent trends. These quantitative findings provide an aggregated picture of DIH effectiveness as perceived by firms, forming one pillar of the evaluation.

Before finalizing the quantitative results, the data were checked for any inconsistencies or errors (for example, ensuring that Likert scales were coded correctly as 1–5, and that multiple-response questions were properly handled). The small sample size also meant that any outlier responses could be observed directly; however, no survey was excluded as all 28 were sufficiently complete and credible. The descriptive analysis is presented in Chapter 3 (Data Analysis), where it is also integrated with qualitative insights to allow triangulation of findings.

2.4.2 Qualitative Data Analysis

The qualitative data – comprising the transcripts of the two expert interviews, the DIH operator interview, and the open-ended survey responses – were analyzed using a thematic analysis approach. The goal of the qualitative analysis was to identify recurring themes and patterns in how different stakeholders discuss the effectiveness and weaknesses of DIHs.

All interview recordings were transcribed verbatim into text (with minor editing for clarity and translation into English as needed). Similarly, any textual responses from the survey's

open-ended questions were extracted and included in the qualitative dataset. This resulted in a set of documents that were imported into NVivo (version 12) qualitative analysis software to assist with organizing and coding the data.

Following the guidelines of Braun and Clarke (2006) for thematic analysis, the analysis proceeded through several steps. First, there was an intensive familiarization with the data: reading and re-reading the transcripts to become immersed in the content. Initial notes were made about interesting points or potential codes during this phase. Braun and Clarke define thematic analysis as "a method for identifying, analysing and reporting patterns (themes) within data. It minimally organizes and describes your data set in rich detail.". Guided by this approach, coding was then performed on the textual data.

In the coding phase, each transcript was reviewed line by line in NVivo, and segments of text (phrases or sentences) that conveyed a meaningful idea were labeled with a code. A code in this context is a descriptive tag or category identifying what that piece of text is about. Many codes were derived inductively from the data – meaning they emerged from what the interviewees actually said, rather than being pre-determined – though the research questions provided some sensitizing concepts. For example, when an expert discussed a particular weakness of DIHs (say, "limited outreach to micro firms"), that segment would be coded as "outreach challenge" or similar. Likewise, if a firm's open-ended response praised "improvement in internal skills", it would be coded under "skills development benefit." The coding was done with a fairly low level of granularity to capture nuances (it's common to have dozens of initial codes covering various aspects of DIH impact, service quality, external factors, etc.). NVivo software was useful here to manage the codes and link them to relevant quotations from the text.

After coding all the qualitative data, the next step was to search for themes by examining the codes and grouping them into higher-level categories. A theme represents a broader pattern that answers an important aspect of the research question. For instance, several codes like "skills development," "technology adoption," and "new product development" might cluster under a theme of "Positive Impacts of DIHs on Firms." Similarly, codes such as "lack of

awareness," "bureaucratic delays," and "misalignment of solutions" might be grouped into a theme about "Challenges/Limitations in DIH Implementation." The process involved reviewing all coded data extracts for each potential theme to ensure they coherently relate to that theme. The themes were then reviewed and refined – some were merged, others were split, and some discarded if not sufficiently supported by the data. Clear definitions were developed for each theme to distinguish them. In total, the analysis yielded a set of key themes that encompassed both effectiveness (e.g., types of benefits firms experienced, success factors for DIHs) and weaknesses (e.g., common barriers, shortcomings in DIH services or structure) as identified across the interviews and open comments.

Throughout the qualitative analysis, efforts were made to maintain trustworthiness of the process. This included keeping an audit trail of coding decisions and memos in NVivo (notes on why certain groupings were made, or interpretations of what an expert likely meant by a statement). Triangulation within the qualitative data was also considered: for example, checking if a theme arising from expert interviews also appeared in the firm comments or the DIH operator's perspective, and noting areas of agreement or divergence. In cases of divergence (say, experts highlight an issue that firms did not mention), those were flagged for further consideration in the discussion to understand the discrepancy. NVivo's query functions (like word frequency or text search) complemented the manual thematic analysis by ensuring no major topic was overlooked.

The end result of the qualitative analysis is a set of richly described themes, supported by representative quotations from participants.By using thematic analysis, the study systematically distilled the qualitative data into meaningful findings, while retaining illustrative examples from participants' own words to give voice to their experiences.

2.5 Methodological Rigor and Triangulation

Ensuring the rigor and validity of the research findings was a priority in the study's design and execution. A key strategy for enhancing rigor was the triangulated mixed-methods approach. As Denzin (1978) explains, triangulation enhances the credibility of qualitative

findings by examining a phenomenon through multiple lenses. By drawing evidence from multiple sources and using multiple methods, the study cross-verifies findings and reduces the likelihood of systematic bias. This approach aligns with the broader notion that triangulation increases internal validity by combining different perspectives and techniques. Rather than relying on a single data point, conclusions are built upon converging information from the firm survey, expert interviews, and the DIH practitioner interview.One aspect of rigor is data triangulation: using multiple data sources to examine the same phenomenon. In this research, data triangulation is evident in incorporating views from distinct stakeholder groups (firms, experts, implementers). Each group might have its own biases or blind spots, but by comparing them, the study can identify common patterns that are likely robust. For example, if both firms and the DIH manager independently point to "skills development" as a major benefit of the hub, this consistency strengthens the validity of that finding. Conversely, if one group raises an issue that others do not, the triangulation approach brings that discrepancy to light, prompting a closer analysis of why perceptions differ. In essence, the multiple sources act as checks on each other, helping to ensure the research findings are not overly influenced by the viewpoint of a single group. This technique helps ensure that the findings are not biased by a single data source.

Another aspect is methodological triangulation: employing different methods (quantitative and qualitative) to study the research questions. Each method has inherent strengths and limitations. Surveys can gather input from many firms efficiently and produce quantifiable indicators, but they may not capture context or deeper explanations. Interviews yield rich detail and insight into causality or mechanisms, but with a limited number of participants they may not be broadly representative. By using both, the methods complement one another. The qualitative evidence can explain why the quantitative trends are occurring, and the quantitative data can indicate how prevalent or significant certain qualitative insights might be. This combination enhances the overall reliability of results, because findings supported by both numbers and narratives are less likely to be artifacts of one particular method. In other words, the study's conclusions do not rest on one single mode of inquiry. Methodological triangulation thus mitigates method-specific biases – for instance, reducing

the risk that survey wording alone shaped the results, or that an interviewee's personal opinion is taken out of context – since each key point can be cross-checked through an alternative form of evidence.

The integration of data in this study was done carefully to uphold rigor. After separate analyses, the quantitative and qualitative findings were compared during interpretation. The researcher looked for points of convergence (where survey results and interviews told a consistent story) as well as divergence (where one might indicate something different from the other). Converging evidence was taken as stronger confirmation of a result's validity. For example, if a majority of survey respondents reported improved productivity and the DIH manager also emphasized a productivity gain case study, these reinforcing pieces suggest a credible finding. On the other hand, divergent evidence was not ignored but examined – often, it provided insight into conditions or context (e.g., experts might criticize some aspect that firms did not mention, possibly due to differences in perspective or information asymmetry). By explicitly addressing such differences, the study adds nuance and ensures that conclusions are well-contextualized rather than one-sided. This reflects the idea that triangulation not only strengthens confirmation but can also reveal richer complexity.

Additionally, standard measures were taken to maintain research quality: the survey instrument was reviewed for face validity and clarity, interviews were conducted in a consistent manner using an interview guide (improving reliability across interviews), and all data was documented and stored systematically (transcripts, coding files) to allow auditability. The use of software (SPSS for quantitative, NVivo for qualitative) provided transparency in how analyses were carried out and helped prevent clerical errors. Where feasible, respondent validation was done informally – for instance, at the end of expert interviews, the interviewer summarized key points to the interviewee to confirm accuracy of understanding.

By leveraging triangulation, the study enhances internal validity: findings supported by multiple independent pieces of evidence inspire greater confidence. Researchers have noted that combining multiple data sources and methods enables the identification of

inconsistencies and biases, thereby increasing the overall validity of research findings. In this thesis, triangulation serves exactly that purpose – it functions as a form of built-in cross-examination of the data. Moreover, the multi-method, multi-respondent design provides a more holistic view of DIH effectiveness. It ensures that the evaluation considers technical outcomes, user satisfaction, strategic alignment, and implementation processes together. This comprehensive perspective is a direct result of methodological rigor in design.

In summary, the research methodology was deliberately structured to maximize rigor through triangulation and careful analytical procedures. By validating results across different sources and methods, the study's conclusions about DIH effectiveness and weaknesses are made more robust and credible.

2.6 Limitations

While the chosen methodology provides valuable insights, it is important to acknowledge its limitations. These limitations temper the interpretation of the findings and suggest caution in generalizing results beyond the study context:

- Limited Sample Size (Quantitative Survey): The survey component achieved 28 firm responses, which is a relatively small sample. With such a modest N, the quantitative results should be viewed as exploratory and descriptive rather than definitively representative of all firms engaging with DIHs. A small sample size limits the statistical power and means that the survey findings may not capture the full variability of experiences in the wider population of DIH users. For instance, if only a few firms in our sample reported a certain issue, it's unclear whether this issue is truly rare overall or simply under-sampled. Thus, the ability to generalize numerical findings (e.g., "X% of all DIH-assisted firms achieve a certain outcome") to other contexts or regions is limited. The results primarily reflect the particular group of firms surveyed, which were mostly from the Italian DIH context in 2024.
- Potential Selection Bias: There is a possibility of self-selection bias in both the survey and interview participation. Firms that chose to respond to the survey might differ

systematically from those that did not. It could be that more engaged or satisfied firms were more willing to take the time to respond, or conversely, that firms with strong opinions (positive or negative) responded while more indifferent ones did not. This means the survey results might skew toward either more positive experiences or highlight more problems than the average, depending on who responded. Similarly, the experts interviewed were specifically selected for their roles and expertise; their views, while highly informed, might not represent all possible expert opinions (for example, another expert might have different perspectives on DIHs depending on their involvement or ideology). The DIH representative interviewed is from one particular competence center (Artes 4.0), which might be a best-case scenario or, alternatively, might have unique challenges not found elsewhere. In short, the stakeholders consulted do not constitute a random or exhaustive sample of all relevant voices. This selection limitation means findings must be interpreted in context and not over-generalized.

- Geographical and Contextual Scope: The study is focused largely on the Italian context (with the firm survey and DIH interview centered on an Italian EDIH case, and experts familiar with European/Italian policy). DIHs in other countries or regions might operate differently. Additionally, the timing (mid-2020s) may influence results, as EDIHs were a relatively new initiative and still evolving. Therefore, the findings may not apply equally to more mature hubs or those in different innovation ecosystems. The contextual specificity is a limitation on the external validityof the study.
- Reliance on Perceptions and Self-Reported Data: The data gathered – both survey and interviews – are perceptual and self-reported. They capture what respondents believe or recall about DIH effectiveness, which can be subjective. Firms' assessments of improvement (in skills, innovation, etc.) are not independently verified by performance metrics; they are the firms' own perceptions. Human subjects data can be influenced by memory lapses, personal bias, or desire to give socially acceptable answers. For example, some firm respondents might overstate benefits to appear appreciative of public support, or conversely understate them if they had other

frustrations. Likewise, an expert or DIH representative might have biases based on their role (a tendency to defend the initiative, or a critical stance wanting to push for changes). The study attempted to mitigate this by assuring anonymity in the survey and encouraging candid responses, but the limitation remains that the data are not objective measurements but subjective evaluations.

- Limited Depth in Each Qualitative Sub-sample: Only two experts were interviewed, and two DIH implementing body representative. While their insights were rich, having such a small number of interviewees in each category means there could be important viewpoints or experiences not captured. For instance, another DIH center might have different operational challenges than Artes 4.0 or CETMA, or another policy expert might emphasize different criteria for effectiveness. The qualitative findings are thus illustrative rather than exhaustive. With a small qualitative sample, there is also the risk that idiosyncratic opinions could carry weight. The thematic analysis mitigated this by focusing on points that were supported by evidence or echoed by more than one source (including the open-ended survey comments which provided a few additional voices), but still the qualitative conclusions should be seen as emerging hypotheses or insights that would benefit from further validation in larger or comparative studies.
- Cross-sectional Design: The research design is essentially cross-sectional – capturing perceptions at one point in time – rather than longitudinal. As such, it cannot conclusively determine causality or how perceptions might change over time. For example, it assesses whether firms felt that DIH involvement helped them innovate, but it does not track firm performance before and after DIH engagement to objectively measure change. Similarly, the experts' and DIH manager's views are snapshots and might evolve as the DIH program progresses. A longitudinal approach or pre-post analysis was beyond the scope of this thesis but would strengthen claims of effectiveness by observing actual change. The current design relies on stakeholders' attribution of outcomes to DIH support, which, while insightful, may be subject to recall bias or other confounding factors (firms might credit the DIH for a result that had multiple contributing causes).

In acknowledging these limitations, the intention is to be transparent about what the methodology can and cannot support. The findings of this study should be understood within these constraints. They provide valuable evidence and insights into DIH effectiveness and weaknesses, but they are not the final word on the matter. Wherever possible, the thesis will note these limitations when discussing results – for instance, by phrasing conclusions cautiously (e.g., "the data suggest…" rather than "prove"), and by recommending in Chapter 4 that further research with larger and broader samples be conducted to confirm and expand upon these findings. Despite the limitations, the mixed-methods triangulated approach of this study provides a credible exploratory assessment, and the convergence of evidence across methods lends weight to the key findings within the context studied.

CHAPTER 3: DATA ANALYSIS

3.1 Survey Sample Overview

3.1.1 Firm size and sectorial distribution

Building on the methodological approach outlined in Chapter 2, this section presents the empirical findings from the survey conducted among firms engaged with the European Digital Innovation Hub (EDIH). The analysis begins by profiling the sample of participating SMEs, providing an overview of their size, sectoral distribution, and market orientation.This study's survey was completed by a total of 28 firms engaged with the EDIH. As shown in Figure 3.1 all respondents fall within the small and medium-sized enterprise (SME) category, with a breakdown by firm size as follows: nearly half of the sample were micro-enterprises (13 firms with fewer than 10 employees), followed by small enterprises (11 firms with 10–49 employees) and a smaller group of medium enterprises (4 firms with 50–249 employees). This distribution indicates a strong representation of smaller firms, which aligns with the EDIH's mandate to support SME digitalization. As illustrated in Figure 3.2, the majority of respondent firms operate in manufacturing and industrial sectors (20 firms, representing approximately 71% of the sample). The remaining firms were split evenly between the services sector (4 firms, ~14%) and the ICT/high-tech sector (4 firms, ~14%). The predominance of manufacturing/industrial firms in the sample is notable, suggesting that industrial SMEs constitute the core client base for the hub's initiatives, whereas service-oriented and high-tech firms were less prevalent among the respondents.

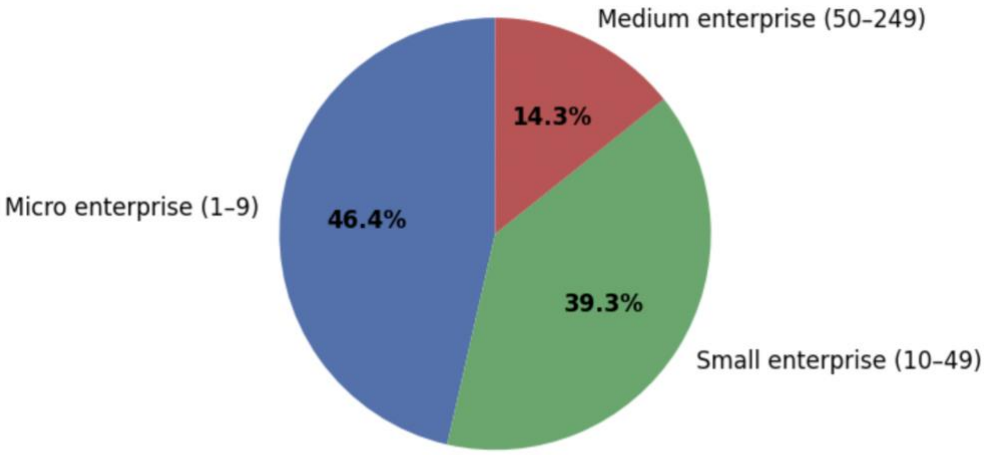

Figure 3.1 – Distribution of firms by size (N=28).
Breakdown of surveyed firmsby firm size: micro enterprises (1–9 employees), small enterprises (10–49 employees), and medium enterprises (50–249 employees).

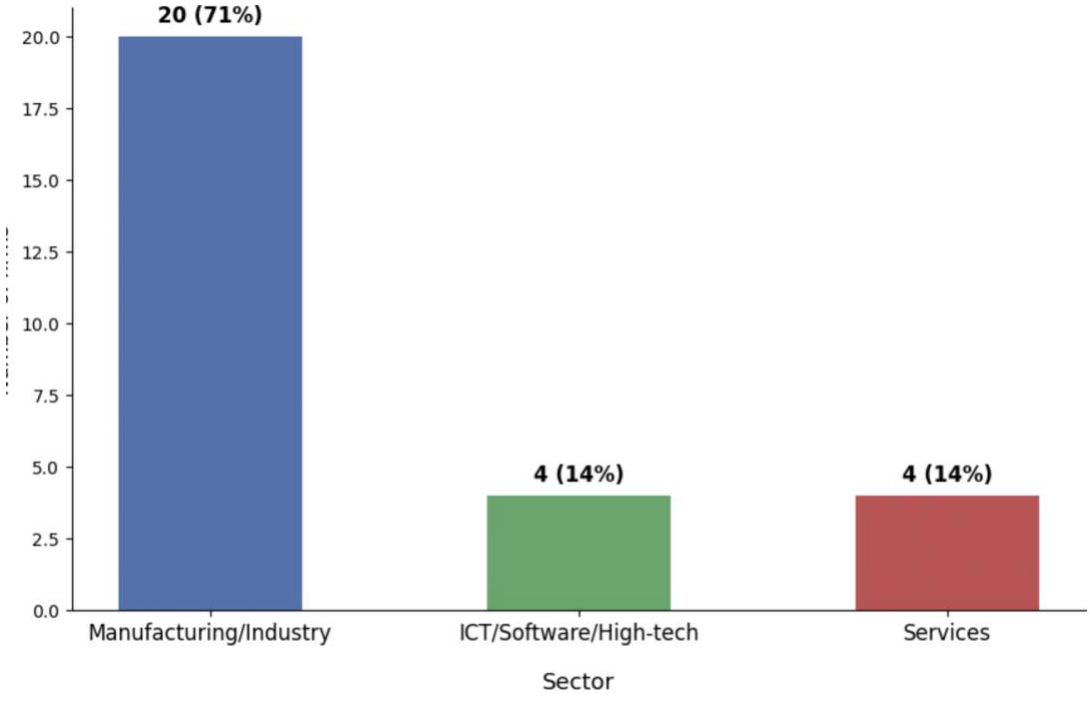

Figure 3.2 – Distribution of firms by sector (N=28).
Sectoral distribution of surveyed firms (N=28). The majority operate in manufacturing and industry (71%), while services (14%) and ICT/high-tech (14%) are less represented.

3.1.2 Market scope and geographic reach

The surveyed firms also varied in their market scope and geographic reach. Most of the firmsreported operating primarily in the domestic market: 18 out of 28 firms indicated that their commercial and operational activities are mainly within the national (Italian) market. An additional 9 firms described a mixed market scope, meaning they engage in both domestic and international markets. Only 1 firm in the sample operates exclusively at an international scale. This indicates that while a few participating firmshave a broader global presence, the typical EDIH-engaged firm in this study tends to serve domestic markets, sometimes with some international exposure. It is possible that firms focused on local markets seek out the EDIH's support to strengthen their capabilities before expanding abroad, though a minority are already internationally active, as illustrated in Figure 3.3.

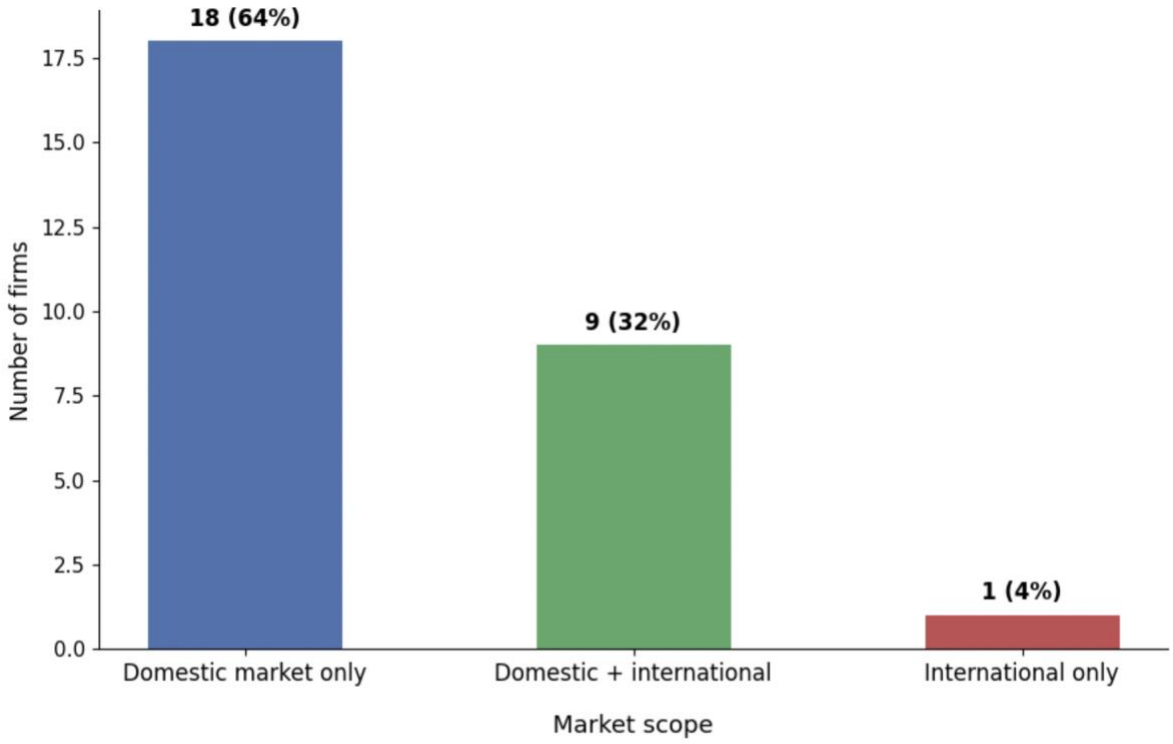

Figure 3.3 – Distribution of firms by market scope (N=28).
Geographic scope of respondent firms' activities, distinguishing between firmsactive primarily in the domestic (Italian) market, in both domestic and international markets, or exclusively abroad.

3.1.3 Duration of engagement

With regard to engagement duration with the EDIH, respondents had varying lengths of collaboration at the time of the survey. As shown in Figure 3.4, about one-third of the firms (9 out of 28) had been working with the hub for a relatively short period (less than 6 months). The largest group, over half of the sample (15 firms), reported a collaboration duration of between 6 and 12 months. A smaller subset (4 firms) had more than one year of ongoing engagement with the EDIH. These figures suggest that most respondents had at least half a year of experience with the hub's services, and a few had deep, long-term engagements exceeding one year. This range of collaboration lengths is useful for interpreting the results: firms with only a few months of engagement might not yet have realized the full benefits of the programs, whereas those with year-long collaborations could provide insight into longer-term impacts.

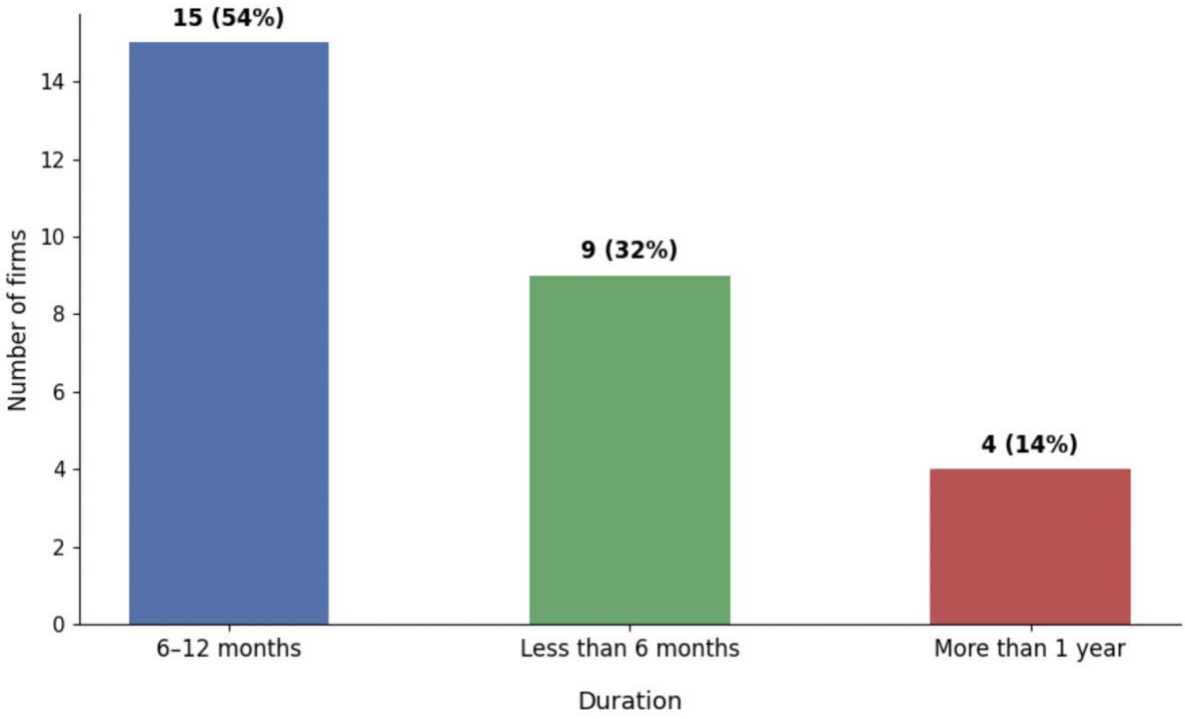

Figure 3.4 – Duration of collaboration with the EDIH (N=28).
Length of time firms have been engaged with the EDIH, including less than 6 months, 6–12 months, and more than 1 year of collaboration.

3.1.4 EDIH services used by firms

Finally, it is important to understand which DIH services the firms actually utilized, as this context helps frame the results of the study. The survey asked firmsto indicate all the EDIH services they had used, and the results are presented in Figure 3.5.The most commonly accessed service was “test-before-invest,” which was utilized by 15 out of 28 firms. This service allows firmsto experiment with or pilot new technologies before committing to significant investments, reflecting a high demand for practical, trial-based innovation support. The next most frequently used service was funding and investment support (selected by 10 firms), indicating that many firmslooked to the hub for assistance in finding financing or investment opportunities for innovation projects. Digital skills training and development was also a significant service area, used by 7 firms, showing an appetite for workshops, courses, or on-the-job training to boost employee competencies. Additionally, 5 firms reported using the hub’s networking and ecosystem access services, which connect SMEs with partners, technology providers, universities, or research centers to foster collaboration. A smaller number of firms (4) engaged in consulting or mentoring services through the EDIH. In summary, while all the offered service categories saw some use, test-before-invest and funding support emerged as the most in-demand services among the surveyed companies. This pattern suggests that the ability to trial new technologies and to secure financial backing are top priorities for SMEs embarking on digital innovation, whereas training, networking, and consultancy, though important, were slightly less widely utilized by this particular sample.

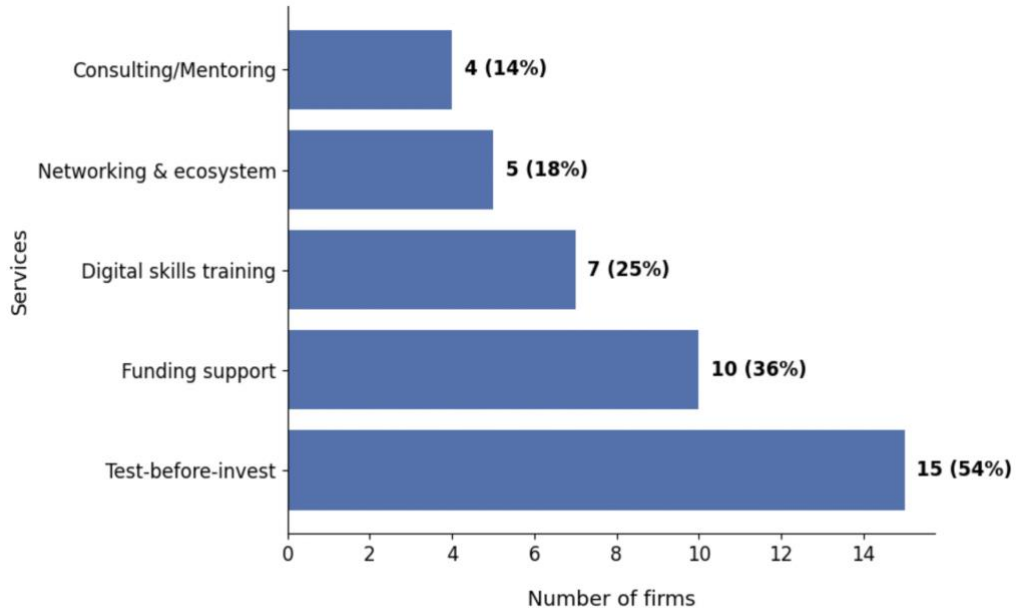

Figure 3.5 – EDIH services utilized by firms (N=28).
Frequency of use of EDIH services, including test-before-invest, digital skills training, funding support, networking and ecosystem access, and consulting/mentoring.

3.2 Quantitative Results

3.2.1 Descriptive statistics of Likert items

Having outlined the profile of the survey sample, this section turns to the quantitative results from the structured survey questions. The survey asked respondents to evaluate the outcomes of their engagement with the EDIH across several key dimensions. In particular, firms rated their level of agreement with statements regarding: (a) improvements in internal digital skills, (b) development of innovations (such as new products or services), (c) enhancements in operational efficiency or productivity, and (d) expansion of market share or entry into new markets. Each of these outcome areas was measured on a five-point Likert scale (where a higher score corresponds to stronger agreement that the outcome was achieved). For analytical clarity, the responses have been grouped into three categories: “positive” (agree or

strongly agree), “neutral” (neither agree nor disagree), and “negative” (disagree or strongly disagree). Table 3.1 summarizes the distribution of responses, while Figure 3.6 provides a visual representation.

Outcome dimension	Mean	Std. Dev.	Median
Improvement of internal digital skills	3.70	0.95	4
Improvement of efficiency/productivity	3.61	0.99	4
Development of new products/services	3.18	1.19	3
Expansion of market share / entry into new markets	2.75	0.97	3

Table 3.1 – Descriptive statistics of Likert-scale items (N=28).
Summary of means, medians, and standard deviations for four outcome dimensions. Results indicate that internal improvements (digital skills and efficiency) received higher scores, while innovation outputs and market expansion were rated lower.

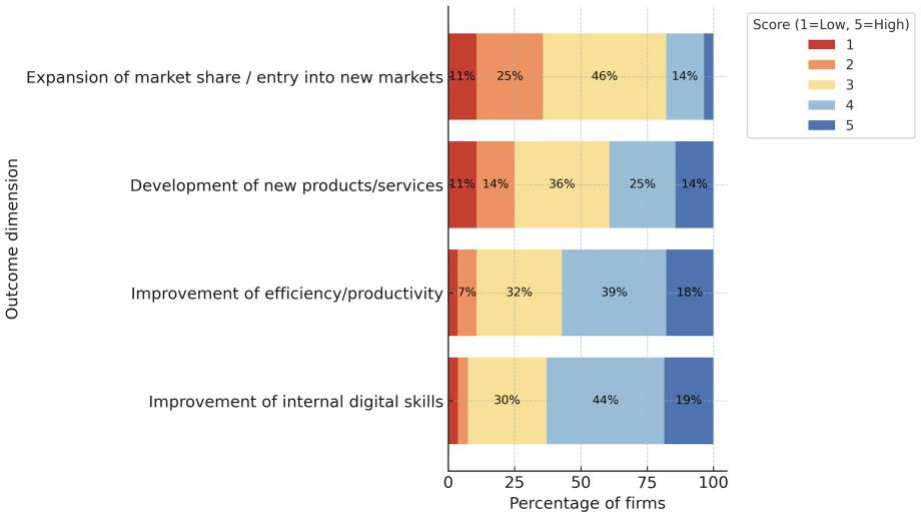

Figure 3.6– Distribution of Likert-scale responses (N=28).
Percentage distribution of firms’ responses (1 = strongly disagree/very low, 5 = strongly agree/very high) across the four outcome dimensions. The figure illustrates that the majority of firms reported positive outcomes in digital skills and efficiency, while responses were more neutral or negative for innovation outputs and market expansion.

Figure 3.7 illustrates the average scores and standard deviations for each outcome dimension, confirming that internal improvements achieved higher mean values than external outcomes.

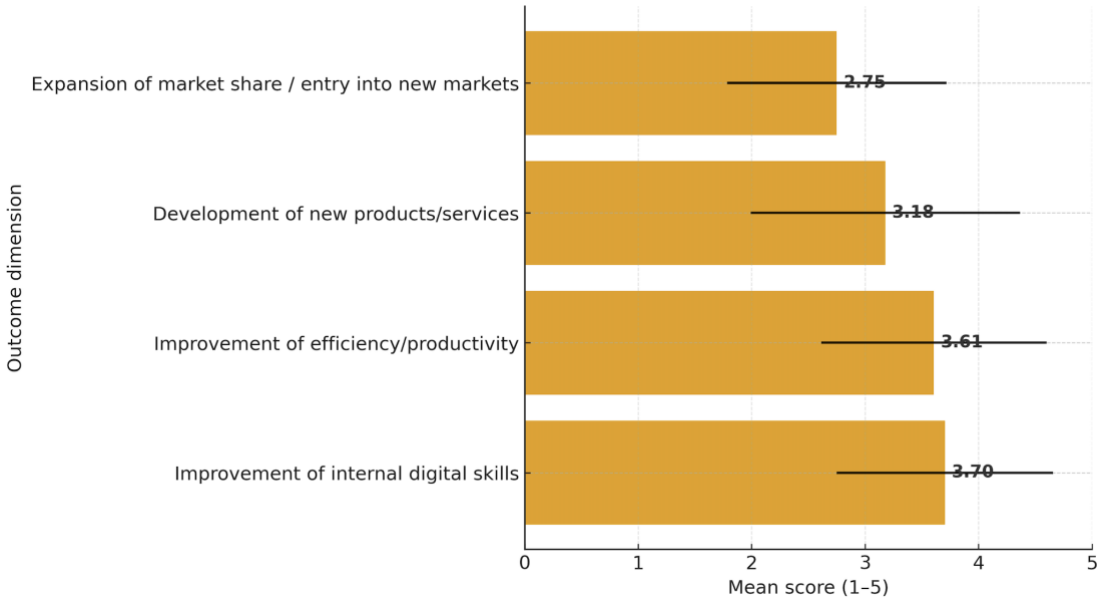

Figure 3.7 – Perceived impact of EDIH support (N=28).
Average Likert scores (1–5) across four outcome dimensions, with higher values indicating stronger agreement. The figure shows that internal digital skills and efficiency/productivity achieved the highest mean ratings, while innovation outputs and market expansion lagged behind.

To complement the statistical overview provided in Table 3.1 and Figures 3.6–3.7, the following subsections examine each outcome dimension in greater detail. This step allows us to go beyond the aggregate trends and to highlight specific patterns in how firms perceived the effects of their engagement with the EDIH.

Internal Digital Skills Improvement: The data indicate that participation in the EDIH was widely perceived to have a beneficial effect on the digital competencies of the firms' personnel. A majority of respondents (approximately 61%) reported a positive outcome, i.e. they agreed or strongly agreed that the EDIH collaboration improved the internal digital skills of their workforce. In contrast, only a small minority (7% of firms) disagreed with this

statement. The remaining respondents (about 29%) were neutral. This result suggests that one of the clearest early benefits of engaging with the hub was human capital development.

Operational Efficiency and Productivity: Over half of the firms(57%) reported that they experienced increased efficiency or productivity as a result of implementing digital solutions with the EDIH's help. About one-third of the firms (32%) remained neutral, while a small fraction (11%) reported negative outcomes. The presence of a few negative responses could reflect cases where digital interventions did not yield expected gains or where short-term disruptions outweighed benefits.

Innovation Outputs: When asked whether the EDIH support had enabled the firm to develop new products or services, only 39% of firms responded positively, while 36% were neutral and 25% disagreed. The high neutral proportion suggests that many firms had not yet seen innovation results at the time of the survey.

Market Expansion: This was the least reported positive impact. Only 18% of firmsagreed that they had expanded their market presence as a result of the EDIH's support, while 46% were neutral and 36% disagreed. This result indicates that, while internal capacities may have improved, translating those gains into market-level outcomes proved more challenging.

Taken together, these results suggest that the EDIH's most immediate and widely recognized benefits relate to internal capacity-building, while external market outcomes are less frequently reported and may require longer engagement periods to materialize.

3.2.2 Exploratory cross-tabulations

In line with the methodological framework described in Chapter 2, exploratory cross-tabulations were conducted to investigate whether firms with different characteristics reported systematically different experiences with the EDIH. These analyses were not

intended to test for statistical significance, given the limited sample size, but rather to identify potential patterns and trends across subgroups. The results provide additional nuance to the aggregate findings presented above, highlighting how firm size, sector, or engagement duration may shape perceived outcomes of EDIH support.

The cross-tabulation in Table 3.2 suggests a clear association between the duration of engagement with the EDIH and firms' perceptions of efficiency and productivity improvements.

Engagement duration	**Negative**	**Neutral**	**Positive**
< 6 months	2 (22%)	4 (44%)	3 (33%)
6–12 months	1 (7%)	5 (33%)	9 (60%)
> 1 year	0 (0%)	0 (0%)	4 (100%)

Note: Percentages may not sum to 100% due to rounding.

Table 3.2 – Exploratory cross-tabulation of engagement duration and perceived efficiency improvement (N=28)

(Row percentages; outcome measured on a five-point Likert scale and grouped as Positive = Agree/Strongly Agree; Neutral = Neither; Negative = Disagree/Strongly Disagree.)

Among firms that had collaborated with the hub for less than six months, evaluations were mixed: 33% reported positive outcomes, 44% remained neutral, and 22% expressed negative views. This distribution indicates that short-term collaborations may not provide sufficient time for firms to fully realize benefits, with many respondents still undecided about the impact. In contrast, firms engaged for six to twelve months showed a stronger positive orientation: 60% reported improvements, while neutrality decreased to 33% and negative responses fell to just 7%. The most striking pattern emerged among firms with more than one year of engagement, all of whom reported positive effects (100%), with no neutral or negative evaluations. Although this subgroup is small (n=4), the consistency of responses suggests that longer collaboration may be critical for the realization of efficiency gains. Taken together, these results align with the expectation that digital transformation benefits

accumulate gradually over time, as firms move from initial implementation and adjustment to consolidation and measurable performance improvements.

The cross-tabulation in Table 3.3 explores whether firms' sector of activity influenced their perceptions of innovation outcomes, specifically the development of new products or services supported by the EDIH.

Sector	**Negative**	**Neutral**	**Positive**
ICT/Software/High-Tech	0 (0%)	1 (50%)	1 (50%)
Manufacturing/Industry	6 (30%)	6 (30%)	8 (40%)
Services	1 (25%)	2 (50%)	1 (25%)

Note: Percentages may not sum to 100% due to rounding.

Table 3.3– Exploratory cross-tabulation of sector and perceived development of new products/services (N=28)

(Row percentages; outcome measured on a five-point Likert scale and grouped as Positive = Agree/Strongly Agree; Neutral = Neither; Negative = Disagree/Strongly Disagree.)

The results reveal modest but notable variations. Firms in the ICT/high-tech sector reported no negative responses; half were neutral and half positive, suggesting a generally favorable perception but with some uncertainty about tangible outputs. Manufacturing firms, which represent the majority of the sample, displayed a more diverse distribution: 40% perceived positive innovation outcomes, yet 30% remained neutral and another 30% reported negative experiences. This indicates that while many industrial firms benefited, a substantial share had either not yet observed concrete innovation results or encountered difficulties in translating support into new offerings. Service firms were the most cautious: half remained neutral, while the remainder was split evenly between positive and negative responses. Taken together, these findings suggest that sectoral characteristics may shape the pace and extent of innovation impacts. ICT/high-tech firms appear more immediately receptive to innovation outcomes, while service firms and parts of the manufacturing sector may require longer

engagement or additional forms of support to realize tangible product or service development.

These exploratory cross-tabulations enrich the quantitative analysis by showing how firm characteristics such as engagement duration and sector may shape the perceived benefits of EDIH support. While the small sample size limits the scope for firm conclusions, the observed patterns point to meaningful trends that complement the aggregate results. To deepen this understanding, the next section turns to the qualitative evidence collected through open-ended survey responses, which provides additional context on the opportunities and challenges experienced by firms.

In order to further investigate potential differences across firm types, we considered it important to analyze whether micro-enterprises (with fewer than 10 employees) perceive the benefits of DIH engagement differently compared to other SMEs. The following table presents the mean scores for four key dimensions: digital skills, efficiency/productivity, development of new products/services, and market share expansion comparing micro firms with larger SMEs. This exploratory cross-tabulation offers preliminary evidence on how firm size may influence the perceived outcomes of DIH support.

Outcome Dimension	**Micro (1–9 employees)**	**Other SMEs (10–249 employees)**
Digital Skills	3.75	3.67
Efficiency/Productivity	3.54	3.67
New Products/Services	3.54	2.87
Market Share Expansion	2.85	2.67

Table 3.4 – Comparative mean scores of DIH outcomes by firm size (Micro enterprises vs. other SMEs, >10 employees).

The table reports mean values on a Likert scale from 1 (not at all) to 5 (very much). Micro enterprises (1–9 employees) are compared against a single aggregated group including all other SMEs with more than 10 employees. Higher scores indicate stronger perceived outcomes. Source: Author's elaboration from survey data.

The results presented in Table 3.4 provide relevant evidence on how the perceived effectiveness of DIHs varies with firm size. Concerning internal outcomes, both micro enterprises and other SMEs report positive effects on digital skills and efficiency/productivity, with mean scores in the range of 3.5 to 3.7 on a five-point Likert scale. Micro firms appear to attribute slightly greater importance to improvements in digital skills (3.75 compared to 3.67), whereas larger SMEs report marginally higher benefits in terms of efficiency and productivity (3.67 compared to 3.54). This pattern suggests that the support offered by DIHs may be valued differently depending on the organizational structure and resource base of the firm: micro enterprises tend to place more emphasis on training and competence development, while larger SMEs may leverage digital solutions primarily to optimize internal processes.

With regard to external outcomes, the differences across firm categories are more pronounced. Micro enterprises report a higher average score for the development of new products and services (3.54 compared to 2.87), indicating that DIHs can play an enabling role for innovation in smaller firms, possibly compensating for their limited internal resources. By contrast, both groups report relatively low values for market expansion (2.85 for micro and 2.67 for other SMEs), suggesting that while DIHs contribute to strengthening internal capabilities and product innovation, their direct impact on external competitiveness and access to new markets remains modest.

Overall, these findings indicate that DIHs are perceived as more effective in fostering internal transformation and innovation capacity than in directly supporting firms' expansion into new markets. Furthermore, the differentiated outcomes by firm size underline the importance of tailoring DIH services to the specific needs and absorptive capacities of different categories of enterprises.

In addition to the analysis of perceived outcomes, it is crucial to examine the weaknesses and limitations reported by participating firms. Table 3.5 presents the main barriers identified by respondents, distinguishing between micro enterprises (1–9 employees) and other SMEs (with more than 10 employees). The responses have been systematically recoded into a set of recurring categories, thereby condensing a diverse range of qualitative inputs into analytically comparable themes. This approach enables a clearer and more rigorous comparison of perceived obstacles across firm size categories.

Firm Size	Organizational complexity	Communication issues	Difficulties in implementation	Lack of coherence with needs	No obstacles	Other obstacles
Micro	8	8	2	3	11	3
Others	0	0	4	5	11	0

Table 3.5 – Reported barriers and limitations in DIH engagement, by firm size (Micro enterprises vs. other SMEs, >10 employees).

The table presents the frequency of responses related to perceived obstacles. Firms could select multiple options. Micro enterprises (1–9 employees) are compared against an aggregated group of all other SMEs with more than 10 employees.

The evidence presented in Table 3.5 indicates that, although both micro enterprises and other SMEs frequently report the absence of significant obstacles, important differences emerge in the types of barriers encountered. Micro firms most often highlight bureaucratic and organizational complexity, as well as issues of communication and visibility, which reflects their more limited managerial resources and the greater difficulty they face in navigating institutional and inter-organizational settings. Larger SMEs, on the other hand, tend to emphasize difficulties in implementation and a lack of coherence between DIH services and their specific needs, which may be related to the higher level of integration and customization required in more complex organizational structures.

Overall, these findings suggest that firm size influences not only the extent but also the nature of the barriers perceived. While micro firms are more sensitive to relational, organizational,

and visibility issues, larger SMEs are more concerned with the alignment and applicability of DIH services. This highlights the need for differentiated policy and organizational approaches that tailor DIH support mechanisms to the heterogeneous needs and absorptive capacities of different categories of firms.

3.3 Qualitative Insights

3.3.1 Open-ended survey responses

In addition to the closed-ended questions, the survey included three open-ended items designed to capture the qualitative experiences of firms in their collaboration with the EDIH. These questions asked respondents to describe: (a) new digital skills acquired, (b) obstacles or barriers encountered, and (c) concrete examples of how the EDIH contributed to firm performance. This qualitative component enriches the analysis by uncovering nuances and perceptions that are not fully visible in the Likert-scale responses. Thematic coding was applied to the responses, resulting in three overarching themes: skills gained, barriers encountered, and tangible outcomes.The main themes, sub-themes, and illustrative quotations are summarized in Table 3.4 and further elaborated, theme by theme, in the subsequent discussion.

Theme	**Sub-themes**	**Example responses**
Skills gained	Artificial intelligence, data analysis, digital twin and simulation, additive manufacturing, Internet of Things, sustainability, product design, awareness of digital opportunities	"We acquired knowledge of AI models and their potential business applications." "We gained competences in digital twin and simulation."

Barriers encountered	No significant obstacles (majority), mismatch between proposed solutions and company needs, operational implementation difficulties, bureaucracy or organizational complexity, unfamiliarity with state-aid rules	"We did not encounter significant obstacles." "We faced difficulties in the operational implementation of solutions, despite recognizing their usefulness."
Tangible outcomes	Supply chain performance (on-time delivery), adoption of AI-based solutions, targeted financial planning, process analysis leading to Industry 4.0/5.0 adoption, sustainability initiatives, investment in transition 5.0	"We improved on-time delivery through new optimization tools for supply chain management." "Thanks to EDIH consultancy, we launched an investment in transition 5.0."

Table 3.4 – Thematic coding of open-ended survey responses (N=28)

Thematic coding of open-ended survey responses (N=28). The table reports the three overarching themes identified (skills gained, barriers encountered, and tangible outcomes), associated sub-themes, and selected illustrative quotations from respondents.

3.3.1.1 Skills gained

A large number of respondents emphasized the acquisition of new digital skills as a direct outcome of their engagement with the hub. Skills mentioned include artificial intelligence, data analytics, digital twin and simulation, additive manufacturing, and IoT applications. Beyond technical competences, firms also noted an increased awareness of opportunities offered by enabling technologies. This combination of technical know-how and strategic awareness suggests that EDIHs play a dual role in fostering both human capital development and organizational readiness for digital transformation.

3.3.1.2 Barriers encountered

Responses concerning barriers and obstacles were mixed. The majority of firms reported no significant difficulties, which indicates that the services were generally well aligned with their expectations. Nonetheless, some respondents pointed out specific challenges: misalignment between proposed solutions and company needs, difficulties in operationalizing digital solutions despite recognizing their usefulness, and issues related to bureaucracy or organizational complexity. A particularly detailed response highlighted the limited understanding of state-aid rules among some beneficiaries, as well as the need for the hub to actively stimulate demand for innovative services. These insights reflect that, while the EDIH reduces some barriers to digitalization, others—especially regulatory or organizational—remain persistent.

3.3.1.3Tangible outcomes

Several firms also described concrete outcomes of their engagement with the EDIH. Examples included improved on-time delivery in supply chain operations, the adoption of AI-based business models, and targeted financial planning that supported sustainable investment strategies. Others cited process analysis leading to the introduction of Industry 4.0 and 5.0 technologies, enhanced efficiency and sustainability, and the initiation of strategic investments associated with transition 5.0. These accounts demonstrate that, beyond skills and knowledge, EDIHs can generate measurable improvements in operational and strategic performance, even within relatively short collaboration periods.

These perspectives from SMEs provide a bottom-up view of the benefits and challenges of engaging with the EDIH. In the following section, this analysis is complemented by insights from expert interviews and implementing entities, which offer a top-down perspective on the hub's role and impact.

3.3.2 Thematic Analysis of Expert and Implementer Interviews

This section presents a thematic analysis of four semi-structured interviews, comparing insights from two expert informants and two implementing entities of a European Digital Innovation Hub (EDIH). Following the coding structure in Table 3.5, the findings are organized into four themes: (1) Role and mission of the EDIH, (2) Challenges and limitations, (3) Benefits and early impacts, and (4) Future outlook. This comparative narrative highlights where on-the-ground implementers (hub coordinators) and high-level experts (a policy official and a research strategist) converge or diverge in their views. All interviewees were aligned on the core purpose of EDIHs, yet they emphasized different facets reflecting their respective vantage points. The interviews were originally conducted in Italian and subsequently translated into English. The analysis is grounded in verbatim content (translated and paraphrased into fluent English), ensuring fidelity to the qualitative data and coherence with the study's methodological approach. Table 3.5summarizes the thematic coding of the interviews, including the overarching themes, sub-themes, and selected illustrative quotations. In the subsequent discussion, each theme is examined in depth to highlight convergences and divergences between experts and implementing entities.

Theme	**Insights from experts**	**Insights from implementing bodies**	**Example quotes**
Role and mission of EDIHs	Position hubs as strategic nodes of the European innovation ecosystem; emphasize alignment with EU digitalization and sustainability agendas; highlight importance of visibility and credibility.	Stress their role as first contact points for SMEs, providing concrete support such as training, test-before-invest services, and consultancy.	Expert: "EDIHs should not only provide services but act as connectors within the European digital ecosystem." Implementer: "We are often the first door SMEs knock on when looking for guidance on digital transformation."

Challenges and limitations	Point out structural barriers: limited SME awareness of EDIHs, risk of duplication with other initiatives, need for long-term sustainability beyond EU funding.	Report operational difficulties: aligning services with heterogeneous SME needs, bureaucratic and administrative burdens, lack of familiarity with state-aid rules among beneficiaries.	Expert: "The challenge is to avoid becoming just another EU project; continuity is crucial." Implementer: "Some firmsstruggled to understand the procedures linked to state aid and funding."
Benefits and early impacts	Highlight increased regional awareness of digitalization and first signs of networking effects across SMEs and institutions.	Report tangible firm-level impacts: improvement of internal skills, efficiency, and concrete project outcomes (AI adoption, supply chain optimization, targeted investment).	Expert: "EDIHs are starting to raise the level of discussion on digital innovation." Implementer: "One SME improved its on-time delivery thanks to optimization tools introduced by the hub."
Future outlook	Stress the need to consolidate the EDIHs within a European network, focus on Industry 5.0, sustainability, and international cooperation.	Emphasize continuity of services, financial sustainability, and capacity to adapt to evolving SME needs.	Expert: "The next step is connecting EDIHs across Europe to scale their impact." Implementer: "To remain relevant, hubs must secure stable funding and evolve with the technological landscape."

Table 3.5 – Thematic coding of interviews with experts and implementing entities (N=4).
The table reports the four main themes identified (role and mission, challenges, benefits, and future outlook), with corresponding sub-themes and illustrative quotations highlighting convergences and divergences between experts and implementers.

Taken together, the survey data, the open-ended responses, and the interviews provide a triangulated perspective: while quantitative evidence highlights the prevalence of certain outcomes, qualitative testimonies from both firms and experts explain the mechanisms and contextual challenges behind them.

3.3.2.1Role and mission of the EDIH

Both practitioners and experts portrayed the EDIH as a crucial bridge between advanced digital innovation and the needs of SMEs. Implementers described their hubs as multi-actor consortia providing one-stop support services – from technology test-beds and training to funding advice and network facilitation – all with the primary objective of guiding small firms through digital transformation. One hub manager explained that their main mission is to "accompany enterprises toward sustainable digital transformation" in line with the Industry 5.0 paradigm. In practice, this means offering SMEs hands-on opportunities to experiment with new technologies (e.g. AI, cybersecurity, high-performance computing) and acquire new skills before making large investments. Another implementer highlighted that the hub is fundamental in bringing traditionally "distant" technologies closer to local businesses, by demonstrating concrete benefits and creating direct interfaces between SMEs, research centers and innovative startups. The expert interviews echo this vision: one expert concurred that EDIHs are conceived as "a lean and concrete model of support for companies' innovation", essentially a public–private instrument to connect university-derived know-how with industrial needs. According to these experts, EDIHs represent an evolution of earlier competence centers – a policy pivot to strengthen university–industry linkages through regional hubs. They stressed that an EDIH's ability to fulfill its mission hinges on its embeddedness in a strong local innovation ecosystem. A well-structured hub with "broad shoulders" – ample capacity and solid regional partnerships – can become a prominent node and good practice example for others, whereas a smaller or isolated hub may struggle to make an impact. In sum, both groups see the EDIH's role as bridging gaps (knowledge, technology, networks) for SMEs, but implementers emphasize the day-to-day service delivery and

immediate enterprise engagement, while experts focus on the strategic function of hubs as connectors in the broader innovation system.

3.3.2.2. Challenges and limitations

The interviews revealed a range of operational and systemic challenges that have tempered the EDIH initiative's early implementation. Practitioners stressed bureaucratic and administrative hurdles as a primary difficulty. Both implementing entities recounted that stringent procedures tied to the funding scheme (a mix of EU and national Recovery Plan funds) caused protracted delays in getting the hubs fully operational. One regional hub had to wait months for formal ministerial contracts to be signed, with projects "officially starting about one year later than expected" due to compliance checks. Another manager noted that overlapping European and national funding rules (to avoid double-financing) forced them to segregate certain activities, adding complexity and confusion in the setup phase. Moreover, the rigid reporting requirements of the national Recovery Plan (PNRR) imposed a heavy administrative load: "the controls and rules are very strict – we needed at least four full-time administrative staff for eligibility verification and documentation for each project, which slowed everything down". This bureaucratic weight, as she summarized, ended up "weighing far more than expected, taking time away from technical work." Another implementation-level limitation was consortium management and partner coordination. Particularly, involving very large corporate or public partners was described as a double-edged sword. While big players contribute valuable know-how and credibility, they often bring slow internal processes and rigid protocols. One coordinator candidly observed that having major firms on board "created enormous bottlenecks – their internal procedures were so slow that operationally it was easier to work with smaller, more agile partners", making the large partners' net contribution "more disadvantageous than advantageous" in practice. Large organizations, sometimes participating in multiple hubs or funding lines simultaneously, could not always commit consistent effort to a given EDIH, leading to gaps in execution. By contrast, smaller local partners were seen as more flexible and faster to act, highlighting a

tension between scale and agility within EDIH consortia.Implementers also pointed to demand-side challenges, especially in less digitally mature contexts. In Southern Italian regions, for example, the hub struggled at first to attract SMEs that were unaware or skeptical of the free innovation services on offer. As one interviewee explained, many small businesses initially viewed advanced topics like AI or cybersecurity as "too distant" from their everyday realities, underestimating the relevance and value of these technologies. This necessitated an intensive outreach effort – investing in communication, workshops and alliances with local industry associations – to educate firms on the opportunities (e.g. free training, assessments, networking) and to build trust. The experts reinforced this point from a systemic angle: there remains a core awareness and engagement gap, particularly in economically weaker areas. National program targets mandated that 40% of the EDIH resources be directed to Southern Italy, yet an expert noted this has proven difficult to achieve "because there isn't sufficient demand from firms" in those areas so far. In other words, even with full public funding, uptake varies with the regional economic fabric – a structural limitation that policy must contend with.

Beyond these issues, the experts highlighted additional structural constraints and uncertainties. The government official interviewee remarked that assessing concrete outcomes on firm competitiveness is inherently challenging at this early stage: traditional output metrics (number of firms served, etc.) are being closely monitored via KPI systems like the Regis platform, but capturing causal impact will require longer-term observation. This expert drew parallels to prior innovation incentive programs where generous support was easy for firms to claim, yet "it was hard to evaluate the effective impact on productivity" due to attribution difficulties. His comments suggest that a similar evaluation challenge looms for EDIHs – a limitation in demonstrating success that is not due to a flaw in the concept per se, but rather the complexity of measuring innovation outcomes. Another systemic issue raised was the tension between the EDIHs' European mandate and national funding constraints. In theory, any EU business can approach any European DIH for services, and indeed the program encouraged cross-border networking, forming thematic alliances of hubs across countries. In practice, however, the Italian hubs found that national grant rules

prevented them from serving foreign firms with their ministerial funds. One implementer reported signing collaboration agreements with other European EDIHs that "never materialized into real joint activities, because we simply could not fund services for firmsabroad." This highlights a design limitation: without flexible funding mechanisms, the full EU-wide "one-stop-shop" vision of EDIHs remains unrealized at the operational level. In summary, implementers painted a picture of significant procedural and practical hurdles in the EDIH rollout, while experts underscored systemic issues like uneven regional demand and evaluation complexity – all of which represent critical constraints that needed to be navigated in the early phases of the initiative.

3.3.2.3. Benefits and early impacts

Despite the challenges, both experts and implementers identified encouraging early impacts and clear benefits emerging from the EDIH activities. All interviewees were cautious to note that it is "still early to talk about structural impacts", given that many hubs faced delays and have only been fully operational for a short time. However, the initial outcomes at both the firm level and network level suggest the program is gaining traction. From the implementers' perspective, one of the most tangible indicators of success has been the strong demand and uptake of services by the target group. For instance, a regional hub representative reported that within the first year they had already engaged around 250 firms and delivered roughly 279 service instances, ranging from technology test projects to multiple training courses for certain companies. This uptake exceeded expectations (the initial target was \~250 services in total), with training modules proving especially popular as many SMEs sought to upskill their workforce in digital competencies. Such numbers, in the words of the interviewee, reflect a substantial appetite among local SMEs for the support that the EDIH provides – a positive sign that the hub is addressing a real need. Experts at the national level echoed this, citing aggregate figures to illustrate reach: by mid-2025, over 5,000 digitalization services had been provided to approximately 4,000 firmsacross all Italian hubs. They anticipate that up to 10,000 firms could be engaged by the end of the current funding cycle, which is a

significant portion of the innovation-active SME population. One expert argued that even before long-term performance impacts can be measured, this broad engagement is itself an important outcome: it means thousands of firms are now exposed to new technologies, aware of innovation opportunities and financing, and connected to a support network – "the very fact of getting firms involved and making them realize there are important digital opportunities is a measure of success", as he explained. In other words, building awareness and initial readiness is seen as a crucial early impact of the EDIH initiative, given the historically low digital adoption rates among small firms.

Beyond quantitative uptake, the interviews provided qualitative examples of benefits at the firm and ecosystem level. One implementer recounted a concrete success story resulting from an EDIH-facilitated open innovation project in the tourism sector. In that case, the hub brought together a group of traditional hotels and a set of digital startups offering innovative solutions for hospitality. Through a series of needs assessments and collaborative sessions (supported by the hub and a corporate banking partner), the hotels identified digital service innovations that could enhance their business. The outcome was that several hotels decided to directly invest in the startup solutions piloted during the project – "without waiting for public contributions", as the interviewee noted. This illustrates an early impact where the EDIH acted as a catalyst: lowering barriers for SMEs to experiment with new technology, and ultimately giving them the confidence to invest with their own resources after seeing the demonstrated value. For the startups involved, it likewise provided an opportunity to refine their product with end-users and secure new clients. Although limited in scale, such cases signal how EDIHs can spur mutual learning and innovation investment in a local ecosystem. Another benefit highlighted by practitioners is the creation of a comprehensive service catalog and skill base through the consortium model. By pooling the diverse competencies of 10–15 partner organizations (research centers, SMEs, large firms, universities), hubs can address a wide spectrum of firm needs. One interviewee noted that thanks to their broad partner network, "there is always someone able to respond to a given enterprise need", whether it's specialized training or a domain-specific technology test, and they have managed

to avoid major gaps between what local firmsseek and what the hub can deliver. This suggests that the multi-partner structure is yielding benefits in terms of service coverage and flexibility to tailor support (for example, offering customized training courses when standard offerings do not fit a firm's specific requirements).

At a network level, the EDIH program has also started to foster greater collaboration and knowledge exchange among innovation actors – an intended systemic benefit of the initiative. The experts and implementers both observed an emerging "network of hubs" effect. Nationally, regular coordination meetings and information systems are in place (under the Ministry's monitoring framework) that allow hubs to share progress and learn from each other's experiences. The Commission's support for cross-hub learning was also noted, such as the EU-wide portal listing all hubs and their best practices, and periodic events or training sessions for hubs across Europe. From the implementer viewpoint, this has materialized in concrete inter-hub cooperation at least on a regional scale. One interviewee described how the EDIHs in Southern Italy formed an alliance to integrate their services, agreeing that "if one hub doesn't provide a certain service, it can refer the client to another hub." This kind of resource-sharing and referral system has begun to take shape and "works, but should be strengthened" as demand grows. It effectively extends the reach of each hub beyond its own consortium's capacities and prevents firms from falling through the cracks due to any single hub's limitations. At the European level, the expert from the ministry reported that thematic and sectoral alliances are being created among EDIHs across countries (for example, hubs focusing on manufacturing in different regions have linked up). While true cross-border service delivery to firms remains rare (due to the funding issues noted earlier), these alliances still provide value by enabling best-practice exchange and joint learning among hubs. In summary, early impacts of the EDIH initiative are visible in the high engagement of SMEs, initial success stories of digital adoption, and the strengthening of collaboration networks. Both the ground-level and high-level perspectives agree that, although it is too soon for definitive impact assessments, the trajectory is positive – EDIHs are actively lowering barriers for many firms and sowing the seeds of a more connected innovation ecosystem.

3.3.2.4 Future outlook

Looking ahead, the interviews conveyed a mix of optimism about the EDIH concept's potential and realism about the challenges that must be managed to ensure long-term success. Implementing actors are focusing on sustainability and depth of impact, knowing that the current public funding is time-bound. One hub coordinator admitted that the continuity of their operations beyond the initial project period is uncertain – "in the long run, everything will depend on whether the Ministry (MIMIT) provides renewed funding." To prepare for a possible scenario of no immediate re-financing, hubs are striving to embed themselves in the local innovation ecosystem so that their value is recognized and supported by regional stakeholders. For example, the Southern Italy EDIH has heavily ramped up its visibility and partnerships on the ground – participating in sectoral trade fairs, working closely with Chambers of Commerce and industry associations, and generally building an "innovation ecosystem" around the hub's activities. The logic is that by becoming integral to the community (as a go-to resource for digital advice and experimentation), the hub may attract alternative support or generate revenue streams to continue its mission if public funds wane. In terms of strategy, implementers indicated a deliberate shift to emphasize quality and lasting impact in the next phase, even if it means reaching fewer firms. As one manager put it, "for the future, our goal is to offer broader service packages to companies, even if that means serving a smaller number of them – we believe the quality of impact matters more than quantity." This reflects a lesson learned: rather than chasing high outreach numbers, it may be more beneficial to work intensively with each firm to achieve a real digital leap forward that can showcase the hub's value. Such an approach could improve the long-term outcomes (e.g. measurable performance improvements in those firms) and strengthen the case for sustained funding. It also aligns with the original intent that EDIH services be demonstration-oriented (not ongoing consulting) – i.e. they give firms a taste of innovation and skills to continue on their own or via market solutions. The future challenge for

implementers will be balancing this deeper engagement model with the need to cover their broad mandate and hit target numbers in the short term.

The experts, for their part, remain cautiously optimistic yet cognizant of the adjustments needed at policy level. From the government perspective, one priority is to ensure more uniform adoption of EDIH services across regions and sectors, given the disparity observed so far. Plans are underway to tighten collaboration with regional authorities – for instance, through formal program agreements that co-finance and promote hub activities at the regional level – in order to stimulate demand in areas where uptake has lagged. The expert noted that bridging the geographic gap is crucial, since national targets (like dedicating 40% of investments to the less-developed South) are at risk if local firms do not actively seek out digital opportunities. This implies that the future success of the EDIH initiative will partially hinge on complementary measures to generate grassroots demand (such as regional digitalization incentives or awareness campaigns) alongside the hubs' supply of services. Additionally, the experts foresee a need to integrate the EDIHs more tightly into existing innovation policy frameworks so that they continue beyond the life of the EU Recovery funding. This might involve anchoring the hubs to long-term programs or institutions. The ministry official hinted at the creation of a national network of digital innovation poles managed by major business associations (e.g. Confindustria, Chambers of Commerce, etc.) as a structural backbone. Such a network, which in fact has been initiated, is expected to ensure capillarity of outreach and act as a conduit between the multitude of SMEs and the high-level technology centers (competence centers, universities, etc.). In parallel, the expert from the research sphere emphasized the importance of human capital development to sustain the digital transition. He pointed out that there is still a scarcity of professionals who can bridge the gap between technical innovation and business application – "innovation managers" with both technological fluency and business acumen. In his view, nurturing such profiles (through specialized training or even new academic programs in innovation management) will be vital for the future, as these individuals could act as the connective tissue between SMEs, hubs, and knowledge centers, translating novel ideas into practical

enterprise changes. This insight suggests that the EDIH program may increasingly need to dovetail with education and workforce initiatives to amplify its impact.

Finally, both experts stressed the importance of patience and sustained commitment. The digital transformation of SMEs is a long-term process: one expert reiterated that "you cannot simply 'install AI' in a firm and call it a day – it requires building a data-driven culture and new capabilities, which takes time." As such, they view the current phase as just the beginning. If initial engagement targets are met and interim successes demonstrated, the expectation is that policymakers will continue to support the effort (through refinanced programs or new instruments), and that over the coming years more substantial impacts – such as productivity gains, increased innovation outcomes in SMEs, and stronger regional innovation ecosystems – will start to materialize. The outlook for EDIHs is thus one of guarded hope: the concept is affirmed by both implementation experience and expert opinion as strategically sound and beneficial, but its long-term fruition will depend on addressing the present challenges (bureaucracy, regional disparities, sustainability) and maintaining momentum so that the early gains translate into enduring innovation capacity in the SME sector.

In conclusion, the qualitative evidence from the interviews highlights both the shared vision and the differing emphases of experts and implementing entities. All interviewees agreed on the pivotal role of EDIHs in supporting SME digitalization, but while experts framed this within broader policy and structural considerations, implementers emphasized the operational realities of managing hubs and engaging firms. Early benefits were recognized, alongside persistent challenges such as bureaucracy, limited demand in certain regions, and funding constraints. These findings provide a nuanced understanding of the initiative from complementary perspectives and serve as an essential input for the overall interpretation of results.

3.4 Preliminary Interpretation

Taken together, the quantitative survey results, the open-ended responses, and the interviews with experts and implementing bodies offer a multi-layered picture of the EDIH initiative. At the firm level, the evidence suggests that the most immediate benefits of hub engagement lie in strengthening digital skills and improving operational processes, while outcomes related to innovation outputs and market expansion remain more limited at this stage. The qualitative testimonies reinforce this pattern, highlighting both success stories of capacity-building and the persistent barriers of bureaucracy, limited demand in less digitally mature regions, and the time required for innovation to materialize. At the systemic level, experts view the EDIHs as a strategically sound instrument, but stress the need for continuity, stronger regional outreach, and integration into broader policy frameworks. In sum, Chapter 3 has shown that the EDIHs are beginning to fulfill their mission of lowering entry barriers for SMEs in digital transformation, yet the full realization of their impact depends on addressing structural and organizational challenges. These preliminary findings set the stage for the discussion in Chapter 4, where the results are interpreted in light of the theoretical framework and wider debates on digital innovation policy.

CHAPTER 4: DISCUSSION

This study set out to evaluate whether Digital Innovation Hubs (DIHs) – funded through EU cohesion policy – effectively stimulate innovation and private investment in SMEs. In doing so, the findings must be interpreted in light of the thesis's theoretical framework encompassing market failure theory, innovation uncertainty, absorptive capacity, and innovation systems theory. Overall, our results provide evidence that aligns closely with these theories: DIHs appear to correct classic market failures, mitigate innovation uncertainties, build firms' absorptive capacities, and strengthen the innovation ecosystem. At the same time, the data reveal practical limitations and nuances that enrich these theoretical perspectives. In this section, we contrast the empirical evidence from the SME survey and expert interviews with each major theoretical lens, ensuring a rigorous comparison between what theory would predict and what was observed in practice.

4.1 Addressing Market Failures in Innovation

A core premise of public support for innovation is the correction of market failures – situations where private markets under-provide socially optimal innovation due to knowledge spillovers and other externalities. Both Arrow (1962) and Nelson (1959) famously argued that because knowledge is a non-rival, only partially excludable good, private firms in a laissez-faire market will invest less in R&D and innovation than is socially desirable (Arrow 1962; Nelson 1959). Our findings strongly reinforce this rationale. Many of the surveyed SMEs admitted that, without DIH support, they would not have pursued certain innovative projects – or would have done so on a much smaller scale. Several firms reported that the DIH gave them access to knowledge, expertise, or facilities (e.g. prototyping labs, "test-before-invest" platforms) that they could not have obtained on their own due to cost or lack of availability. In other words, the DIH effectively provided a public good—technical information, demonstrations, networking opportunities—that individual companies would have been unlikely to secure through the market. This aligns with Arrow's observation that new knowledge generates positive externalities which private investors cannot fully

appropriate. By lowering the cost of that first "unit" of knowledge (through subsidized training or free initial consultations), the DIH encouraged innovation projects that otherwise would have been left on the shelf – a clear indication of underinvestment being addressed.

The interviews with policy professionals echoed this point. Experts noted that DIHs fill a gap where private consulting or financing fails to support high-risk, early-stage digital innovation for SMEs. In the language of theory, DIHs help internalize the externalities of innovation. One policy manager pointed out that *"the market on its own wasn't delivering digital advisory services to our small firms – there's just not enough profit in coaching a 10-person manufacturing firm through an AI pilot."* The DIH, funded by European and regional sources, steps into this breach. This reflects the classic Nelson-Arrow argument that a free enterprise economy will tend to underinvest in innovative activities without public intervention (Arrow 1962; Nelson 1959). Indeed, our study provides on-the-ground validation that public support (via DIHs) can correct such market inefficiencies by enabling projects with high social value but uncertain private returns.

Importantly, the nature of the services provided by the DIH also maps to specific market failures identified in the literature. For example, information asymmetry in innovation financing is a known barrier – entrepreneurs often cannot credibly signal the quality of their idea to financiers, leading to credit rationing (Stiglitz and Weiss 1981). The DIH's provision of financing advice and investor linkages helps bridge this gap. Several firms noted that DIH experts guided them on how to prepare grant applications or introduced them to potential investors, thereby easing capital constraints on innovation. This addresses the "funding gap" for risky projects that theory predicts when information problems are severe (Stiglitz and Weiss 1981). In sum, the empirical evidence demonstrates that DIHs operationalize the market-failure rationale for innovation policy: they provide knowledge, coordination, and risk-sharing functions that the private market under-supplies, thus spurring additional private innovation investment.

4.2 Uncertainty, Risk, and the Role of Public Support

Another theoretical pillar of this thesis is the inherent uncertainty in innovation and how that deters private investment. Arrow (1962) highlighted that R&D outcomes are highly uncertain and not fully contractible – inventors cannot insure against the risk of failure, especially when effort and success are unobservable.This creates a cautious bias in firms, particularly SMEs with limited buffers, leading to underinvestment in new technologies. Our findings suggest that DIHs help mitigate the perceived risk and uncertainty that SMEs face in digital innovation.

The survey of SMEs revealed that a major benefit of DIH engagement was "risk reduction." SMEs frequently cited the DIH's "test before invest" offerings – such as trial access to advanced equipment or pilot project support – as crucial in proving the concept of an innovation before committing their own capital. One respondent described how their company was uncertain about investing in a new data analytics system until the DIH arranged a small-scale pilot at a tech lab, demonstrating tangible productivity improvements. This experience significantly reduced the uncertainty (both technical and financial) in the innovation's outcome, making the firm comfortable to proceed with purchasing the full system. This closely aligns with theoretical expectations. By providing a safe testing environment and expert guidance, the DIH acted as a risk absorber for the firm – analogous to a partial insurance mechanism against innovation failure. As Arrow posited, if uncertainty is reduced or shared, firms become more willing to invest in innovation (Arrow 1962). Our empirical data confirm this phenomenon: SMEs in our sample credited the DIH with giving them the confidence to invest by lowering the uncertainty hurdle.

Interviews with DIH managers reinforced this point. DIH staff observed that many SMEs initially approach them with hesitation about novel technologies (e.g. artificial intelligence, Internet of Things, advanced robotics). The DIH's role, as they described it, is to "hold the company's hand through the early, most uncertain phase of innovation." Concretely, this involves feasibility studies, expert consultations, and small pilot funding – all of which decrease ambiguity around the innovation's potential benefits. One manager noted that by

splitting the cost and providing expertise, the DIH essentially shares the risk: *"SMEs feel that if the experiment fails, at least they haven't bet the whole firm – we've absorbed some of that risk with them."* This practice speaks directly to the theory of public intervention under uncertainty: the state (through DIHs) is smoothing the risk–reward profile of innovation projects, making them more palatable for firms. It confirms that uncertainty, as a barrier, can be partially overcome by public support, leading to higher innovation uptake than would occur otherwise.

It is also notable that uncertainty was not eliminated entirely – nor would theory expect it to be. Some SMEs still decided against further investment even after DIH pilots, citing ongoing doubts about market demand or implementation challenges. This highlights a nuance: while DIHs reduce many risks (technical feasibility, initial cost), residual uncertainties (e.g. commercial viability, organizational readiness) remain. The interviews with policy experts suggest that complementary measures (like market development assistance or continued mentoring) might be needed to address these remaining unknowns. In theoretical terms, this underscores Arrow's point (1962) that some aspects of innovation risk (such as the effort and internal adaptation required within the firm) cannot be fully hedged. The DIH addresses the technical uncertainty, but managerial and market uncertainties may persist. Therefore, our findings both validate the importance of public support in an uncertain innovation environment and reveal the limits of such support – a balanced insight valuable for policy design.

4.3 Absorptive Capacity and SME Readiness to Innovate

Cohen and Levinthal (1990) introduced the concept of absorptive capacity, positing that a firm's ability to utilize external knowledge depends on its prior knowledge base and learning capabilities. This theory was directly relevant to our investigation, as DIHs assume that providing knowledge and connections will spur innovation – an assumption that only holds if firms have enough capacity to absorb and act on the inputs. The empirical evidence suggests a complex interplay between DIH support and firms' absorptive capacities.

On one hand, many SMEs clearly benefited from capability-building through the DIH. Our survey indicated that over two-thirds of the firms undertook some form of training or skills development via the hub (for example, sending employees to a workshop on digital marketing or machine learning). Several firms noted that these trainings enhanced their internal know-how, enabling them to better understand and implement new technologies introduced by the DIH. In other words, the DIH explicitly worked to raise the absorptive capacity of client firms – consistent with the idea that prior related knowledge improves a firm's ability to recognize and exploit new information (Cohen and Levinthal 1990). The expert interviews underscored this point: DIH managers emphasized that a big part of their mission is educational, coaching SMEs in new digital skills so that the firms can eventually innovate independently. This reflects an understanding of Cohen and Levinthal's insight – the state (via the hub) helps firms *"learn to learn,"* thereby increasing the long-term impact of the intervention. In successful cases, our data showed a virtuous cycle: initial DIH support built new capabilities in the SME (e.g. data analysis skills), which then made the SME more proactive and effective in subsequent innovation efforts. One firm manager described how after attending DIH training sessions, their team was *"able to scout and implement new digital tools on our own – we don't need hand-holding as much now."* This outcome exemplifies the transformation of external assistance into internal capacity that absorptive capacity theory would predict (Cohen and Levinthal 1990).

On the other hand, the findings also reveal heterogeneity: not all SMEs were equally prepared to absorb what the DIH offered. The cross-tabulated results by firm size further illustrate this point. Micro enterprises reported relatively higher gains in digital skills and new product development, whereas larger SMEs emphasized efficiency and productivity improvements. This suggests that absorptive capacity interacts with firm size, shaping the type of benefits perceived from DIH support.

Both survey responses and interviews pointed out that firms starting with very low digital maturity had trouble fully leveraging DIH services. For instance, an SME with almost no in-house IT expertise struggled to make sense of an advanced data analytics pilot; despite the DIH's guidance, the firm lacked personnel capable of continuing the project beyond the pilot

stage. From a theoretical perspective, this mirrors Cohen and Levinthal's argument that prior knowledge is critical: firms with insufficient baseline capacity may fail to assimilate external knowledge even when it is made available (Cohen and Levinthal 1990).

The policy experts we interviewed acknowledged this tension: those SMEs that benefitted most were often the ones with "at least a minimal digital team or some R&D activity already," whereas more traditional, low-tech firms required more basic upskilling before they could exploit DIH offerings. The implication is clear: building absorptive capacity is a prerequisite for maximizing the impact of DIHs. As one expert noted, "the hub can show the door, but the firm must have the ability to walk through it." In practical terms, DIHs may need to differentiate their support by offering more foundational training for novices while providing advanced technical collaborations for firms with higher capacity.

In summary, our study confirms that absorptive capacity is both a target and a moderating factor in DIH effectiveness. DIHs do enhance firms' capacities through training and exposure to new knowledge (supporting Cohen and Levinthal's (1990) view that external knowledge can be internalized), but the initial capacity of the firm strongly shapes outcomes. This nuanced finding enriches absorptive capacity theory by illustrating it in a policy context: it is not only the availability of external support that matters, but also the readiness of firms to absorb it that determines innovation success.

4.4 DIHs as Systemic Intermediaries in the Innovation Ecosystem

Innovation systems theory, as articulated by scholars like Lundvall (1992) and Freeman (1987), emphasizes that innovation is not an isolated act but a collective, systemic process involving interactions between firms, universities, government agencies, and other institutions. Failures in these systems – such as weak linkages or missing institutions – can impede innovation even when market incentives exist. Our research offers strong evidence that DIHs function as critical systemic intermediaries, aligning with this theoretical perspective.

A prominent theme from the interviews was collaboration**.** DIH managers described their role as a "network orchestrator" – bringing together SMEs with researchers, larger technology companies, and funding bodies. Many SMEs leveraged the hub's connections to find suitable partners for their innovation projects. For example, one manufacturing SME was interested in applying advanced sensors in its production line; the DIH introduced the firm to a university mechatronics department and a mid-cap sensor supplier, resulting in a successful collaboration that the SME manager said *"we never could have arranged on our own."* This illustrates the DIH's function in the innovation ecosystem: it bridges gaps between different actors, consistent with Lundvall's notion of innovation as an interactive network of users and producers (Lundvall 1992). In purely market-based or hierarchical arrangements, such connections often do not form due to high transaction costs or lack of trust – precisely the gaps that an intermediary like a DIH can fill. The DIH, however, provides a platform for interactive learning, where firms can engage in dialogue with technology experts (producers of innovation) and iterate on solutions – exactly the kind of dynamic that systems theory highlights as essential for innovation.

Our findings also show that DIHs contribute to addressing "systemic failures." Systemic failures refer to missing links or misaligned incentives in the innovation system (as opposed to market failures, which are about price signals and externalities). The regional presence of the DIH was crucial in this regard. SMEs repeatedly stressed the importance of having a local, trusted center that understood their context. The DIH staff often acted as innovation coaches, visiting companies on-site and tailoring advice to the firm's circumstances. This local embeddedness is something a distant national program might lack. From an innovation systems viewpoint, the DIH enhances the regional system's performance by being a node that actively connects local actors and global knowledge. As noted in our theoretical framework, effective innovation often requires institutions that facilitate knowledge flows and cooperation (Freeman 1987). Our case study confirms that DIHs fulfill this institutional role: they are one-stop shops where multiple channels of support converge (technical, financial, organizational), making it easier for SMEs to navigate the innovation ecosystem.

Notably, policymakers in our interviews emphasized the pan-European network aspect of DIHs as well. The DIH we studied is linked into the broader European Digital Innovation Hubs (EDIH) network, allowing it to tap expertise from other regions or refer companies to specialized centers when needed. One policy expert mentioned an instance where an Italian DIH connected a local SME with an advanced prototyping facility in Germany through the EDIH network – something that would rarely happen without an orchestrating structure. This reflects the multi-level nature of the innovation system (regional, national, European) and showcases DIHs as connectors across these levels. Lundvall's theory of interactive learning and Nelson's work on national systems both point to the importance of such cross-organization linkages. By facilitating inter-regional knowledge transfer, DIHs not only strengthen the local ecosystem but also integrate it into a larger innovation network (European Commission 2023). Our findings suggest that this design – local roots with global links – is a key strength of the DIH model, allowing SMEs to benefit from both localized support and the scale of wider networks (European Commission 2023).

In theoretical terms, the evidence affirms that DIHs embody the principles of innovation systems theory. They treat innovation as a collaborative endeavor rather than a solitary one, and they address what the literature calls "systemic failures" – gaps in networks, missing information channels, or weak institutional support (Lundvall 1992; Freeman 1987; Nelson 1993). For instance, before the DIH's establishment, many SMEs in our sample reported not knowing where to seek help for digital upgrades (a classic network failure). Post-intervention, these firms now have an entry point into the system. In the words of one SME CEO, *"The hub is like a lighthouse – it showed us the available resources and brought us into a community of innovators."* This community-building aspect directly resonates with the ideas of Lundvall and Freeman, who argue that vibrant innovation arises from dense networks of interaction and shared learning (Lundvall 1992; Freeman 1987). Our empirical data provides a concrete instantiation of this principle: DIHs can be seen as system organizers that amplify collective learning and innovation capacity in a region.

4.5 Tensions and Trade-offs: A Balanced View

While the overarching narrative is that our empirical results support the theoretical rationales for DIHs, it is important to acknowledge tensions and trade-offs observed. Not every expectation from theory was perfectly met, and some findings highlight challenges that theory abstracts away from. For instance, market failure theory assumes public intervention will be welfare-enhancing, yet our interviews revealed concerns about potential crowding out: a few private consultants felt that heavily subsidized DIH services sometimes displaced what could have been business for them. This hints at a possible downside – if not well-targeted, public hubs might inadvertently compete with nascent private solution providers, an outcome not fully anticipated by standard theory. Additionally, innovation systems theory celebrates collaboration, but our data show that collaboration itself can be time-consuming and complex. One SME noted that partnering via the DIH introduced bureaucratic processes (e.g. memoranda of understanding, joint IP agreements) that slowed down their project. This reflects a real-world complexity: system-building comes with coordination costs that need managing.

Moreover, the cross-tabulated analysis of perceived barriers suggests that these challenges are not homogeneous across firms. Micro enterprises were more likely to report bureaucratic and organizational complexity, as well as communication and visibility issues, whereas larger SMEs emphasized difficulties in implementation and mismatches between DIH services and their specific needs. This divergence points to a structural tension: the same institutional design may be experienced differently depending on firm size and absorptive capacity. In other words, what theory frames as generic "coordination costs" or "barriers" in practice manifests as distinct constraints shaped by organizational scale and resources.

In terms of uncertainty and absorptive capacity, we saw that theory provides justification for support, but practice requires fine calibration. For highly uncertain cutting-edge technologies, even DIHs struggle to find success stories – two of the surveyed firms that pursued very novel AI solutions did not see immediate payoffs, despite DIH backing, illustrating that public support reduces but cannot eliminate innovation failures. Likewise,

improving absorptive capacity is a gradual process; one training session cannot transform a firm's culture overnight. These nuances underscore that theory provides an essential guiding framework, but implementation must contend with ground-level realities such as firm culture, policy bureaucracy, and external economic factors.

In conclusion, contrasting our empirical evidence with the thesis's theoretical foundation reveals a strong consonance: the DIH in our study functioned largely as the theories of innovation policy would hope – correcting market failures by providing public-good knowledge and risk-sharing, alleviating uncertainty, enhancing absorptive capacities, and serving as a hub in the innovation system. At the same time, the data inject a healthy dose of pragmatism into the discussion, highlighting that outcomes depend on execution details and that there are diminishing returns or challenges in certain scenarios. This balanced understanding is crucial as we move to discuss what the findings imply for various stakeholders and how they can apply these insights.

4.6 Implications for Stakeholders

The dual analysis of theory and evidence allows us to derive nuanced implications for the key stakeholders involved in or affected by cohesion policy instruments like DIHs. Specifically, our study offers important lessons for policy makers who design and fund innovation support programs, for SMEs as the target beneficiaries of these programs, and for the Digital Innovation Hubs themselves as implementers. In the following, we distill the findings into concrete implications for each of these groups, recognizing that effective innovation policy is a multi-actor effort. We aim to keep the discussion analytical yet applied—translating our results into practical guidance while anchoring it in the conceptual insights discussed above.

4.6.1 Implications for Policy Makers (EU and Regional Cohesion Policy Designers)

For policy makers at the EU and regional levels, the findings highlight both the value of DIHs as a policy tool and areas requiring strategic attention. First and foremost, our evidence confirms that DIHs are effective mechanisms to stimulate SME innovation in line with cohesion policy goals. The fact that numerous SMEs undertook new digital projects because of DIH support is tangible evidence that public funds can leverage additional private investment – essentially turning *"European funds into private investments,"* as per the thesis title. This should encourage policy makers to continue investing in and expanding DIH programs as part of regional development and innovation strategies. The data validates the rationale behind such funding: DIHs demonstrably address market failures by delivering services that SMEs would not otherwise obtain. In EU cohesion policy terms, this means DIHs can be a cornerstone in efforts to boost the competitiveness of lagging regions and industries by de-risking innovation and building capacity at the firm level.

However, the study also surfaces important design and implementation considerations. One key implication is the need for ensuring inclusivity and breadth of reach. Our findings showed that some SMEs, particularly micro-enterprises or those with very low digital maturity, benefited less from the DIH. For policy makers, this raises the question: are current DIHs reaching the "harder-to-help" firms, or only the already somewhat innovative SMEs? To truly fulfill the cohesion objective of spreading innovation, policy makers might need to tailor DIH initiatives to different segments of firms. For example, additional funding could be earmarked for outreach and basic digital skills training in very small companies, preparing them to utilize DIH services. Policy could encourage DIHs to offer tiered programs – from introductory digital literacy up to advanced tech consulting – to avoid a gap where the smallest companies are left behind. Our cross-tabulated results by firm size reinforce this implication: micro firms reported greater improvements in digital skills and new product development, while larger SMEs emphasized efficiency and productivity. Conversely, barriers were also perceived differently, with micro firms highlighting bureaucratic and visibility issues, and larger SMEs pointing to implementation difficulties and mismatches with their needs. This divergence suggests that inclusivity cannot be understood only in terms

of access, but also in terms of differentiated service design that addresses distinct structural challenges**.**In essence, absorptive capacity-building at a wider scale should be built into policy mandates (e.g. through requirements or incentives in DIH funding agreements) so that the benefits of DIHs are more evenly distributed across the SME population.

Another implication for policy makers revolves around the sustainability and integration of DIHs. Interviews with DIH managers and policy experts revealed concern about the long-term funding and institutionalization of hubs. Many DIHs, including the one studied, rely on time-bound project funding (often a mix of EU and national funds). Policymakers should recognize that building innovation ecosystems is not a short project – it's a long-term infrastructure. Therefore, they should consider ensuring more stable funding streams or core support for DIHs, perhaps by blending EU structural funds with regional co-financing commitments beyond the typical 3–5 year project cycle. A more permanent footing would allow DIHs to plan multi-year support programs and retain expert staff, thereby increasing their effectiveness. Additionally, policy makers should work on integrating DIHs with other policy instruments. Our study participants pointed out that sometimes there is a disconnect between different programs (for instance, an SME might get advice from a DIH but then struggle to obtain a grant from a separate scheme to implement that advice). To address this, cohesion policy designers can create smoother linkages – for example, fast-track access to innovation grants or loans for SMEs that come through DIH pipelines, or joint programs where DIHs and financial agencies collaborate. By aligning DIHs with funding mechanisms, training initiatives, and cluster development policies, policy makers can amplify the impact (essentially a systemic fix consistent with innovation-systems thinking).

Finally, the evidence suggests policy makers should pay attention to performance measurement and knowledge sharing across the DIH network. Given our finding that DIHs serve as a bridge between local and international resources, the EU's role in fostering cross-hub learning is vital. Policy makers should continue to support the pan-European network of DIHs (European Commission 2023), including platforms to exchange best practices and data on what works. If one region's DIH finds an effective model to engage, say, traditional artisans in digital innovation, that model should be disseminated and possibly funded for

replication elsewhere. Our research also implies that impact metrics for DIHs should go beyond simple counts (e.g. number of firms served). Instead, metrics could capture capacity built and private investment triggered – for instance, tracking how many SMEs introduced a new product or process 1–2 years after DIH support, and what follow-on investments they made. These metrics would provide feedback to policy makers to refine support programs. In summary, for policy designers the message is: DIHs work and merit continued support, but fine-tuning their inclusivity, sustainability, integration with other tools, and performance evaluation will be key to maximizing their contribution to cohesion and growth objectives.

4.6.2 Implications for SMEs (Innovation Adopters and Users)

Small and medium-sized enterprises themselves can draw several lessons from this study about how to engage with public innovation support and what internal steps are needed to fully benefit. One clear implication is that SMEs should proactively leverage resources like DIHs as part of their innovation strategy. The evidence from our surveyed firms is that those who actively reached out to the DIH and participated in its programs reaped significant gains – new knowledge, partnerships, and even increased competitive performance in some cases. In practical terms, SMEs – especially those feeling "stuck" in their digital transformation – should view DIHs as accessible and effective partners rather than distant bureaucratic entities. The positive experiences reported (e.g. rapid prototyping assistance, expert diagnostics of business processes, referrals to funding) suggest that engaging with a DIH can substantially lower the hurdles to innovation. Thus, SMEs with limited R&D budgets or expertise should not hesitate to seek out their regional DIH; it can be a strategic move to access capabilities that would be unaffordable individually.

At the same time, our findings carry an important message: SMEs must invest in building their own absorptive capacity to maximize benefits. The variation in outcomes indicated that firms with a bit more readiness (some skilled staff, openness to organizational change) could capitalize on DIH support much better than those without. For SME owners and managers, this means that internal development – such as training employees, upgrading IT systems, and fostering a culture of innovation – is crucial. Even when external help is available, the

firm needs the ability to understand and implement that help. A practical step would be for SMEs to assign an "innovation champion" or team internally whenever they engage with a DIH. This internal team can work closely with the hub's experts, learn from them, and then disseminate that knowledge within the company. Our study showed that when firms treated the DIH project not as an outsourced activity but as a learning opportunity for their staff, the results were more sustainable (for example, the firm continued making improvements after the official DIH project ended). Thus, SMEs should approach interventions like DIHs not as one-off assistance but as a chance to build long-term innovation competence. This aligns with Cohen and Levinthal's insight that the more a firm knows, the more it can learn (Cohen and Levinthal 1990). SMEs should take that to heart: make the most of DIH support by concurrently upskilling and engaging in learning-by-doing alongside the provided experts.

Another implication for SMEs is the value of networking and peer learning, which came out strongly in the results. Through the DIH, many firms discovered they were not alone in facing certain innovation challenges, and by interacting with peer companies (e.g. at joint workshops or showcase events organized by the hub) they picked up new ideas and even formed partnerships. SMEs should thus see engagement with DIHs as not only a way to get direct support, but also as a gateway to the broader innovation ecosystem. We recommend that SMEs participate in the community activities facilitated by the hub – attend meet-ups, join pilot programs, share experiences. Our data suggest that such involvement can spark insights (for example, one firm learned of a new digital tool from another SME at a DIH event and later adopted it). By being active community members, SMEs increase their visibility and can attract collaboration opportunities that further their innovation objectives. In short, the more an SME puts into the engagement (time, openness, personnel), the more it stands to gain from the rich environment that a DIH fosters.

Finally, SMEs should plan for post-support follow-through. One pattern observed was that a few firms struggled after the initial DIH project to carry the momentum forward – for example, they had a successful prototype but hesitated on full implementation. The implication is that SMEs need to prepare for what comes *after* the DIH engagement. This could involve financial planning (setting aside resources to invest if the pilot succeeds),

change management (readying the organization for new processes), or further funding applications (using the DIH's advice to apply for grants or loans). Essentially, SMEs should use the DIH engagement as a springboard, with a clear roadmap of next steps once the public support is completed. SMEs that treated the DIH intervention as part of a broader innovation strategy (rather than an isolated experiment) saw more concrete growth outcomes in our study. Therefore, we advise SMEs to integrate DIH support into their strategic planning – for example, if the DIH helps develop a digital prototype, plan early for how to scale it up and who will champion it internally. By doing so, SMEs can ensure that the short-term boosts from public support translate into long-term competitive gains, thus justifying the time and effort invested in engaging with such programs.

4.6.3 Implications for Digital Innovation Hubs (Implementers)

For the Digital Innovation Hubs themselves – the organizations on the front line of delivering support – the research yields insights that can help improve their effectiveness and demonstrate their value. One clear implication is the importance of tailoring services to firm needs and capacities. Our findings revealed a diversity of SME backgrounds and readiness levels, which means a one-size-fits-all approach is suboptimal. DIHs should consider segmenting their client SMEs and customizing their support accordingly. For example, for very small or traditional firms, the hub might offer more hands-on, prolonged engagements focusing on basic digital adoption and mindset change. For more advanced SMEs, the hub could provide high-level expertise, connect them to cutting-edge technology trials, or facilitate R&D collaborations. In our case, some dissatisfaction occurred when services didn't match the SME's expectations or abilities (one firm felt a workshop was too theoretical; another found an offered solution too complex to implement). By gathering feedback and perhaps conducting initial assessments of each SME's digital maturity, DIHs can better match their interventions to the client's starting point. This client-centric approach not only improves outcomes but also ensures efficient use of hub resources (effort is spent where it can have impact). It mirrors the idea from innovation-systems theory that effective intermediation requires understanding each actor's role and capacity in the system – the hub must adapt to fit those varied needs.

Another implication for DIHs is the value of strengthening their own networks and partnerships. The study highlighted that the hub's ability to pull in outside expertise or refer firms to other institutions was a major success factor. To build on this, DIHs should continue to cultivate relationships with universities, research centers, industry experts, and funding bodies. Regular interaction (e.g. joint events with universities, memoranda of understanding with banks or venture capital funds) will expand the toolkit that the DIH can offer to SMEs. Our evidence showed that when an SME's need exceeded the hub's internal capacity, the best outcomes arose when the hub had a partner to call upon (such as tapping a university lab for specialized testing). Therefore, DIHs should invest time in mapping the innovation ecosystem around them and establishing formal links – effectively acting as an innovation broker on behalf of SMEs. Additionally, engaging actively in the European network of DIHs can enhance each hub's effectiveness. Sharing practices on what services work best, or co-developing tools (like the digital maturity assessment mentioned in EU documents) can save individual hubs from reinventing the wheel (European Commission 2023). The implication is that DIHs should not operate in isolation; by being a networked hub, they amplify their value proposition to SMEs and funders alike.

From an operational standpoint, the findings suggest DIHs should pay attention to monitoring outcomes and pursuing continuous improvement. We observed that some benefits of the DIH are immediately visible (number of firms served, pilots run), while others (like improved firm performance) manifest later. It would serve DIHs well to track client progress over time – for instance, keeping in touch with supported SMEs at 6 months and 12 months after an intervention to see if recommendations were implemented or if further barriers emerged. By doing so, hubs can gather data on their long-term impact, which is crucial for demonstrating success to funders (and securing ongoing financing). It also helps the hub learn what works and what doesn't. In our study, such follow-ups could have identified, for example, that half of the firms needed additional help with change management – an insight that the hub could use to introduce a new service or partnership (like offering managerial training or connecting firms to consultants for implementation). Essentially, closing the feedback loop will allow DIHs to refine their service mix. Moreover, by documenting success stories (e.g. a case where

a firm's revenue grew after a DIH-assisted innovation), the hub can make a stronger case for its impact. Given that public accountability is high, DIHs should be prepared with evidence of how they contribute to private-sector growth – our research provides some, but each hub should accumulate its own portfolio of impact cases.

Lastly, the study underscores that DIHs should not neglect the human element and trust-building aspect of their work. SMEs in the survey frequently praised the approachability and understanding attitude of DIH staff. This soft aspect – being able to speak the "language of business" to a small firm, empathize with their constraints, and build trust – is a critical ingredient for success. DIH personnel often act as change agents within firms, and change is as much psychological as it is technical. The implication is that hubs might invest in training their own staff in consultative and communication skills, not just technical knowledge. Additionally, maintaining a client-oriented culture (where the SME's perspective is always considered) will help ensure that the hub remains relevant and valuable. In practical terms, DIHs could implement measures like client satisfaction surveys, advisory boards with SME representatives, or collaborative design of programs with input from past participants. By keeping the service user at the center, hubs can adapt to the evolving needs of businesses. Our findings that some firms felt truly "heard" and others occasionally "talked down to" by experts suggests that consistency in engagement approach is vital. Every positive outcome often began with a foundation of trust and mutual understanding between the SME and the DIH. Thus, an effective hub is one that combines top-notch technical expertise with a facilitative, empathetic approach that empowers SMEs to embrace innovation confidently.

4.7 Study Limitations

While this research provides meaningful insights, it is important to acknowledge its limitations. These limitations temper the generalizability of the findings and suggest caution in interpretation. First, the sample size and scope of the empirical data were constrained. We surveyed 28 SMEs and conducted a handful of expert interviews within a specific regional context (Italian DIHs and stakeholders). As a result, the findings may not be statistically representative of all SMEs or all DIHs across Europe. The relatively small sample of firms

means that quantitative results (e.g. the percentage of firms reporting a certain benefit) should be viewed as indicative rather than definitive. Moreover, the firms in our sample were self-selected in the sense that they had engaged with a DIH – this could introduce a positive bias (firms already interested in innovation are over-represented). There might be a silent group of SMEs who chose not to interact with the DIH, and their perspectives (perhaps marked by skepticism or lack of awareness) are not captured in our study. Similarly, our expert interviews, while rich in insight, covered managers and policy professionals closely linked to the DIH initiative; their views might inherently favor the concept of DIHs. We did not interview, for example, independent critics or firms that had a negative experience with the hub, which could have provided counterpoints. In short, the sample may be biased toward success stories and engaged stakeholders, which is worth considering when evaluating the outcomes.

Second, there are limitations related to measurement and data depth. The study relied significantly on perceptual data – survey responses about perceived effectiveness, interviews about perceived challenges and benefits. These perceptions, while valuable, may not always align perfectly with objective outcomes. For instance, an SME might report that it became "more competitive" thanks to the DIH, but our study did not independently measure performance indicators (like productivity or revenue growth) to validate this. We prioritized breadth of issues over depth in any single dimension, which means some claims (e.g. improved innovation capability) are based on self-report and qualitative judgment. The time frame of the research also poses a limitation: data were collected relatively soon after the DIH interventions for many firms. Innovation benefits often materialize over a longer horizon. Thus, our study might not capture long-term outcomes or may overstate short-term impressions. A firm might have been positive immediately after a pilot but perhaps the project stalled later – such longitudinal developments are outside our snapshot. Additionally, given that this was a case study approach, contextual factors (like the specific region's economic conditions or the particular expertise of the DIH staff) could have influenced results in ways not fully controlled for. The uniqueness of the Italian DIH we examined – for example, its specialization in Industry 4.0 technologies – might limit how directly the

conclusions transfer to DIHs with different focus areas (for instance, an agriculture-focused DIH in another country).

Another limitation concerns potential response and confirmation bias. In interviews, DIH managers and policy experts have a stake in the success of the program, which might incline them to highlight positives and downplay negatives. We tried to mitigate this by assuring anonymity and explicitly asking about challenges as well, but nonetheless the qualitative data could be biased by the respondents' affiliations. On the firms' side, survey respondents who maintained a close relationship with the DIH might have been inclined to express gratitude or give favorable feedback, especially if they foresee needing more help in the future (a form of courtesy bias). Also, because the researcher introduced the study as an evaluation of a public program, some SMEs might have provided answers they thought were "expected" or socially desirable. These human-factor biases are difficult to eliminate completely and represent a limitation to the reliability of the data.

Lastly, our application of theory, while rigorous, has limitations in scope. We focused on certain frameworks (market failure, uncertainty, absorptive capacity, innovation systems) that are highly relevant. However, we might have neglected other theoretical perspectives that could also explain the findings. For example, diffusion-of-innovation theory (Rogers 2003) or the literature on technology adoption in organizations might offer additional insights. Our discussion touched on some of these, such as Paul David's historical analysis of technology diffusion (David 1990), but the analysis wasn't exhaustive. This means our interpretation is framed by the theories we selected; other interpretations might emerge under a different theoretical lens. Recognizing this is important for academic completeness – our conclusions are drawn within a certain conceptual boundary.

In summary, while the study offers valuable contributions, these limitations suggest that results should be generalized with care. The context-specific nature of the research, potential biases in data, and the focused theoretical lens all circumscribe the claims we can make. These caveats notwithstanding, the insights form a solid basis for understanding DIH impacts, and they open avenues for further inquiry to build on and validate what we observed.

4.8 Directions for Future Research

Building on this research, there are several clear directions for future investigation to deepen and broaden our understanding of how cohesion policy instruments like DIHs stimulate private-sector innovation. First, a natural next step would be to conduct larger-scale, comparative studies of Digital Innovation Hubs across different regions or countries. Expanding the sample of SMEs and including multiple hubs could allow for quantitative analysis of impact (e.g. using control groups or matching techniques) to estimate the causal effect of DIH support on firm performance. For instance, future research could compare outcomes for firms that engaged with a DIH versus similar firms that did not, helping to isolate the additionality of the intervention. A comparative approach could also shed light on which hub models or practices are most effective. Perhaps certain governance structures, funding models, or service specializations yield better SME outcomes – a broader study might identify best practices and contextual factors. The insights from such research would be invaluable for policy refinement (e.g. deciding how to structure DIHs in less-developed regions versus more advanced regions). In essence, scaling up the empirical evidence would move the discussion from largely qualitative validation (as in our case) to more rigorous impact evaluation of DIHs as an innovation policy tool.

Second**,** future research should consider a longitudinal approach to capture the evolution of impacts over time. As noted in the limitations, many innovation benefits are delayed or cumulative. Following a cohort of SMEs over several years post-DIH intervention would reveal whether initial positive changes (new processes, products, mindset shifts) translate into sustained performance improvements (growth, productivity, innovation rates). Longitudinal case studies or panel data analysis could also identify if and when firms relapse (for example, do some SMEs innovate during the DIH project but then stop afterward? If so, why?). This temporal perspective would enrich our understanding of the durability of DIH-induced changes and what additional support might be needed. It would also allow researchers to examine the life cycle of the DIH itself – how the hub's role might evolve as the regional ecosystem matures. For example, after five years, does the DIH focus more on

advanced topics as baseline capabilities rise? Observing these dynamics could inform the design of exit strategies or the transition of hubs from EU funding to other models.

Another avenue is to delve deeper into the micro-level processes and organizational changes within firms that make public innovation support effective. Our study highlighted the importance of absorptive capacity and internal change, but more granular research (perhaps ethnographic or using detailed interviews within firms) could uncover how exactly DIH advice is implemented internally. Questions like: *What internal obstacles do SMEs face when trying to adopt DIH-recommended innovations? How do employees react to external expertise?* could be explored. Such research might involve before-and-after analyses of firm organizational culture, or social network analysis within firms to see if knowledge from the DIH "diffuses" among staff. Understanding these processes would help tailor interventions to not just deliver a technology or training, but also to facilitate the internal assimilation of that innovation within firms. This connects to a broader scholarly interest in innovation management: how external knowledge is internalized. Studying this could refine theories of absorptive capacity by adding practical detail (for example, identifying common failure points in absorption and how to address them).

Furthermore, future studies could broaden the theoretical lens. For instance, investigating DIHs through the perspective of regional innovation systems or economic geography might reveal how hubs influence not just individual firms, but also inter-firm relations and regional development paths. Do DIHs contribute to creating local innovation champions or new clusters of digital businesses? Are there spillovers to firms that did not directly use the hub (through demonstration effects or increased competition)? Methods like network mapping or regional economic modeling could be employed to capture these systemic effects. Also, considering cost–benefit analysis would be valuable from a policy perspective: future research could attempt to quantify the return on investment for DIHs by measuring the private investment stimulated per public euro spent. This would require collecting financial outcome data from firms (e.g. investment amounts, revenue changes attributable to innovation) and comparing it to program costs. While challenging, such analysis would provide a concrete economic efficiency perspective to complement the qualitative success narratives.

Finally, given that our research focused on digital innovation in SMEs, future work could explore sector-specific or technology-specific questions. For example, do DIHs have different levels of effectiveness in manufacturing vs. services, or for simpler digital technologies (like basic ICT adoption) vs. frontier ones (like AI and blockchain)? There may be differing needs and outcomes that our aggregate view did not distinguish. Tailored studies in particular industries (say, agri-food SMEs adopting digital tech via hubs, or healthcare startups working with DIHs) could yield insights relevant for customizing policy. Similarly, comparative research on DIHs versus other forms of innovation support (e.g. incubators, R&D subsidies, tax credits) could help position the unique contribution of hubs in the broader policy mix. Are DIHs more effective at the diffusion and adoption stage, while R&D grants help more at the invention stage? Understanding these complementarities can guide integrated policy design.

In conclusion, the promising results of this study should be seen as a springboard for more extensive research. By scaling up, following longer time frames, peering inside the "black box" of firm-level change, and diversifying theoretical viewpoints, future studies can significantly advance our understanding of how public interventions translate into private-sector growth. Such research will not only contribute to academic knowledge on innovation systems and policy evaluation, but also provide practical guidance to decision-makers seeking to foster innovation-driven economic development in line with cohesion goals. The digital transformation of SMEs is an ongoing journey, and continued research will ensure that policy support along this journey is as effective and evidence-based as possible.

CONCLUSION

The evidence from this research demonstrates that Digital Innovation Hubs (DIHs) are a potent policy instrument for stimulating SME digital innovation and competitiveness. Across the surveyed firms and interviews, DIH support proved catalytic: numerous SMEs pursued new digital projects that they would not have undertaken otherwise, confirming that public funds channelled through DIHs can leverage additional private investment. In essence, the DIH model has shown itself capable of turning European funds into private investments by bridging gaps that had previously held back innovation. By providing access to cutting-edge knowledge, expert mentoring, and facilities like "test-before-invest" sandboxes, DIHs lowered key barriers that often deter small firms from innovating. Entrepreneurs who lacked information, skills, or confidence to adopt advanced technologies were enabled to do so with the hub's guidance. This meant that projects with high social value but uncertain private returns – the kind that classic market theory predicts would be under-funded – were actually realized. The findings therefore strongly support the thesis argument: DIHs translate targeted public support into enhanced firm-level capacity and concrete innovation outcomes, effectively reducing barriers to digital innovation (financial, technical, and organisational) and improving SMEs' capacity to innovate. In short, DIHs serve as crucial intermediaries that help small businesses overcome knowledge deficits and risk aversion, thereby unlocking new private-sector investment in digital transformation.

Importantly, this study's insights go beyond confirming that DIHs work – they also shed light on *how* and *under what conditions* DIHs achieve impact. A core finding is that DIHs function as comprehensive one-stop shops offering a bundle of services (technical consulting, skills training, networking, and even investor linkages) which SMEs would not otherwise obtain on the market. By delivering these public-good services, the hub addressed classic innovation market failures: it supplied expertise and facilities that individual micro or small firms could not afford, and it shared the risk of experimentation through pilot projects and prototyping support. As a result, SMEs in the programme reported greater willingness to invest in new technologies after the DIH de-risked those opportunities. This aligns with broader observations in the European context – for example, studies have noted that small businesses'

digital adoption is hindered not just by lack of finance but by non-financial factors such as limited know-how and ambition, and DIHs have emerged as key enablers to tackle these gaps. In our case, participating firms frequently credited the hub with expanding their know-how (boosting their *absorptive capacity*) and instilling confidence to proceed with innovation. Thus, beyond immediate project outcomes, DIHs also strengthened firms' underlying capabilities, leaving them better prepared to continue innovating in the future. This capacity-building role is fundamental – as one EU policy handbook observes, *investing in DIHs is essentially investing in greater regional capacities for digital innovation*. Our findings validate this view by showing that DIH interventions can durably enhance the skills and innovation culture within SMEs, amplifying their long-term competitiveness.

While DIHs are clearly a powerful tool for innovation, the research also highlights that their success depends on sustained support and an inclusive approach. Not all SMEs benefited equally from the hub in our study. In particular, the **s**mallest firms (micro-enterprises) and those with very low digital maturity tended to engage less or derive fewer gains, even when services were available. This finding sounds a note of caution: without deliberate effort, DIHs might end up primarily serving the "low-hanging fruit" (firms already predisposed to innovate) and risk leaving behind structurally weaker businesses and regions**.** Indeed, the data suggest that truly *inclusive* impact requires tailoring the intervention to reach those firms that need the most help. For policy makers, this means paying special attention to micro-enterprises and lagging regions when designing and funding DIH initiatives. Targeted measures could include dedicated outreach and basic digital skills programmes for very small companies, so that even firms starting from a low knowledge base can take advantage of hub services. Likewise, weaker or peripheral regions may need additional support to establish and maintain hubs, ensuring a more balanced geographic coverage. In EU cohesion policy terms, DIHs can be a cornerstone for boosting competitiveness in *less-developed areas*, but only if there is commitment to planting and nurturing hubs where they are most scarce. The European Investment Bank, for example, has noted that while many hubs exist, more are needed in underserved regions of Europe, and they should intensify their support for small firms. Our research reinforces this point: to maximise impact on a continental scale, the DIH

network must be expanded and calibrated so that even SMEs in remote or structurally weak locales can access its benefits. The specific needs of micro-enterprises – from simpler initial training to trust-building outreach – should be explicitly addressed in DIH programmes. By broadening their reach in this way, DIHs can avoid exacerbating digital divides and instead become engines of more inclusive innovation-led growth.

Another pivotal conclusion is that the long-term effectiveness of DIHs hinges on sustained policy commitment. A recurring theme in our interviews was concern about the longevity and stability of hub operations. Many hubs (including the one studied) rely on short-term project funding cycles, which can create uncertainty about their future and limit their strategic horizon. Yet building up local innovation ecosystems is inherently a long-term endeavour – analogous to constructing infrastructure or developing human capital – and it cannot be achieved if support is fleeting or sporadic. The policy implication is clear: if DIHs are to fully realize their potential, they must be backed by consistent, long-range funding and institutional support. Policymakers should treat DIHs as *permanent innovation infrastructure* rather than one-off pilot projects. This might entail blending European and national/regional funds to ensure core financing beyond the typical 3–5 year EU project span. With a more secure footing, hubs could retain expert staff, plan multi-year initiatives, and build deeper relationships with local industry, all of which would increase their impact. Additionally, sustained support should go hand-in-hand with better integration of DIHs into the wider policy mix**.** Our study participants observed that a firm's journey often spans multiple support instruments – for instance, after receiving technical advice from a DIH, an SME might need a grant or loan to implement the solution. Thus, aligning DIHs with other programmes (innovation grants, digitalisation loans, training schemes, etc.) would create a smoother pathway for SMEs from initial idea to full deployment. Such integration ensures that the momentum gained through DIH assistance is not lost due to downstream funding gaps or bureaucratic hurdles. In summary, continuity and coordination in policy support emerge as vital ingredients for DIH success. The message to policy designers is that DIHs do work and merit continued support, but to maximize their contribution to

competitiveness and cohesion, we must solidify their foundations and knit them into a coherent support ecosystem.

In conclusion, this thesis finds that Digital Innovation Hubs have proven their value as a bridge between public investment and private-sector innovation. They exemplify how well-crafted public policy can stimulate businesses to step beyond their comfort zone – to experiment, invest, and upgrade technologically – by cushioning risks and filling resource gaps. The strong alignment between our empirical evidence and the theoretical rationale for innovation support lends weight to the argument that DIHs transform public funding into private investment by de-risking innovation and building absorptive capacity at the firm level. Crucially, however, the full promise of DIHs will only be fulfilled if policy makers remain committed for the long haul and ensure that the benefits extend to all corners of the SME landscape. The final implication is therefore a call for a sustained, inclusive policy vision: one that treats DIHs as a strategic long-term instrument and tailors them to the diversity of regions and firm sizes. With steady support and thoughtful calibration, DIHs can continue to be powerful engines of digital transformation**,** converting Europe's public funds into broad-based private innovation and driving the competitiveness of even the smallest firms in even the least advantaged regions. This concluding insight underlines the broader lesson of the study – that reducing innovation disparities and unlocking SME potential is not a one-time feat, but an ongoing process requiring perseverance, targeted attention, and a recognition that inclusive innovation is key to sustainable economic growth.

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