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DESIGN CAPABILITIES AND ENTREPRENEURIAL ECOSYSTEMS

INVESTIGATING DESIGN UNDER AN ADAPTIVE LOGIC OF COMPETITION FOR DEVELOPING NEW PRODUCTS IN MANUFACTURING

Ph.D. Candidate Caterina Dastoli

Supervisor Barbara Del Curto

Co-Supervisor Cabirio Cautela

External advisor and reviewer Carlos Teixeira, IIT Institute of Design

External reviewer Pieter Jan Stappers, TU Delft

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Caterina

“(...) It is not the critic who counts; not the man who points out how the strong man stumbles, or where the doer of deeds could have done them better. The credit belongs to the man who is actually in the arena, whose face is marred by dust and sweat and blood; who strives valiantly; who errs, who comes short again and again, because there is no effort without error and shortcoming; but who does actually strive to do the deeds; who knows great enthusiasms, the great devotions; who spends himself in a worthy cause; who at the best knows in the end the triumph of high achievement, and who at the worst, if he fails, at least fails while daring greatly, so that his place shall never be with those cold and timid souls who neither know victory nor defeat”.

Theodore Roosevelt - The Man in the Arena (Citizenship in a Republic), 1910

ABSTRACT

This research investigates the relationship between design capabilities and entrepreneurial ecosystems aiming to expand the discussion on new product development in manufacturing. By proposing a comprehensive model that informs about design capabilities impacts when used to develop new products through the multi-actor interface of entrepreneurial ecosystems, this work opens a new investigation area that intends to reduce the gap between design and entrepreneurial ecosystems research communities.

Even though design capabilities strategically support the development of superior company products by capturing, codifying, and synthesizing heterogeneous technical and market knowledge distributed at the level of the system, their support to companies on accessing and strengthening knowledge about the entrepreneurial process (i.e., entrepreneurial knowledge) can be considered unexplored. This interest in the research draws on the current challenges for manufacturing companies to stay competitive in the current industrial panorama as rapid technological advancements and disruptions are challenging the linear dynamics at the intersection of the production and consumption system. As such, manufacturing companies often need to expand their knowledge base by moving from the vertical to the horizontal level of knowledge access and strength, thus adopting an organizational perspective of new product development.

This research draws on the recent concept of entrepreneurial ecosystems to overcome the gap between design capabilities and their impacts at the organizational level of new product development in horizontal contexts of entrepreneurial knowledge interaction. Entrepreneurial ecosystems are defined as the process of system-level entrepreneurial knowledge co-creation leading to the emergence of entrepreneurial activity. Due to the

ability of companies to employ dynamic capabilities defined by specific teleologies (i.e., aims and goals), the entrepreneurial process of new product development is enabled by a community perspective. Therefore, the entrepreneurial ecosystems approach represents a supportive theoretical model that informs the thesis investigation.

The thesis selects new product development projects as the unit of analysis and packaging manufacturing in the food industry as a favorable sector for investigating *how design capabilities can support manufacturing companies to co-create entrepreneurial ecosystems for new product development* rather than informing firm-level strategies for new product development. Aiming to identify the impacts of design capabilities when the development of new products is enabled by the ability of companies to enter a complex system of entrepreneurial relationships, this research preliminarily provides an engagement-driven taxonomy of design capabilities as informed by the open innovation literature. Then, the research sets the empirical investigation under two main factors of change: the logic of competition and the complexity of the technology driving the projects, as they are described as influencing entrepreneurial actions for new product development through entrepreneurial ecosystems.

By adopting exploratory and descriptive approaches, which are reflected in the case study research method, this research focuses on identifying and then comparing the impacts of design capabilities in the co-creation of entrepreneurial ecosystems under the influence of the two factors of change. Design capabilities and related impacts were identified by analyzing and interpreting the projects' activities. The examined projects derived from strategic design-driven business experiments developed by professional designers in the academic context and from semi-structured interviews of the top management of selected packaging manufacturing companies. The research preliminary developed a framework that supported the qualitative analysis and interpretation of collected data by visually displaying design capabilities nourishment to entrepreneurial capabilities teleologies when the relationship emerged from empirical evidence.

Findings are presented as an integrated unit of the investigation results to contribute to the professional practice of new product development managers and designers when interested in adopting an economic adaptation logic of new product development. Furthermore, the research opens the possibility to managers and researchers to expand the discussion by answering the broader research question about how design capabilities can support the co-creation of entrepreneurial ecosystems for new product development within different contexts and sectors.

TABLE OF CONTENTS

LIST OF TABLES

1. THE MULTI-ACTOR INTERFACE OF NPD

2. THE ENTREPRENEURIAL ECOSYSTEMS GAP IN DESIGN

3. METHODOLOGY

4. INVESTIGATING THE RELATIONSHIP

LIST OF FIGURES

3. METHODOLOGY

4. INVESTIGATING THE RELATIONSHIP

LIST OF ABBREVIATIONS

EEs Entrepreneurial Ecosystems

NPD New Product Development

INTRODUCTION

Knowledge economy is transforming the rules of competition that drive the development of new products. When competition defines new goals to be pursued for successful new product development, knowledge interaction strategies enabling new product development change. The development of new products reflects the combination of complementary and heterogeneous knowledge that productively collaborate toward economic growth and prosperity. However, when technological and social forces challenge the linear dynamics between the production and consumption systems, economic prosperity depends on the ability of companies to adapt to the consequences of technical and social change when interacting towards economic growth.

New successful manufacturing products relied on technical and market knowledge sharing and diffusion within local production networks throughout the twentieth century. The proximity and density of heterogeneous knowledge collaborating within an industry catalyzed the development of new successful products. Consequently, by participating in local technical and market knowledge interactions, manufacturing companies fostered the economy's efficiency by developing high-performance manufacturing systems.

Currently, the continuous sharing and diffusion of technical and market knowledge supported by territorial models of new product development often represents the engine of the industry's efficiency as local production networks foster the establishment of dominant designs, or standards, which represents the goal toward which manufacturing companies specialize for staying competitive. By reducing costs of technical and market knowledge access due to tacit knowledge exchange mechanisms, manufacturing companies participating in local production networks gain competitive advantage as they can satisfy consumer demand faster and at lower costs than competitors. In this context, design capabilities for new product development represent a strategic resource for manufacturing companies, which can develop superior products due to the ability of design to capture and synthesize system-level knowledge. The focus on satisfying customers' needs made design capabilities specialize into methods and practices that inform firm-level strategies of competitive new product development within an industry, thus becoming a widely acknowledged strategic resource for manufacturing companies.

If, from one hand, developing new products toward dominant designs leads to faster advancements in technology due to the large amount of technical and market knowledge employed, from the other, continuous technological advancements often lead to consumers embracing major changes faster than the reaction of the production system. Consequently, standards are continuously being disrupted as consumers demand is fast changing. However, until establishing dominant designs is perceived as the activity that nurtures manufacturing companies in terms of profits and competitive advantage, manufacturing companies continue to specialize and investing in design capabilities for reinforcing mechanisms of technical and market knowledge sharing and diffusion, even if they do not effectively contribute to reducing uncertainty about what to do to satisfy consumers demand.

Starting from this point, this research shows interest in the recent concept of entrepreneurial ecosystems as it represents an alternative approach to new product development for economic growth in times of uncertainty. Entrepreneurial ecosystems move the logic of competition of participating companies from relying on industry efficiency through the establishment of dominant designs to taking advantage from the collective usage of the high amount of available knowledge through “industry agnostic” adaptation (Spigel & Harrison, 2018). Specifically, new product development in entrepreneurial ecosystems is dependent on the ability of companies to adapt their available technologies to new organizational configurations of entrepreneurial knowledge, or the knowledge about the entrepreneurial process. Indeed, by following the entrepreneurial ecosystems approach, available technologies reflect actionable technological properties that creates feasibility spaces for social practice. Consequently, the ability of companies to access and strengthen complex entrepreneurial knowledge networks support the identification, development and implementation of new technology application opportunities through social exchange and collaboration.

Entering complex networks of entrepreneurial knowledge means manufacturing companies focusing on the relational dimension of new product development, also defined as the "fuzzier medium" (Benkler, 2008) as it enables complementarity, or the symbiosis and interdependence among multiple entrepreneurial actors due to the enhancement of trust through collaboration. When complementarity enables the emergence of new products, manufacturing companies should invest in the relational dimension of new product development. This means perceiving the ability to access and strengthen system-level entrepreneurial knowledge as the primary enabler of competitive advantage. Although manufacturing companies participating in territorial models of new product development traditionally rely on trust relationships for accessing other companies' technical and market knowledge, their ability in acquiring and applying knowledge about the entrepreneurial process through a multi-actor interface of entrepreneurial knowledge does not represent the focus of the studies.

Hence, in entrepreneurial ecosystems, new product development is defined as the entrepreneurial process described by system-level dimensions of entrepreneurial knowledge engagement, namely opportunity identification (i.e., sensing), resources mobilization (i.e., seizing), and knowledge reconfiguration (i.e., reconfiguring). Under this perspective, specific entrepreneurial capabilities within each dimension enable sensing, seizing, and reconfiguring, respectively, as they aim to support companies to access and strengthen knowledge for complementarity through entrepreneurial collaboration.

By focusing on social exchange and collaboration, also defined as entrepreneurial co-creation, over sensing, seizing, and reconfiguring, companies find a sustainable way for developing new products in times of uncertainty. Therefore, although consumers are considered part of entrepreneurial knowledge that can inform companies about what to do, they are no longer the focal resource for gaining knowledge around which companies shape products for competitive advantage. Indeed, consumers represent one type among heterogeneous entrepreneurial stakeholders that can benefit from multi-actor entrepreneurial knowledge interactions.

Even though the strategic support of design capabilities for new product development in manufacturing through the engagement of system-level knowledge has long been recognized, the impact of design capabilities when supporting new product development under a relational perspective of entrepreneurial co-creation seems to be unexplored. Researchers that intersect participatory design with actor-network theory provide a supportive direction for defining new product development as emerging from heterogeneous and complementary actors interactions. However, the focus of interaction dynamics seems not to expand the discussion on the organizational level of system-level entrepreneurial knowledge engagement. Nevertheless, the ontological characteristics of design capabilities for superior new product development show this potential.

This research proposes to reduce this gap by expanding the discussion on new product development in manufacturing by focusing on a specific sector, or packaging manufacturing, within the food industry ecosystem for setting and conducting the empirical investigations. The food industry ecosystems is a favorable context of examination as it represents a complex and adaptive ecosystem with a high number of agents that interact and co-evolve. In this context, packaging manufacturing represents a favorable sector as the development of new products often deals with complex issues resolution such as environmental problems, logistics, and technological adaptation.

By following the main research question of *how design capabilities can support packaging manufacturing companies to co-create entrepreneurial ecosystems for new product development*, this research starts from the assumption that if design capabilities can engage with systemic knowledge to serve internal companies' new product development strategies, they can potentially engage with systemic knowledge to co-create entrepreneurial ecosystems for new product development. Then, the research has been driven by three sub-questions to inform the primary research question:

- Which are the design capabilities that might enable the co-creation of entrepreneurial ecosystems?
- What is the relationship between design capabilities and the organizational dimensions of new product development in entrepreneurial ecosystems?
- Which are the impacts of design capabilities when co-creating entrepreneurial ecosystems?

Rather than working in traditional disciplinary silos, this research integrates contributions from the entrepreneurial ecosystems literature as it considered two factors of change described as influencing entrepreneurial ecosystems co-creation, namely the logic of competition served when developing new products, and the complexity of the technology driving new product development. Then by selecting new product development projects as the unit of analysis, this research adopts an exploratory and a descriptive approach reflected by the case study method for investigating the relationship between design capabilities and entrepreneurial ecosystems under the two factors of change.

Furthermore, this research is informed by open innovation literature in the way it provides a theoretical bridge enabling the investigation from a knowledge engagement perspective on capabilities from the two domains. Although design capabilities traditionally deal with heterogeneous knowledge engagement when employed for new product development, the finalities by which they are classified reflect a product-centered rather than a system-centered orientation of engagement. In this context, open innovation describes the engagement dimensions when system-level knowledge is searched and collected, which are defined by cognitive and experiential practices. Hence, open innovation literature informed the dimensions of classification of design capabilities, thus contributing to the development of an engagement-driven ontological taxonomy. By classifying design capabilities for new product development in cognitive and experiential ontological terms and identifying the related activities as observable items, it was possible to investigate in the projects which design capabilities could satisfy the entrepreneurial capabilities interactional teleologies (i.e., aims and goals) that enable the development of new products through system-level entrepreneurial knowledge interactions over sensing, seizing, and reconfiguring phases.

Consequently, a framework that visually could display the relationship was considered as key preliminary activity before the empirical research investigation, as it could provide a fundamental analytical and interpretative tool for data once collected. Then, the development of a framework that grouped design capabilities under cognitive and experiential dimensions and entrepreneurial capabilities under sensing, seizing, and reconfiguring enabled the visualization of their links in the form of intersection nodes.

The technical research design of this thesis is then defined by two main investigations of packaging new product development projects for innovating in the food industry. The first investigation explores the relationship by focusing on the logic of competition as the factor of influence. The second describes the relationship by considering projects under the two logic of competition as influenced by the complexity of the driving technology. The two investigations were conducted under two different settings due to the researcher doctoral path and the investigations intended finalities: the first investigation was developed within the "Organizational model for innovation" academic course over the researcher visiting PhD period at IIT Institute of Design (Chicago). The course was intended as a research platform that reflected the exploratory phase of the research empirical work. In this setting, professional designers envisioned six design-driven business experiments in the form of visual models and project plans that expanded the selected companies intervention for new product development through system-level knowledge engagement. The second investigation was developed by interviewing the top management of four packaging companies participating in the food industry innovation. The interviews focused on the description of selected new product development projects and supported the descriptive phase of the research empirical work. Although the examined projects did not intentionally worked following an entrepreneurial ecosystems approach for new product development, adopting a result perspective supported their classification in term of the logic of competition they served as defined by the variation in their goals and intended effects. Moreover, projects cloud be classified under higher of lower technology complexity given their "age", or patent publication year. This allowed for understanding the influence of the factors of change on the design capabilities ontological characteristics and impacts that support entrepreneurial ecosystems co-creation over sensing, seizing and reconfiguring.

Although in both the investigations cognitive design capabilities showed a wider intervention when the finalities of entrepreneurial capabilities had to be satisfied, they showed different entrepreneurial dimensions of intervention when a higher or lower complexity of the technology drove the projects. As a result, the researcher created an integrated model as a informative tool that clarifies design capabilities ontological dimensions and related impacts over sensing, seizing and reconfiguring under the influence of the logic of competition adopted by the project and the complexity of the project driving technology. when new product development is defined as the entrepreneurial process described by system-level dimensions of entrepreneurial knowledge engagement, namely opportunity identification (i.e., sensing), resources mobilization (i.e., seizing), and knowledge reconfiguration (i.e., reconfiguring). The model is described in this dissertation, and can be useful for new product development managers, researchers and designers interested in employing design capabilities for developing new products when new product development is defined as the entrepreneurial process described by system-level dimensions of entrepreneurial knowledge engagement, namely opportunity identification (i.e., sensing), resources mobilization (i.e., seizing), and knowledge reconfiguration (i.e., reconfiguring).

Overall, the structure of this dissertation can be divided as follows: chapter 1 introduces the theoretical framework of this research. The chapter challenges the traditional logic of competition and consequent knowledge dynamics defining new product development in manufacturing by introducing and describing the alternative entrepreneurial ecosystem approach to competition for new product development. By adopting a practice-based approach, the theoretical framework describes the necessary conditions and entrepreneurial capabilities defining new product development in entrepreneurial ecosystems. Chapter 2 discusses the knowledge gap in design and its capabilities as they seem to be limited in supporting the alternative logic of entrepreneurial ecosystems for addressing the contemporary uncertainty of successful new product development, including the necessary organizational perspective of system-level entrepreneurial knowledge engagement. Chapter 3 narrows the concepts discussed in Chapters 1 and 2 to the specific context of the food industry ecosystem and to the packaging manufacturing sector, as their characteristics reflect a favorable research setting. The chapter focuses on outlining the research objectives and assumption, also introducing the conditions of change that might challenge the research assumption. Moreover, this chapter focuses on describing the method that informed this

qualitative research methodology, reflected in case study research. Finally, this chapter also presents the research design and the sampling strategy that enabled the empirical investigations.
Chapter 4 presents a high-level description of the empirical research work. Specifically, this chapter shows the development of a framework as the enabling tool for data analysis and interpretation before entering the description of the two main research investigations. The chapter ends by integrating the findings retrieved from the previous investigations in an informative model showing design capabilities impacts and spaces of intervention for new product development in entrepreneurial ecosystems. Chapter 5 presents and discusses the main points deriving from the final model development and reports the implications for the professional practices of new product development managers, researchers, and design practitioners. Specifically, this chapter provides the answers to the research questions from a critical perspective. Chapter 6 concludes this dissertation with a summary of the contribution, including its limitation and relevance, and suggests possibilities for expanding this area of investigation through future research in the field of design and entrepreneurial ecosystems.

Although this research can be relevant to the entrepreneurial ecosystems field interested in exploring new product development in manufacturing from a capabilities perspective, this thesis aims to contribute to design knowledge by providing a new approach to applying design capabilities by following the principles of an alternative and adaptive logic of competition for new product development in manufacturing. During the last four decades, design capabilities contributed to informing and transforming firm-level new product development strategies toward the definition of consumer-centered production and consumption standards. By focusing on codifying and synthesizing system-level technical and market knowledge, design capabilities contributed to fostering the efficiency of the industry in which they intervened. If design capabilities undeniably led to a competitive advantage for manufacturing companies, it might often be challenging to create long-term value through new product development when technological advancements are developing at speeds never seen before. When technology advances so fast, the dynamics of consumption may embrace major changes faster than the reaction of the industrial system. Consequently, manufacturing companies might find it challenging to benefit from the efficiency of an industry when standards are constantly being disrupted.

By considering the entrepreneurial ecosystems approach as a promising direction that expands the level of knowledge engagement for economic growth from a consumer-centered to a stakeholder-centered orientation, design capabilities have greater opportunities to drive competitive advantage as they do at the firm level.

1. THE MULTI-ACTOR INTERFACE OF NPD

1.1. Introducing entrepreneurial ecosystems

The evolving perspective on entrepreneurship

The fundamental concepts behind entrepreneurial ecosystems emerged in the 1990s as part of a shift in entrepreneurship studies away from individualistic, personality-based research towards a broader community perspective of the entrepreneurship process (Stam & Van de Ven, 2019). Therefore, entrepreneurial ecosystems reflect the collaborative process that *enables* entrepreneurship. Several authors define entrepreneurial ecosystems. Among the others, Stam (2015, p. 1765) defines entrepreneurial ecosystems as "a set of interdependent actors and factors coordinated in such a way that they enable productive entrepreneurship within a particular territory." Bruns et al. (2017, p. 1) define them as "a multidimensional set of interacting factors that moderate the effect of entrepreneurial activity on economic growth." Shwetzer et al. (2019, p. 79) define entrepreneurial ecosystems as "a set of interconnected entrepreneurial actors, organizations, institutions and entrepreneurial processes, which formally and informally coalesce to connect, mediate and govern the performance within the local entrepreneurial environment, involving a dynamic and systemic nature, within a supportive environment." Hence, entrepreneurial ecosystems define entrepreneurship as an interactive process among heterogeneous actors describing the development of systemic entrepreneurial activity.

Although this concept might not sound new for those interested in the territorial models of entrepreneurship, such as local production systems, entrepreneurial ecosystems open up a new holistic and dynamic approach to engagement for entrepreneurship (Feld, 2012; D. J. Isenberg, 2011). The term *entrepreneurial* in entrepreneurial ecosystems describes the process of exploring, evaluating, and exploiting opportunities for new goods and services creation (Schumpeter, 1934). Although the literature often narrows down the focus on forming and scaling start-ups (Mason & Brown, 2014; World Economic Forum, 2013), the entrepreneurial process of interaction involves all the entrepreneurial actors that dynamically participate in the emergence of entrepreneurial activity in a region, including mature companies (D. Isenberg, 2014). Therefore, the entrepreneurship process is not defined by an industrial system's resources but by the interactive process involving intra- and inter-industry entrepreneurial relationships (Roundy et al., 2018; Spigel & Harrison, 2018).

The term *ecosystem* refers to the biological metaphor that focuses on living organisms' interactions with their physical environment (J. F. Moore, 1993). In the entrepreneurial ecosystems literature, the term emphasizes the community of interdependent actors where the entrepreneurial activity occurs (J. H. Freeman & Audia, 2006). Specifically, the literature studies the social context's support to entrepreneurship. Although the management literature on ecosystems focuses on the concept of value chain or organizational dynamics within a single industry (Iansiti & Levien, 2004; J. F. Moore, 1993), entrepreneurial ecosystems draw on the social agency of systemic knowledge that leads to the emergence of entrepreneurship within geographical boundaries.

Although entrepreneurial ecosystems are an emerging field of study within the broader entrepreneurship context, they are recently receiving much scholarly attention as the participation in entrepreneurial dynamics refers to the possibility for companies to draw entrepreneurial knowledge from a broader knowledge repository. Therefore, knowledge is defined as a "key element" and "systemic condition" of entrepreneurial ecosystems (Stam, 2015, p. 1765), and the fundamental social approach to entrepreneurship allows ecosystem members to access entrepreneurial knowledge freely (Auerswald & Dani, 2017; Bruns et al., 2017). Roundy (2020) describes entrepreneurial ecosystems as functioning as repositories of knowledge about opportunities, technologies, and the entrepreneurial process that flow through the systems' networks. The most acknowledged entrepreneurial ecosystem is Silicon Valley (Spigel & Harrison, 2018). The high *diversity* and *complementarity* of entrepreneurial knowledge in the region support companies and entrepreneurs in acquiring and managing knowledge over time. Although Silicon Valley grew up and continues raising due to particularly favorable conditions, such as entrepreneurial resources injections and entrepreneurial density, scholars often report the benefits of entrepreneurial relationship-building activities also in less munificent territories (e.g., see Spigel, 2017a; Spigel & Harrison, 2018).

The practical possibility to widen the search space of opportunities, technologies, and entrepreneurial knowledge toward systemic goals (i.e., systemic entrepreneurial activity) makes entrepreneurial ecosystems be defined as a new economic development approach (Mason & Brown, 2014; World Economic Forum, 2013). As entrepreneurial ecosystems focus on growing regional entrepreneurial activity, they contribute to economic growth and prosperity. Stam (2015) describes new economic growth potentials residing in the productive entrepreneurship that distinguishes entrepreneurial ecosystems. In entrepreneurial ecosystems, productive entrepreneurship often includes enterprises that provided a fertile ground for consequent entrepreneurial opportunities through failure, thus creating the social value network that catalyzes entrepreneurship. Hence, the social value of entrepreneurial ecosystems that emerge from entrepreneurial activity is more than the sum of the value created by the private individual entrepreneurs or companies (Roundy et al., 2018).

Consequently, economic, technological, and societal impacts rely on the ability of entrepreneurial ecosystems participants to access and distribute knowledge critical for other agents in the ecosystems (Audretsch et al., 2019). Although other ecosystem approaches sustain economic prosperity, they do not focus on the actors' relational dynamics leading to economic growth as the necessary pre-condition for prosperity. Specifically, other ecosystems studies mainly focus on the economic activities leading to customer-facing solutions (i.e., innovation ecosystems) (e.g., see Adner & Kapoor, 2010; Nambisan & Baron, 2013), on tacit knowledge flows that enable entrepreneurship (i.e., knowledge ecosystems) (e.g., see Clarysse et al., 2014), or on value chains and organizational dynamics within a single industry (i.e., business ecosystems) (e.g., see Iansiti & Levien, 2004; J. F. Moore, 1993). Hence, by focusing on the individual actions of knowledge access and strength for entrepreneurship, entrepreneurial ecosystems studies contribute to understanding the (social) value co-creation processes through entrepreneurial actors interactions.

The following section describes the main similarities and differences between entrepreneurial ecosystems and their antecedents to emphasize the new directions followed by this research.

The antecedents of entrepreneurial ecosystems

Manufacturing companies boast a long tradition of organizing entrepreneurship within local networks of highly specialized expertise as contexts of knowledge diversity and proximity catalyze industry efficiency. When the efficiency of an industry depends on local and heterogeneous knowledge sharing and combination, manufacturing companies participate in territorial models of new product development and innovation. While providing a taxonomy of territorial models typologies, Moulaert and Sekia (2003) describe industrial districts, or local production systems, as the first type of industrial agglomerations. The theory of industrial districts strongly emphasizes the innovation capacity of companies, and specifically SMEs, that participate in new product development within the same industry and local space (i.e., see Bagnasco, 1977). Indeed, the division of work in terms of specialized manufacturing companies within the industrial district and the companies' proximity allows for forming an industrial community that explicitly and tacitly diffuses technical and market knowledge among its members (Becattini, 2002).

In this context, companies engage in local interactions to develop new products as new technologies emerge from the highly productive context. When new technologies emerge, companies organize into local manufacturing systems that maximize industry efficiency due to diversity and proximity. Schilling (2010) describes that technical and market knowledge sharing leads to the specialization of production processes and products, which converge in the formation of high-performance manufacturing systems. Hence, specialization in an industry allows firms to gain a competitive advantage from local knowledge-sharing interactions (Porter, 1998).

The competitive advantage achieved by companies that developed new products and innovations through socio-economic communities based on collaboration and complementarity led to the diversification of industrial districts into several territorial models, such as innovative milieus, learning regions, and industrial clusters (Belussi & Sedita, 2019; Moulaert & Sekia, 2003). When the focus of companies in territorial models moves from production to innovation, multiple theoretical perspectives describe the entrepreneurship dynamics. Nevertheless, the models share the focus on innovation catalyzation, entrepreneurial initiatives, competitiveness supporting economic growth, long-term development, performance, and success (Scaringella & Radziwon, 2018).

Entrepreneurial ecosystems theory explicitly links entrepreneurial ecosystems to several principles of industrial clusters (Feld, 2012; D. J. Isenberg, 2011). The presence of other companies as a source of competitive advantage for entrepreneurial activity creation, the importance of external company knowledge for the company's increased competitiveness, and knowledge processing and creation are reported as the primary commonalities between the two models (e.g., see Spigel & Harrison, 2018). However, entrepreneurial ecosystems as a re-formation of industrial clusters' theory report different perspectives on entrepreneurship that lead to the acknowledgment of the concept as distinct.

Spigel and Harrison (2018) emphasize that entrepreneurial ecosystems are defined by the process of interaction between heterogeneous knowledge agents rather than by the resources they contain. While industrial clusters are traditionally related to the specialized knowledge representing a certain industry (Belussi & Sedita, 2019), entrepreneurial ecosystems focus on the entrepreneurial process leading to entrepreneurial activity. Although the industrial clusters literature widely acknowledges knowledge spillovers as a fundamental support to entrepreneurship, they focus on technical and market knowledge sharing dynamics rather than on the ability of companies to access this system-level knowledge (Roundy, 2020; Spigel, 2017b). Consequently, studies on entrepreneurial ecosystems focus on the entrepreneurial ability of companies to engage with external knowledge agents toward the emergence of entrepreneurial activity.

Specifically, entrepreneurial ecosystems differ in the way they define the role of knowledge in the entrepreneurship process. While industrial clusters focus on technical and market knowledge as the primary sources enabling entrepreneurial activity, entrepreneurial ecosystems also include entrepreneurial knowledge or the knowledge about the entrepreneurial process itself (Spigel & Harrison, 2018; Stam & Spigel, 2017). When developing new products might be challenging under uncertain conditions of change, entrepreneurial knowledge support companies in overcoming new product development challenges, such as identifying new opportunities, mobilizing resources, and reconfiguring activities to innovate (Teece, 2007; Teece et al., 2009). By focusing on entrepreneurial knowledge as the driving force of entrepreneurial activity, entrepreneurial ecosystems are defined as a wider repository of opportunities, technologies, and entrepreneurial processes that flow through the systems' networks (Roundy, 2020). However, accessing entrepreneurial knowledge to develop new products requires companies to adopt an organizational perspective of new product development.

The organizational perspective is a fundamental differentiator between industrial clusters and entrepreneurial ecosystems as it defines the entrepreneurial process as largely transcending the industry boundaries. When the supporting entrepreneurial knowledge is dispersed at the level of the system, it is not necessarily contained within the industry edges. Consequently, companies in entrepreneurial ecosystems are defined as “industry agnostic” (Spigel & Harrison, 2018, p. 156) in their decisions when searching for entrepreneurial knowledge for new product development. Ratten (2020) highlights that these decisions are driven by the technology characteristics that companies aim to apply. Hence, technology in entrepreneurial ecosystems refers to the way an action is conducted as informed by the technology characteristics.

Table 1. 1 summarizes the main similarities and differences about entrepreneurship between industrial clusters and entrepreneurial ecosystems theories. Starting from this clarification, the next section describes the advantages that manufacturing companies can gain when engaging with entrepreneurial ecosystems for new product development.

	INDUSTRIAL CLUSTERS	ENTREPRENEURIAL ECOSYSTEMS
SIMILARITIES	The presence of other companies as a source of competitive advantage for entrepreneurial activity creation	
	The importance of external company knowledge for the company's increased competitiveness	
	Knowledge processing and creation	
DIFFERENCES	Defined by the specialized resources they contain	Defined by the process of interaction between heterogeneous agents
	Knowledge sharing dynamics	Knowledge access and strength abilities
	Focus on technical and market knowledge	Focus on entrepreneurial knowledge
	New product development decisions driven by the availability of resources within the industry	Industry-agnostic decision making driven by the technology characteristics

Table 1. 1 The main differences and similarities between industrial clusters and entrepreneurial ecosystems concepts

Technology affordances for social action

Technology drives the dynamics of new product development as its characteristics enable human actions. When technology informs new product development, companies make decisions about how to take advantage of the technology characteristics for developing new products. Under this perspective, decisions are taken coherently with the industrial logic of competition, which defines the purpose of human actions in exploiting technology characteristics for competitive advantage.

Traditionally, manufacturing companies in local production systems perceive technology as related to production functions as it leads to production functions changing toward outputs increasing and labor releasing. Therefore, economic prosperity depends on a technology entering the system and enabling production efficiency. Schilling (2010) describes technology as enabling efficiency in informing companies possibilities to develop new products coherently with dominant designs selected by their industry. As dominant designs reflect breakthrough innovations that best accomplish consumption needs, manufacturing companies directly compete with each other by employing the available technology toward the development of unique products that reflect consumers' needs satisfaction under the standardized direction (Anderson & Tushman, 1990). Consequently, a dominant design logic of competition relies on manufacturing companies specializing and competing toward a specific production and consumption standard satisfaction.

Under this perspective, the concept of competition relies on price-based dynamics as once technology provides the means for new product development, manufacturing companies take advantage of their ability to create economic value. Martin (2009) refers to competitive advantage as the ability of firms to create more economic value than their rivals can replicate. Therefore, economic value is dependent on the positive difference between the customer’s perceived benefits and the company’s cost to deliver products. Although competing under a dominant design logic of new product development leads manufacturing companies to benefit from the industry's efficiency, technology as the driver of new product development actions is perceived in the background of economic growth. And although this perception of the role of technology expands manufacturing companies' possibilities to succeed and compete within linear production and consumption dynamics, different consequences derive from non-linear post-industrial contexts.

Indeed, new product development toward dominant designs led to faster advancements in technology due to the large amount of technical and market knowledge embedded in manufacturing specialization processes. However, continuous technological advancements lead to consumers embracing significant changes faster than the reaction of the production system (Geels, 2004). Consequently, standards are continuously disrupted as consumers demand is fast-changing (Whitney, 2015).

In this context, entrepreneurial ecosystems as a post-industrial approach to economic growth consider technology under an evolutionary perspective (Spigel & Harrison, 2018). When technology is perceived as the primary driver of economic development, it supports non-deterministic approaches to economic growth. Kelly (2010) defines technology as “wanting” and “driving” users' actions to modify systems' organizational configurations for new product development. Accordingly, Neff et al. (2012) describe technology as provided with “affordances,” namely actionable properties that reflect its characteristics. Benkler (2008) refers to technology affordances as creating new feasibility spaces for social practice. Hence, entrepreneurial ecosystems focus on creating new organizational configurations of social action for new product development as informed by a driving technology's actionable properties.

By considering technology from an evolutionary perspective that enables collective action for new product development (Thomas & Autio, 2014), the affordances of technology provide the possibility to organize arrangements of entrepreneurial knowledge to identify new opportunities, mobilize resources, and reconfiguring them toward a new product (Roundy & Fayard, 2019). Specifically, as Arthur (2013) describes, the complexity of technologies can inform actors about new configuration possibilities. Hence, products result from multiple system-level knowledge that collectively exploits available technologies' more or less complex technology characteristics (Thomas & Autio, 2014).

This perspective is strictly linked with evolutionary economics and its emergence from the collective usage of system-level knowledge. The next section describes this topic as driving the dynamics of new product development in entrepreneurial ecosystems.

1.2. Adaptability for new product development

Products as manifestations of knowledge dynamics

Hausmann et al. (Hausmann et al., 2014) describe products as manifestations of the productive knowledge they embed. Productive knowledge can be understood as the combination of complementary and diverse knowledge resulting in specialized production expertise embedded at the level of the individuals or grouped in organizations and into networks of organizations (e.g., industrial clusters, entrepreneurial ecosystems) (Stam & Spigel, 2017). When a large amount of diverse knowledge becomes productive through complementary combination, individuals, companies, and networks specialize. Hausmann et al. (Hausmann et al., 2014) claim that specialization has allowed modern society to access a quantity of knowledge that it would not have been possible to hold individually. Hence, by reinterpreting Adam Smith's idea that the division of labor directly leads to wealth creation (Smith, 1776), the authors emphasize that the division of labor in terms of collective usage of high amounts of knowledge represents the modern formula for the evolution of society and economic prosperity (see also Hidalgo & Hausmann, 2009).

As individuals, companies, or networks specialize, knowledge becomes more fragmented. Consequently, the development of diverse products resides in the ability of companies to combine knowledge across large networks of people. When companies generate a diverse mix of knowledge-intensive products, the economy is complex. Hausmann et al. (2014, p. 27) define economic complexity as "the multiplicity of fragmented knowledge embedded in the productive structure of an economy." Although organizing knowledge in complex economics might be challenging, companies that can develop new products by engaging with diverse and dispersed knowledge increase products diversity and complexity. Thus, complex economics provide companies with a competitive advantage that derives from their ability to develop new products at the organizational level (G. P. Pisano & Shih, 2012).

This perspective on competition is driven by the consideration of the economy as driven by knowledge. Hence, a knowledge economy approach drives new product development for complex economies (Benkler, 2008). The OECD (1996, p. 7) defines knowledge economy as "an economy that is directly based on the production, distribution, and use of knowledge and information." When knowledge drives economic growth and prosperity, companies compete by focusing on capturing knowledge as the primary asset for competition. Several economic theories emphasize knowledge as the basis of economic prosperity and growth. Among the others, Romer (Romer, 1989, 2016) defines economic growth as strictly dependent on companies investing in human capital and scientific research. The author emphasizes that non-material investments for new product development allow companies to capture new and complementary knowledge and translate it into offers. Hence, the competitive success of companies relies on the large amount of useful knowledge already contained in their social context.

Nevertheless, the specialization and thus the fragmentation of knowledge among individuals, companies, and networks often make engagement with knowledge actors challenging (G. Roos, 2014). When knowledge fragmentation challenges productivity, manufacturing companies are confronted with dispersed and diverse specialized knowledge. And when new product development through collective actions represents the heart of competitive advantage (G. P. Pisano & Shih, 2012), manufacturing companies are required to organize systemic knowledge into productive use (Benkler, 2008; Hausmann et al., 2014; G. P. Pisano & Shih, 2012).

For this purpose, Roos (2011) describes how manufacturing supports economic growth from research and innovation to goods recycling. Indeed, the traditional meaning of manufacturing as a sector made of companies that transform raw materials into finished products is becoming outdated in the knowledge economy. Therefore, the author argues that manufacturing companies should focus more on these pre- and post-production activities to develop distinct and complex products and survive the competition. This means that productivity in the knowledge economy results from the ability of companies to codify and synthesize dispersed and diverse knowledge toward collective action for productive knowledge use (Ratten, 2020).

As Pisano and Shih (2012) emphasize, every product embeds a deeper set of hidden organizational capabilities that enable product development and delivery. Consequently, manufacturing companies have a fundamental role in today's knowledge economy if they can enterprise new product development from an organizational perspective of knowledge engagement at the level of the system.

The following section explains how new product development derives from an organizational approach in entrepreneurial ecosystems.

Entrepreneurial co-creation in complex adaptive systems

Value co-creation represents the primary form of competitive advantage in the knowledge economy because it draws on stakeholder relationships and interactions as a source of social capital that can increase entrepreneurial success. When companies adopt a collaborative stakeholder orientation, they survive and prosper due to value co-creation. By focusing on the collaborative aspect of co-creation, Grönroos (2012, p. 1520) defines value co-creation as “a function of interaction” and as “joint activities by parties involved in direct interactions, aiming at contributing to the value that emerges for one or both (or all involved) parties.”

According to more classical definitions, co-creation has generally involved specific relationships between the company and a defined stakeholder, often the customer. Companies engaged mainly with customers as creating personalized customer experiences rather than the product itself was more valuable in terms of its profitability and consumer satisfaction (Prahalad & Ramaswamy, 2004). Therefore, co-creation is raised as a process that could bring benefits at the firm-level. Although the customer-centric orientation of new product development evolved into established industrial paradigms, i.e., mass customization (Tseng & Piller, 2003), the challenges in understanding what the consumer actually needs and desires over its daily life triggered a shift toward a broader level of stakeholders engagement. Hence, when companies require a wider knowledge base to develop successful products, they interact and collaborate with several stakeholders.

Specifically, a stakeholder-centered orientation defines entrepreneurial co-creation. Shams and Kaufmann (2016) emphasize that stakeholder-centered relationships are the cause and the effect of successful new product development as they enable a mutual sharing of entrepreneurial knowledge. In entrepreneurial ecosystems, stakeholders are perceived as an end for shared value creation as shared value creation relies on productive entrepreneurship. Stam and Spigel (2017) define productive entrepreneurship as the “entrepreneurial activity that creates aggregate welfare increases.” By describing entrepreneurial activity as the output of social interactions that enable companies to access ecosystem resources, productive entrepreneurship depends on the ability of companies to co-create (social) shared value with the ecosystem’s stakeholders.

In these terms, entrepreneurial activity results from productive engagement of ecosystems’ stakeholders rather than individual efforts (Stam & Spigel, 2017).

Ramaswamy and Ozcan (2018) define co-creation as the "enactment of creation through interaction," thus highlighting that the act of creation is modified by and dependent on forces of interactions. Although the dynamics of interaction for value co-creation are often coordinated by a central authority, entrepreneurial co-creation results from dynamics of interaction that follow the rules of self-organization.

As companies access and strengthen entrepreneurial knowledge in the system they can enter a complex network of relationships that continuously inform them about new opportunities and knowledge for opportunities development and seizing, thus continuously adapting to new circumstances of engagement.

1.3. Open innovation as a form of co-creation

Open innovation has become a new paradigm for organizing distributed knowledge sources toward innovation (Bogers et al., 2018; Chesbrough & Bogers, 2014). One reason why open innovation is so relevant in today's economy refers to the uncertain dynamics of growth of productivity and prosperity. If over the last century productivity and prosperity depended on linear dynamics of interaction between production and consumption systems, i.e., mass production and consumption, the 21st century opened up a panorama where production and consumption standards are continuously disrupted (Whitney, 2015). Consequently, many companies find it challenging to satisfy market demand by only relying on their knowledge base. When the knowledge base of many companies becomes inadequate to develop new products, open innovation defines a paradigm for expanding companies' knowledge base.

In entrepreneurial ecosystems, it is widely acknowledged that companies expand their knowledge base by engaging with the diverse set of stakeholders available at the system level, as stakeholders' entrepreneurial knowledge is perceived as fundamental for developing new products. Therefore, new product development in entrepreneurial ecosystems relies on stakeholders engagement. The expression "stakeholder engagement" derives from management and marketing fields, where the term "stakeholder" emerges from the stakeholder theory (R. E. Freeman, 1984), and the term "engagement" deals with interactions, solutions development, or co-creation processes (e.g., see V. Kumar & Pansari, 2016).

Loureiro et al. (2020) summarize that although the business literature lacks consensus in defining engagement, two tenets emerge consistently. First, engagement exists around a focal object or activity. Second, engagement takes place in a relational or interactive context. These two tenets harmonize with two underlying assumptions of the entrepreneurial ecosystems theory: (i) the joint effort of ecosystems' participants in supporting the development of entrepreneurial activity and (ii) the relational or interactive process that defines entrepreneurial ecosystems. The former considers collaboration between stakeholders over entrepreneurial projects development. The latter relates to the necessary social dimension of interaction for effectively enabling and developing entrepreneurial projects.

Interaction and collaboration concern co-creation as much as open innovation as both concepts rely on stakeholder engagement to create value. Nevertheless, Loureiro et al. (2020) describe that co-creation traditionally involves specific company-stakeholders relationships, while open innovation concerns active collaboration among different organizations or groups of stakeholders. Furthermore, if open innovation focuses on the single co-innovation process, co-creation can also involve co-design or co-production, among others. Although the two concepts differ somewhat, the shift of co-creation as a process that focuses from the firm-level level to the system level has blurred the boundaries. Over the last decade, several authors have explored social relationships and systemic processes (e.g., see Drummond et al., 2018; Torvinen & Ulkuniemi, 2016) and focused their research on interaction and collaboration between several stakeholders. Consistently, co-creating through the engagement of several stakeholders has led to the consideration that open innovation is a particular form of co-creation.

The practice perspective on open innovation

Chesbrough (2003b) describes open innovation as a process where knowledge flows across a company's boundary through inbound (or outside-in) and outbound (or inside-out) mechanisms. Following Gassmann and Enkel (2004), a third mechanism, namely coupled, has been added to the open innovation research and combines inbound and outbound mechanisms. Therefore, by enacting one or more types of open innovation, companies manage knowledge inflows and outflows across their boundaries. Whereas the adoption of one mechanism over the others influences strategic decisions in terms of development and/or commercialization of an innovation (Bogers, 2012; Chesbrough & Bogers, 2014), they all depend on practices of boundary spanning to searching for the valuable knowledge to be engaged over the process (Chesbrough, 2003a).

This research focuses on open innovation under the practice rather than on the process perspective of innovation as entrepreneurial ecosystems primarily focus on companies' actions toward resources access and connections strength (Spigel & Harrison, 2018). Under this lens, open innovation as a set of practices defines companies' actions when searching for helpful knowledge concerns dealing with the current highly fragmented scenario of knowledge. When multiple sources of expertise need to be combined and integrated to develop new products and innovate, companies need to possess the capability to leverage boundary-spanning practices within and across organizations.

This capability has for long been recognized as a critical competitive dimension of companies in the knowledge economy (Kogut & Zander, 1992). Lindgren et al. (2008) review the two main theoretical perspectives on the boundary-spanning capability from the innovation literature and the work practice literature. While the innovation literature refers to boundary-spanning as an information-gathering activity essential to competitive advantage, the work-practice literature refers to it as a sense-making activity for innovating through learning. Indeed, if the former is related to a company's solid absorptive capacity (Cohen & Levinthal, 1990), the latter emphasizes the ability of a company to acquire, interpret, and meaningfully use contextual knowledge (i.e., see Balogun et al., 2005; Carlile, 2002).

Although the classification of boundary-spanning practices in terms of different literature streams provides different perspectives that inform the topic, it presents two main limitations when companies need to span boundaries in the context of entrepreneurial ecosystems. First, absorptive capacity aims to strengthen internal competencies for new product development (Cohen & Levinthal, 1990) rather than strengthen the ecosystem connections. Second, contextual knowledge acquisition, interpretation, and use happen across the internal boundaries of the company (Balogun et al., 2005) rather than across its external borders.

Recently, Lopez-Vega et al. (2016) focus on defining the boundary-spanning dimensions of knowledge search in open innovation. In their study, the authors describe how companies search for external knowledge by specifying how they collect and use data in evaluating alternatives when making decisions. Therefore, understanding how companies search for new knowledge in open innovation is better understood by classifying boundary-spanning in terms of heuristics. Lopez-Vega et al. (2016) define an experiential dimension and a cognitive dimension or learning-before-doing of searching heuristics. Pisano (1994) refers to the experiential dimension as learning by doing processes. Hence, data are collected in the form of direct feedback to inform actions. Conversely, the cognitive dimension or learning-before-doing (G. Pisano, 1994) entails using abstractions and representations to collect feed-forward information.

Heuristics search classification does not include nor exclude specific characteristics of entrepreneurial ecosystems. However, it is straightforward in describing the dimensions under which direct the search for external knowledge. For these reasons, it was deemed relevant for classifying design capabilities under specific dimensions of heuristics search that can potentially support the satisfaction of entrepreneurial ecosystems' capabilities finalities.

Table 1. 2 summarizes the different kinds of classification of boundary-spanning practices over the literature.

BOUNDARY-SPANNING PRACTICES			
CLASSIFICATION BASED ON THEORETICAL PERSPECTIVES Lindgren et al. (2008)		CLASSIFICATION BASED ON HEURISTICS SEARCH Lopez-Vega et al. (2016)	
INNOVATION (i.e., see Cohen & Levinthal 1990) Boundary-spanning as an information-gathering activity related to absorptive capacity for the company's competitive advantage	WORK PRACTICE (i.e., see Carlile 2002) Boundary-spanning as an acquisition, interpretation and meaningful use of contextual knowledge across the internal boundaries of the company	EXPERIENTIAL SEARCH (i.e., see Pisano 1994) Boundary-spanning as learning by doing that inform actions through direct feedback data collection	COGNITIVE SEARCH (i.e., see Pisano 1994) Boundary-spanning as learning-before-doing that inform actions through feed-forward information collection

Table 1. 2 Summary of boundary-spanning practices' classification criteria

1.4. An issue of relational capabilities

Why capabilities

The main body of research on the concept of the entrepreneurial ecosystem is primarily related to the identification of entrepreneurial ecosystems attributes and their interconnection outputs (see D. J. Isenberg, 2011; Mason & Brown, 2014; Stam & Spigel, 2017). When entrepreneurial ecosystems research investigates the dynamics that support the development of entrepreneurial activity, a macro-perspective on the resources that support entrepreneurship is taken into account. Specifically, researchers focus on exploring and validating new methods that lead to identifying strengths and weaknesses of entrepreneurial ecosystems (e.g., see Stam, 2015; World Economic Forum, 2013). Although new methods of inquiry expand the discussion on how the attributes of entrepreneurial ecosystems make an ecosystem successful through macro-level interactions, Spigel (2017b) emphasizes that the fundamental driving force toward entrepreneurship is defined by the companies' abilities to access and strengthen system-level entrepreneurial knowledge.

The bottom-up perspective of entrepreneurial ecosystems is a recent approach to investigating entrepreneurship in entrepreneurial ecosystems (Spigel, 2018). As companies' abilities enable entrepreneurship through entrepreneurial knowledge interactions, entrepreneurial ecosystems emerge. Roundy and Fayard (2019) highlight that companies pursuing shared purposes of new product development through experiences, values, and goals exchange improve their ability to act entrepreneurially and to adapt to new opportunities that arise from fast-changing environments. Spigel (2017b) describes companies' entrepreneurial ability as engaging with other entrepreneurial actors and strengthening interdependence among them. Roundy (2020) defines interdependence as the degree to which participants' goals and tasks depend on each other. Hence by focusing on individual-level interaction behaviors, the bottom-up perspective of entrepreneurship can explain the evolution and development of entrepreneurial ecosystems.

Consequently, studies of entrepreneurial ecosystems that adopt a bottom-up approach of investigation rely on the complex adaptive systems theory as it focuses on the “microscopic interactions” at the individual level that have consequences on the macro-level (Holland, 2006; Levin, 2002). Therefore, entrepreneurial ecosystems as complex adaptive systems make entrepreneurship grow due to the participants' diverse and interdependent entrepreneurial knowledge interactions.

Under this perspective, the relational dimension of entrepreneurial ecosystems, in terms of connections between entrepreneurial actors, assumes a central role in studies that draw on a broader community perspective of the entrepreneurship process (Fredin & Lidén, 2020). Understanding the relational actions of collaboration is necessary for entrepreneurial ecosystems as if no relations exist between entrepreneurial actors an answer at the system level would lack.

The following section focuses on defining the interactional dimension of entrepreneurial ecosystems under the relational lens. The strong relational dimension of interaction in entrepreneurial ecosystems supports the definition of companies' capabilities for new product development through entrepreneurial ecosystems knowledge, in terms of superior skills that enable knowledge access and strength toward entrepreneurial ecosystems co-creation.

The relational dimension of interaction in EEs

The relational approach to entrepreneurship is strictly connected to a practice-based perspective (A. Jones, 2014), because the actions of entrepreneurial actors enable new entrepreneurial relations to emerge. When individual actors build relationships, entrepreneurship depends on the actors' relationship-building actions. Spigel (2017a) states that entrepreneurial actions of relationship-building are influenced by the type of capital that actors are intended to accumulate. Capital, or "the labor appropriated on an individual basis" (Spigel, 2017a, p. 6) has been described in economic (money), social (network resources), cultural (knowledge of social rules) and symbolic (prestige) terms (Bourdieu & Wacquant, 1992). Although entrepreneurship is traditionally defined as a form of economic capital that provide companies with profits, in entrepreneurial ecosystems the accumulation of economic capital is rarely perceived as the primary goal of participating companies.

Theodoraki et al. (2018) describe social capital as the primary enabler of entrepreneurial actors' actions in entrepreneurial ecosystems, because it supports sustainable entrepreneurship and *subsequent* economic prosperity and profit. Therefore, profitability in entrepreneurial ecosystems is perceived as a natural consequence of a strong social capital. Stam and Spigel (2017) define a strong social capital in terms of productive entrepreneurship, or the heterogeneous entrepreneurial relations of collaboration that continuously seed a fertile ground for new product development. Indeed, the main reason that moves profitability on the background of entrepreneurship is the long-term competitive advantage that companies gain from others actors assets once they create trust relationships through mutual support (Ratten, 2020).

The creation of trust relationships represents a fundamental driving force of entrepreneurship in entrepreneurial ecosystems as it leads to the strengthen of systems relationships in terms of complementarity. Therefore, investing in the relational dimension when accumulating social capital enhances complementarity. Theodoraki et al. (2018) defines complementarity as symbiotic and interdependent relationships among the ecosystem's members. Then, although interests of entrepreneurial actors might differ, they collaborate as their goals and tasks in specific new product development projects rely on other entrepreneurial actors.

When actors relationships are interdependent, each participant's perception about the value that each entrepreneurial actor brings to the project is explicit (Iansiti & Levien, 2004; J. F. Moore, 1993; Thomas & Autio, 2014). And when the value is explicit, participants can increase the level of technical and market knowledge that might be hard to obtain through diverse knowledge engagement (Godley et al., 2021; Ratten, 2020). Consequently, collaboration in entrepreneurial ecosystems strongly relies on a relational dimension of participation.

Fredin and Lidén (2020) describe that complex network of resources as entrepreneurial ecosystems guarantee productive entrepreneurship because network relations expand the knowledge basis of individual companies. Under this perspective, stakeholder engagement and co-creation both define relational interactions happening under an open innovation approach. The next section describe how open innovation is linked to co-creation when stakeholders engagement in entreprenurships is concerned.

1.5. The entrepreneurial capabilities for co-creation

The necessary conditions of NPD in entrepreneurial ecosystems

It is widely acknowledged that the process of creating new combinations of resources and competencies defines the fundamental essence of entrepreneurship. New combinations embed discrete activities that yield a well-specific output that is difficult to replicate due to the complexity of the combination dynamics (Auerswald, 2015). When the competitive advantage of firms depends on the ability to recombine competencies and resources, building complex relationships become an asset for competitiveness. In this context, the ability of companies to achieve new forms of competitive advantage through the combination of competencies and resources refers to dynamic capabilities (Teece et al., 1997).

Specifically, Teece (2007) describes dynamic capabilities as three sub-capabilities or dimensions that define the necessary actions to undertake over the entrepreneurial activity, namely sensing, seizing, and reconfiguring. When a new opportunity for new product development needs to be identified and shaped, sensing involves the ability to scan local and global markets, search and explore activities across markets, gather information to assess the customer's preferences, and capture employees' ideas. Then, seizing refers to mobilizing resources to address, and reconfiguring to notice the need for recombining current assets and enact the recombination. By combining external and internal resources over the three dimensions, companies participate in entrepreneurship development and economic growth.

Entrepreneurial ecosystems emphasize that entrepreneurship is a social activity, as entrepreneurs are dependent on a complex and interconnected community providing them the assets for identifying and pursuing opportunities. Therefore entrepreneurial activity in entrepreneurial ecosystems is strongly influenced by the ability of entrepreneurs to engage in actions of opportunity identification and construction through a multi-actor and social interface. Under this perspective, Roundy and Fayard (2019) define entrepreneurship in entrepreneurial ecosystems as necessarily depending on a company's ability to engage with the ecosystem actors by employing dynamic capabilities. Specifically, the authors describe the dimensions of dynamic capabilities, namely sensing, seizing, and reconfiguring (Teece, 2007), in the form of the necessary activities to be performed in the social context of entrepreneurial ecosystems toward entrepreneurship. Interestingly, although dynamic capabilities are widely acknowledged within the entrepreneurship literature as a beneficial activity for gaining competitive advantage through external assets, Roundy and Fayard (2019) first introduced this topic under a relational lens of engagement. Hence, dynamic capabilities relate to entrepreneurship in entrepreneurial ecosystems in terms of the relational activities to be performed by engaging system-level competencies and resources.

System-level competencies and resources in entrepreneurial ecosystems can provide different types of support, as they are composed of a heterogeneous group of stakeholders. When entrepreneurial activity in entrepreneurial ecosystems results from interacting with diverse stakeholders, stakeholders and relational engagement activities are different for sensing, seizing, and reconfiguring. The main contribution by Roundy and Fayard (2019) is providing a classification of the ecosystem stakeholders supporting entrepreneurs' activities within each dimension of sensing, seizing, and reconfiguring. Then, the awareness of the different kinds of support available in an entrepreneurial ecosystem allowed the authors to describe the engagement activities to be performed by entrepreneurs within each dynamic capabilities dimension. Their work leads to a deeper understanding of the micro-interactions that can drive entrepreneurial activity in entrepreneurial ecosystems, thus providing the basis for deepening the research investigation under a bottom-up perspective of entrepreneurship. Table 1. 3 summarizes the classification of entrepreneurial ecosystems stakeholders and the engagement activities of companies when engaging with them over the three dimensions of dynamic capabilities, as described by Roundy and Fayard (2019).

An entrepreneurial ecosystem is described by the process of engagement and interaction between multiple and diverse stakeholders. By focusing on the companies perspective, engagement actions over the sensing dimension involve the following stakeholders:

- Entrepreneurs
- Other companies
- Local consumers
- Universities
- Incubators

Engaging with entrepreneurs and other companies allows companies to access the entrepreneurship human capital toward opportunity identification and assessment. For this purpose, companies participate in professional associations where formal and informal meetings allow them to engage in entrepreneurship. By interacting with the human capital of entrepreneurial ecosystems, companies share common values and participate in creating an entrepreneurship-oriented community for opportunity search. Another benefit of engaging with the stakeholders of entrepreneurial ecosystems refers to the possibility of learning to perform entrepreneurial tasks faster and with greater accuracy. By observing other companies' actions through direct and indirect observations, companies can learn from others' successes and failures. Furthermore, companies can engage with universities and incubators to seek information on changing technologies and consumer demands. For this purpose, the deep connectedness of entrepreneurial ecosystems stakeholders allows companies to access easily local consumers for gaining direct feedback on new products and services.

When companies need to seize opportunities through entrepreneurial ecosystems stakeholders, they can engage with stakeholders such as:

- Entrepreneurs
- Other companies
- Accelerators
- Mentors
- Investors

Companies can interact with accelerators that mainly support companies by connecting them to resource providers, such as investors, which can provide financial resources. Given the high number of start-ups characterizing entrepreneurial ecosystems, companies can easily engage with mentors who can offer them entrepreneurship human capital, like entrepreneurs and other companies, to create and scale identified opportunities.

Once opportunities are sensed and then seized, companies need to continually renew and reconfigure their resources and competencies in response to signals from their shifting environment. For this purpose, entrepreneurial ecosystems can provide helpful support when companies engage with:

- Lead users
- Entrepreneurs

During reconfiguration, companies can sense signals of change by involving lead users of innovation such as ventures based on "leading edge" technologies that can provide feedback on changes in technologies and consumer preferences and demand (Roundy & Fayard, 2019). Companies organize market tests to gain feedbacks from lead users. Furthermore, in EEs, many entrepreneurs create businesses across numerous industrial sectors that can inform directions for change. By engaging in activities of business experimentation in the form of workshops, companies take advantage of the experience of other entrepreneurs that initiated early-stage ventures.

DIMENSIONS OF DYNAMIC CAPABILITIES	INVOLVED STAKEHOLDERS	COMPANIES ENGAGEMENT ACTIONS
SENSING	Entrepreneurs	Participating in professional associations for sharing common values
	Other companies	Participating in professional associations for sharing common values; Observing successes and failures
	Local consumers	Gaining feedback on new products and services
	Universities	Seek information on changing technologies and consumer demands
	Incubators	Seek information on changing technologies and consumer demands
SEIZING	Entrepreneurs	Participating in dedicated events for accessing entrepreneurial resources
	Other companies	Participating in dedicated events for accessing entrepreneurial resources
	Accelerators	Participating in dedicated events for accessing financial and human capital
	Mentors	Participating in development programs for scaling opportunities
	Inverstors	Participating in dedicated events for accessing financial resources
RECONFIGURING	Lead users	Organizing market tests for gaining feedback on technological changes and consumer preferences
	Entrepreneurs	Organizing workshops for business configuration experimentations

Table 1. 3 Summary of stakeholders participating in entrepreneurial ecosystems for each dynamic capabilities' dimension and related enabled engagement actions for companies (elaborated from Roundy and Fayard, 2019).

Collaboration: accessing and strengthening entrepreneurial knowledge

While sensing, seizing, and reconfiguring represent the necessary dimensions enabling entrepreneurship in entrepreneurial ecosystems, the ability of companies to access the ecosystem resources and strengthen relationships for increasing network connections constitutes a fundamental driving force. Spigel (2017b) emphasizes that companies in entrepreneurial ecosystems access the resources held within the ecosystem to take advantage of their entrepreneurial knowledge and resources toward opportunity identification. Therefore, companies need to be able to access the network of stakeholders of the entrepreneurial ecosystems if they want to sense new opportunities. Nonetheless, strengthening network connections allows companies to build and attract new resources toward resource mobilization. Consequently, companies need to be able to strengthen network connections so that they can seize opportunities. By continuously accessing and strengthening ecosystems resources, companies improve their reconfiguring ability. Hence, companies develop new products and stay competitive by collaborating with the resources of entrepreneurial ecosystems over accessing and strengthening activities. Table 1. 4 summarizes capabilities for collaboration in entrepreneurial ecosystems over the sensing, seizing, and reconfiguring dimensions.

Sensing through entrepreneurial ecosystems: accessing resources

Accessing ecosystems resources for sensing new opportunities implies companies embracing the entrepreneurial ecosystem's culture: adopting the ecosystem's "simple rules" (Roundy, 2020). Simple rules in entrepreneurial ecosystems, such as "give to the ecosystem before taking," mean that interactions between participants must show mutual interest in support entrepreneurship through activities of collaboration. Therefore, sensing opportunities through entrepreneurial ecosystems require companies to be recognized as legitimated by the entrepreneurial community for accessing helpful resources. For this purpose, companies must be able to *building legitimacy*. Building legitimacy in entrepreneurial ecosystems is the ability to communicate business narratives persuasively to establish the company's action legitimacy when accessing resources within the entrepreneurial community (Spigel, 2017b). Narratives are described as having a determining role for companies to capture attention, influence the cognitive and emotional encoding of information, and be memorable (D. J. Isenberg, 2016; Roundy & Bayer, 2019; Spigel, 2017b). Companies perform building legitimacy capability by sharing common intentions and narratives about entrepreneurship (i.e., success stories, historical accounts, future-oriented narratives). These activities support companies in being accepted by the entrepreneurial community.

While building legitimacy enables companies to access entrepreneurial ecosystems resources, *transactive memory* aspires to create new knowledge from collaboration (Zahra, 2015). Transactive memory is the ability to discover connections between the company-owned knowledge and other stakeholders' knowledge (Roundy, 2020). When companies know who in the entrepreneurial ecosystem can supplement their knowledge gaps, they can engage in collaboration activities for implementing the identified opportunity. Konczal and Motoyama (2013) emphasize that programs and events offered in entrepreneurial ecosystems can support companies in acquiring knowledge about other participants' skills, capabilities, and experiences. For this purpose, companies participate in formal and informal interactions during entrepreneurship-oriented events in which participants develop business ideas.

Sensing through entrepreneurial ecosystems depends on searching and learning through the diversity of available stakeholders (Roundy & Fayard, 2019). While storytelling and transactive memory enable companies to search for new opportunities, *vicarious learning* is the ability to learn from other entrepreneurs' actions and mature organizations in the ecosystem (Roundy, 2020; Roundy & Fayard, 2019; Spigel, 2017b). Therefore, companies can access entrepreneurial ecosystems resources by observing other's actions. Through direct and indirect observations of success stories and others' failures, companies learn about the identified opportunity's next moves. Furthermore, companies observe local customers gaining rapid feedback about the identified opportunity and collect insights about customer needs.

Building legitimacy, transactive memory, and vicarious learning drive entrepreneurial ecosystem resources access when sensing opportunities are required. As described, these capabilities entail engagement and collaboration activities. Hence, collaboration drives and enables sensing opportunities in entrepreneurial ecosystems.

Seizing through entrepreneurial ecosystems: strengthening network connections

If accessing resources of entrepreneurial ecosystems rely on storytelling, transactive memory, and vicarious learning capabilities for sensing, strengthening network connections draw on capabilities that enable the mobilization of resources to address and develop opportunities. Among these, *proactiveness*, the ability to mediate among the claims of one group and those of other groups (Feldman & Zoller, 2012), aims to promote entrepreneurial action. Therefore, companies favor the development and strength of connections by assuming a mediation role between diverse entrepreneurial ecosystems stakeholders (Lyons et al., 2012). Mediation is generally performed by managing events in which the sharing of expertise, information, and resources happens among entrepreneurs and investors to foster collaboration.

In this context, companies can also act as mentors to early-stage entrepreneurs. *Mentoring* is the ability to encourage and legitimize entrepreneurial endeavors (Spigel, 2017a). Companies offer entrepreneurs their direct advice and their access to social networks by providing them feedback on assumptions and expectations and communicating about possible directions for successful new product development. Moreover, companies organize exploratory meetings between entrepreneurs and other ecosystem stakeholders to establish new relationships (Bosma et al., 2011). Therefore, companies that employ mentoring can foster network connections through learning.

Within a context of diversity, as entrepreneurial ecosystems are, the *framing diversity* capability aims to establish a "collaborative advantage" among different organizations, as powerful organizations refuse to relinquish some of their power. When collaboration represents a powerful approach to enact for network strength, and some organizations perceive collaboration as self-defeating, the ability to frame diversity supports the common understanding of the advantages of collaboration. Lyons et al., (2012) define framing diversity as the companies' ability to articulate a multi-frame perspective towards productive collaboration. By framing the diversity of interests and fostering a common understanding among organizations within dedicated events, such as business experimentation workshops (Roundy, 2020), companies favor deals and partnerships that can mobilize collective action.

If different interests and perspectives can find an alignment through framing diversity, the capability of *interactive expertise* supports the interaction dynamics toward productive collaboration. Roundy (2020) defines interactive expertise in entrepreneurial ecosystems as the ability to understand specialized languages or professions without practicing them. Although the concept is not new within cognitive studies (i.e., see Collins, 2004), it has been applied only recently in the context of ecosystems (Bhawe & Zahra, 2019; Roundy, 2020). In entrepreneurial ecosystems, companies perform activities of interpretation and negotiation toward the framing of a shared vision.

These arguments suggest that successful seizing activities in entrepreneurial ecosystems depend on the ability of entrepreneurial companies to build and attract new resources to the ecosystem and support the development of a common purpose.

Therefore, seizing opportunities in entrepreneurial ecosystems rely on the proactiveness, mentoring, framing diversity, and interactive expertise of a company. The finalities of these capabilities involve activities of collaboration that lead to effective network strength when carried out. Hence, collaboration drives and enables seizing opportunities in entrepreneurial ecosystems.

Reconfiguring through entrepreneurial ecosystems: accessing resources and strengthening network connections

Within a context of rapid changes, companies must respond to signals from their shifting environments; existing resources and capabilities become less valuable as competitors replicate them and market shifts (Teece et al., 1997). During reconfiguration, companies in entrepreneurial ecosystems sense signals of change by involving lead users of innovation such as ventures based on "leading edge" technologies that can provide feedback on changes in technologies and consumer preferences and demand (Roundy & Fayard, 2019). Furthermore, in entrepreneurial ecosystems, many entrepreneurs create businesses across numerous industrial sectors that can inform directions for change (Spigel & Harrison, 2018). In this context, vicarious learning through direct and indirect observations of nearby venture activities encourages identifying and combining new components for new product development. If vicarious learning allows for sensing initial opportunities as described before, it supports the *reflectiveness* of entrepreneurial companies' actions when reconfiguring is needed. The ability to evaluate and critique the effectiveness of own actions through the redefinition of action-oriented mental maps of a situation represents a fundamental capability of companies when signals of change towards reconfiguration have been noticed (Feldman & Zoller, 2012; Lyons et al., 2012; Spigel, 2017b).

Once the need for reconfiguration has been noticed, companies must implement new configurations (Roundy & Fayard, 2019). In entrepreneurial ecosystems, the reconfiguration of activities is often enacted by engaging with other local entrepreneurs experienced in early-stage business implementation. As for seizing activities, the development of new configurations requires entrepreneurial companies to engage with entrepreneurial ecosystems participants towards new common-purpose development through proactiveness, framing diversity, transactive memory, and interactive expertise. This allows entrepreneurial companies to question conventional practices and push the limits to expand the opportunity pool for themselves and the community.

COLLABORATION IN ENTREPRENEURIAL ECOSYSTEMS	CAPABILITY	DEFINITION	CAPABILITY FINALITY	OBSERVABLE ITEMS	AUTHORS
ACCESSING RESOURCES FOR SENSING	Storytelling	The ability of a company to communicate business narratives persuasively	Establishing company's legitimacy	Sharing success stories; Sharing historical accounts; Sharing future-oriented narratives	Isenberg, 2016; Roundy & Bayer, 2019; Spigel, 2017b
	Transactive memory	The ability of a company to discover connections between the company-owned knowledge and other stakeholders' knowledge	Identifying useful knowledge	Participating to entrepreneurship-oriented events	Roundy 2020; Zahra, 2015
	Vicarious learning	The ability of a company to learn from other entrepreneurs' actions and mature organizations in the ecosystem	Entrepreneurial learning	Direct/indirect observations of success and failure stories; Direct/indirect observations of local customers	Roundy, 2020; Roundy & Fayard, 2019; Spigel, 2017b
STRENGTHENING NETWORK CONNECTIONS FOR SEIZING	Proactiveness	The ability of a company to mediate among the claims of one group and those of other groups	Fostering collaboration between entrepreneurs and investors	Managing knowledge sharing events	Feldman & Zoller, 2012 Lyons et al., 2012
	Mentoring	The ability of a company to encourage and legitimize entrepreneurial endeavors	Offering entrepreneurial learning	Providing direct advice; Organizing exploratory meetings	Bosma et al., 2011; Spigel, 2017a
	Framing diversity	The ability of a company to articulate a multi-frame perspective	Establishing productive collaboration	Establishing partnerships and deals	Lyons et al., 2012; Roundy 2020
	Interactive expertise	The ability of a company to understand specialized languages or professions without practicing them	Recognising and working with what matters for others	Organizing business experimentation workshops	Bhawe and Zahra 2019; Roundy 2020
ACCESSING RESOURCES AND STRENGTHENING NETWORK CONNECTIONS FOR RECONFIGURING	Reflectiveness	The ability to evaluate and critique the effectiveness of own actions	Sensing and respond to signals of change	Gaining feedbacks from lead users; Organizing business experiments with entrepreneurs	Feldman & Zoller, 2012; Lyons et al., 2012; Spigel, 2017b

Summary of entrepreneurial ecosystems capabilities for new product development

2. THE ENTREPRENEURIAL ECOSYSTEMS GAP IN DESIGN

2.1. New product development in local contexts of participation

The design role in local production systems

In the 19th and early 20th centuries, a significant part of industrial dynamics for product development has relied on agglomerations of small and medium-sized firms specialized in different production and distribution cycles to develop innovative products, namely industrial districts (Belussi & Sedita, 2019). The industrial districts' literature widely acknowledges the social dimension of local production systems as the primary enabler of productive interactions for new product development (e.g., see Becattini, 2002; Morosini, 2004). Camuffo and Grandinetti (2011) describe social relationships as the primary promoter of higher efficiency as informal participation and cooperation allowed for cost-saving in new product development. Therefore, knowledge spillovers, co-located creativity, and the collective development of innovations allowed companies to improve their competitive performance toward the efficiency of the industry they belonged to. Furthermore, as sociological contributions on industrial clusters emphasize (e.g., see Granovetter, 2018; Uzzi, 1997), the embeddedness of the social structure in local production systems, namely the informal ties and personal relationships, supported the development of superior products as it drawn on tacit knowledge exchange. When tacit knowledge exchange allows for developing products that are hard to replicate, it represents a competitive advantage for companies (Benkler, 2008). Hence, the social structure of local production systems enables superior new product development due to interfirm informal relationships of knowledge sharing and exchange.

While the industrial clusters literature acknowledges that competitive new product development depends on relationship-building activities, from a design perspective, informal social relations enable the development of new products as they can inform new business directions. Therefore, design participates in new product development through “a process of interactive construction that tries to reach the precise scope of shaping a new artifact” (Maffei & Zurlo, 2000). In these terms, design in industrial districts primarily supports new product development by synthesizing and codifying technical and market knolwedge. Bertola and Teixeira (2003) define the design capabilities of outsourcing in contexts of informal knowledge circulation as a main competitive advantage for companies participating in industrial districts. Indeed, the codification and synthesis of external users’ and network companies' knowledge allowed companies to define new trajectories for their business that eventually led to collaborative actions in new product development.

While design absorbs knowledge embedded in communities and industrial networks, it can mediate between the company's internal scope of shaping a product and the territorial context (Celaschi et al., 2009). As Deserti and Zurlo (2011) emphasize, the main contribution of design capabilities to distributed and interactive dimensions of local production systems concerns the ability to interpret the external users' knowledge and the company’s needs. By closely interacting with the companies’ entrepreneurs and communicating with heterogeneous stakeholders due to empathy and visual communication skills, design supports the realization of companies’ intents in a context of interactive knowledge.

Although design research in industrial districts expanded the contribution of competitive design capabilities to interactive local contexts of new product development, the focus of the investigation primarily informs innovation processes. Because companies in local production systems rely on sharing technical and market knowledge to shaping new technological opportunities (Schilling, 2010), design provides a strategic contribution when dealing with the market kind of knowledge required to develop new products. Consequently, in local production systems, the competitive capabilities of design mainly provide new business directions, while new product development refers to functional design capabilities aiming to solve technical issues (Deserti & Zurlo, 2011).

Acquiring superior market knowledge represents a wellspring of entrepreneurial innovation in local production systems, and many successful design-led companies rely on this. As the design of innovative products facilitates the emergence of dominant designs within an industry, innovation processes are fostered until the focus of competition shifts from design to manufacturing and the focus of innovation from product innovation to process innovation (Schilling, 2010). However, when technologies advance fast, the dynamics of consumption may embrace major changes faster than the reaction of the production system (Porter & Kramer, 2011; Whitney, 2015). Consequently, manufacturing companies might find it challenging to innovate and compete when standards are constantly being disrupted.

As the design research in the context of industrial districts explains, design capabilities for superior new product development intervene at the network level as they mediate companies' and network knowledge toward new business directions for the company. Although entrepreneurial network-level interventions also distinguish entrepreneurial ecosystems, two main differences are highlighted. First, network-level interventions in entrepreneurial ecosystems focus on accessing and strengthening *entrepreneurial knowledge* (i.e., knowledge about the entrepreneurial process). Second, network-level interventions in entrepreneurial ecosystems generate a *network-level output* that benefits ecosystems' members (i.e., systemic entrepreneurial activity).

From this perspective, the entrepreneurial ecosystems theory distinguishes the role of innovation in local contexts of entrepreneurship. Innovation moves from being the enabler of superior product development to representing the outcome that eventually results from entrepreneurial knowledge access and strength over new product development (Stam & Spigel, 2017). Consequently, new product development represents the ability of companies to access and strengthen dispersed entrepreneurial knowledge that informs the sensing of new opportunities, the mobilization of the required resources, and the eventual reconfiguration of internal capabilities (Roundy, 2020; Roundy & Fayard, 2019; Spigel & Harrison, 2018). This makes new product development a process focusing on enabling a social entrepreneurial structure to emerge from relationship-building activities in distributed and interactive production and consumption systems rather than the consequence of innovation practices.

NPD as matters of concern

As far as entrepreneurial ecosystems theory defines new product development as a relationship-building activity leading to a network-level output, it becomes relevant to understand the relational perspective of design in new product development.

The network-level output of entrepreneurial ecosystems, namely entrepreneurial activity, can be defined as the "product" enabled by the ability of companies to engage with entrepreneurial knowledge in the system. Therefore, relationship-building activities can be considered both the precondition and the result of new product development. Although the traditional meaning of product refers to the fundamental transaction that the company has with its customers (e.g., see Dibb et al., 2005; Eppinger & Ulrich, 2015; Kotler & Armstrong, 2010), Margolin (1995) defines products as "the human-made material and immaterial objects, activities and services, and complex systems or environments that constitute the domain of the artificial." Under this perspective, Krippendorf (2011) describes the design activity of new product development as morphing into the design of communicative and social artifacts.

Consequently, products reflect the active participatory dimension of new product development in network contexts.

Participation represents a defining trait of participatory design. A central argument of participatory design is the active involvement of users over the design process through the interaction with several artifacts (i.e., see Simonsen & Robertson, 2012). Therefore, participatory design strongly relies on users' agency on the participation outputs. While co-designing, designers facilitate users in developing new products that will reflect innovative characteristics deriving from multiple perspectives considerations (Sanders & Stappers, 2008). By focusing on specific design activities, users and designers develop new products that meet the future experiences of people and communities (Halskov & Hansen, 2015).

Whereas co-design projects intervene on specific instances of design events by drawing on users' agency, several authors find the intersection between participatory design and actor-network theory necessary for defining participation in complex socio-technical systems (i.e., see L. B. Andersen et al., 2015; Storni et al., 2015). As Latour (2005) outlines, participation derives from multi-actor interactions, thus moving agency from individual users to the interferences between actors. Furthermore, objects take shape and transform through and by various practices of which they are part. Therefore, according to actor-network theory, participation represents what Latour calls "matters of concern" (Latour, 2004). Consequently, objects underly a sociotechnical gathering of complementary knowledge that enables the product to emerge and become through actors' interactions (Storni, 2012).

The study by Halskov and Hansen (2015) investigates contemporary participatory design research. Their investigation reveals that design focuses on "moments" where clear human intentions constrain skills, practices, activities, and infrastructures. Therefore, participatory design observations are traditionally conducted when participatory elements are already largely established. By expanding the discussion on this point, Storni (2012) describes what lies behind an artifact and how and why it gets its final shape. By stating that the design process refers both to designing artifacts and subjects (i.e., the network of relations that sustains practices and knowledge), the author introduces the notion of "thing." A thing means the gathering of heterogeneous elements and a problematic concern in process of definition.

Consequently, the realization of things always concerns an interdefinition or co-construction, and skills, practices, activities, and infrastructures are the outcome of the process, not the causes. As Latour emphasizes: "Action is not done under the full control of consciousness; action should rather be felt as a node, a knot, and a conglomerate of many surprising sets of agencies that have to be slowly disentangled [...] Action is overtaken or […] Action is other-taken! So it is taken up by others and shared with the masses. It is mysteriously carried out and at the same time distributed to others. We are not alone in the world. 'We', like 'I' is a wasp's nest" (Latour, 2005, pp. 44–45).

In entrepreneurial ecosystems, participation leads to the emergence of entrepreneurial activity, here defined as the "product" of entrepreneurial ecosystems. Therefore, coherently with the actor-network theory, agency represents a network effect. Indeed, companies participating in entrepreneurial ecosystems lack full control of the actions needed when developing new products (i.e., building relationships). Specifically, and coherently with Storni's definition of thing (Storni, 2012), the reason why different actors gather reflects the initial more or less commitment to defining or solving a problem. In entrepreneurial ecosystems, commitment emerge when actors share an interest in adopting the ecosystem's "simple rules" of mutual entrepreneurial support (Roundy, 2020). Furthermore, the reason why actors gather is multiple as they display different organizational interests, goals, and backgrounds in the shared goal (e.g., improving the ecosystem community through entrepreneurial activity). Consequently, the reason for gathering unfolds accordingly with the endless directions that depend on the actors' heterogeneity.

By intersecting participatory design and actor-network theory, the design research provides a different perspective on participation resulting from a distributed, heterogeneous, and relational process (L. B. Andersen et al., 2015). Considering participation as matters of concern rather than an action caused by users’ intentionality supports the definition of new product development in entrepreneurial ecosystems. Indeed, new products derive from the emergence of a socio-technical system that provides the social structure enabling knowledge interactions. Hence, new product development as a relationship-building activity can be afforded by design when design intervention considers the complementary gathering of entrepreneurial knowledge as the fundamental definition of participation.

The next section focuses on the current positioning and definition of design capabilities for new product development in manufacturing, as described in the design literature.

2.2. Situating design capabilities for new product development

Situating design as an investment for competitive advantage

Companies invest in design as design contributes to companies’ competitive advantage. Dong et al. (2021) emphasize that competitive advantage exists when companies adopt and deploy design resources and skills to create more economic value than their competitors can replicate. Therefore, design is recognized as a competitive factor toward companies’ profitability. In this context, design is described to be able to provide companies with superior economic profits by supporting strategic renewal (Cooper & Press, 1995; Ravasi & Lojacono, 2005), creating products differentiation from competitors (Desay et al., 2001; Verganti, 2009), and opening new market opportunities (Capaldo, 2007).

Stevens and Moultrie (2011) summarize that design contributes to companies competitiveness by driving competitive forces of market differentiation and customer value perception; supporting value creation and strategic fit by integrating and mediating between professional domains; shaping and communicating strategic vision by achieving a holistic view of complex systems; exploring uncertainty through prototyping and visualization, and providing an innovative perspective by challenging assumptions. Therefore, design can synthesize and manifest distributed and diverse knowledge within and outside an organization.

In the business context, the design ability to manage complex flows of knowledge for developing new products started to be recognized as an asset for companies’ competitive advantage as it could bring economic profits by satisfying consumers' needs. Martin (2009, p. 6) asserts that companies that “balance analytical mastery and intuitive originality in a dynamic interplay that I call design thinking…will gain a nearly inexhaustible, long-term business advantage." When companies own design resources and deploy design skills, they generate superior profits above the average for the industry. Although design became a competitive resource in companies starting from the 70s, its contribution to profitability became consistent since the 90s. Indeed, the design role moved from the primary aesthetic driver for the products' form differentiation (Creusen & Schoormans, 2005) to a strategic lever that could anticipate evolving consumers' needs (Swan et al., 2005). Hence, in a historical period where mass production and consumption dynamics were triggered by rapid social, economic, and technological changes, design became a valuable asset for solving companies' problems toward competitive advantage.

Whitney (2015) describes how companies over the last century dramatically acquired expertise in making things (i.e., core capabilities) and using new business models, thus providing consumers with an increased variety of products. Therefore, the increased consumers' possibilities of choice caused a high degree of uncertainty in companies about what to develop. The author defines the "innovation gap" (Whitney, 2015, p. 14) as the divergence between a company's core capabilities and business models and its knowledge about the consumers' daily lives. If on the one hand companies managed to have a higher range of solutions for satisfying consumers' desires, on the other, they increased the consumers' need for variety. Hence, companies started facing new problems related to understanding what could reflect consumers' daily lives and thus satisfy their needs.

Kumar and Whitney (2007) emphasize that the main barrier for companies to delighting consumers resides in companies doing market research by focusing on current offerings as the starting point. When current offerings are defined by product, distribution, promotion, and price, they consider the consumer just in the price dimension. Although selling offers at a competitive market price was the main differentiator between successful and ruined companies over the mass production and consumption age (e.g., see Schrager, 2019), it became evident that the industrial paradigm shift toward customization required updated perspectives on how to deliver superior customer value.

In this context, design provided valuable support in solving consumer-centered problems as it brought a different perspective on what a company's offering needs to be. Therefore, for a product to succeed, it would have been useful, usable, and desirable at the same time. For this purpose, Sanders (1992) proposed that integrating knowledge from different fields could support the designers' understanding of users' needs. By introducing the user-centered approach, design developed new tools and methods that integrated diverse knowledge for new product development with the consumer as the primary subject of the design activity (Sanders & Stappers, 2008).

Hence, with design expanding its methods and skills in holistic ways of engaging diverse knowledge for new product development, new consumer engagement paradigms emerged. Human-centered design (i.e., see Buchanan, 2001b), participatory design (i.e., see Sanders & Stappers, 2008), and design thinking (i.e., see Brown, 2009; Martin, 2009) represent an evolution from the linear user-centered approach to a more complex interactive approach of designing new products. By drawing on learning from the interaction with the final users, design can converge learnings into superior products. Consequently, companies moved their strategies from product-oriented to consumer-centered by deploying design resources and skills that synthesize and manifest a wider set of interactions into new valuable products.

Design capabilities for superior product development

The product development literature frequently reports that the competitive success of companies depends on companies' level of efficiency. Therefore productivity and profitability represent the main factors that define companies' competitiveness within an industry. In this context, the success of a product is often measured through company performance variables such as sales, quality, brand development, innovativeness, speed-to-market, and profit (e.g., see Dell'Era & Verganti, 2007; Luchs & Swan, 2011; W. L. Moore et al., 1999; Swan et al., 2005). By focusing on firm-level measures of performance, companies develop and deploy design capabilities allowing for increasing their productivity and profitability.

Under this perspective, Swan et al. (2005) classify four design capabilities that positively influence a company's performance level. The "robust design capabilities," namely functional, aesthetic, technological, and quality-based, allow companies to succeed under changing circumstances as they enable the design of products with similar technology but with the versatility to be adapted into expanded product family variants within different scenarios. The authors emphasize that the adaptability of products to diverse circumstances allows for product variety and thus continuous competition on a global market scale. Consequently, employing robust design capabilities enables companies to adapt to uncertainty by continuously accomplishing consumer needs by establishing dominant designs.

Although the critical role of engineering-related capabilities of design in supporting companies' high-performance levels is widely acknowledged in the product development literature, the increased emphasis on creativity and innovation over the new product development process leads to expanded classifications of design capabilities. When design capabilities deal with creativity and innovation over the new product development process, they can embrace a broader set of aspects beyond product design and engineering. Dickson et al. (1995) describe design capabilities handling marketing-related tasks. In this context, design can support ideas generation and consumer involvement. Accordingly, Perks et al. (2005) derive an expanded taxonomy of design capabilities over the new product development process that involves the knowledge integration and process leadership dimensions besides the functional. Hence, if functional design capabilities determine the successful implementation of embodiments (i.e., physical things and prototypes), the increasing relevance of consumers as a driving force for product innovation leads to a broader understanding of the design role over new product development.

Design raised its popularity in the business context by applying its capabilities in problem-solving activities for new product development. When solving consumers' problems represents the companies' solution to develop new successful products, design supports choice-making through creative problem-solving. Creative problem-solving positively influences the performance of companies as it moves the problem into a solution by expanding the problem boundaries and providing novel solution trajectories (Brown, 2008, 2009; Liedtka, 2015; Martin, 2009). In this context, creativity is defined as a critical design capability for new product development, as it leads to ideas generation for problem-solving (Basadur et al., 2000). Amabile (1988) defines *creativity* as the ability to produce “novel and useful ideas by an individual or a small group of individuals working together.” Therefore, creative problem-solving strongly relies on generating new and alternative ideas for developing new valuable products.

The design literature widely describes how design contributes to problem-solving by focusing on the final user. When the final user is the driving factor leading to a solution, *building empathy* is defined to be critical for gaining a deep understanding of users’ needs (Micheli et al., 2018). Connel and Tenkasi (2015) define empathy as the ability to taking the perspective of anothers to understand what they regard as meaningful. Carlgren et al. (L. Carlgren et al., 2016) describe that empathy is deployed by conducting ethnographic observations in combination with qualitative interviews.

Whereas building empathy allows for understanding the user perspective to find solutions to user needs (L. Carlgren et al., 2016), Bertola and Teixeira (2003) describe *knowledge brokering* as the design ability to “accessing the implicit understanding of products’ function and meaning that are shared inside the users’ cultural community” (Bertola & Teixeira, 2003, p. 189). By externalizing the implicit knowledge shared in users' “everyday life” products through participatory observations, design envision potential and emerging cultural changes. Consequently, design can drive business knowledge toward the development of innovative concepts.

While design captures new product meanings through knowledge brokering, it provides consistent support in communicating the abstract concepts toward the shared agreements of new products criteria through *knowledge integration* (Bertola & Teixeira, 2003). By codifying the different perspectives into product form, function, value, and meaning (Celaschi et al., 2009), design can provide formal representations of abstract concepts, such as models, metaphors, and synthetic images, that facilitate the communication and negotiation of different perspectives.

In this context, the role of visual artifacts is to represent and communicate intangible concepts and ideas. The design ability of *visualization* is defined as making ideas and insights visual and tangible and representing abstract concepts (L. Carlgren et al., 2016; Dell’Era et al., 2020). While describing the characteristics of design thinking, Owen (2007) emphasizes the role of the range of media that design uses to bring a common view to concepts otherwise imagined individually and uniquely in a discussion. Sketches, drawings, mock-ups, prototypes, and in general physical artifacts embody and communicate abstraction. Hence, visualization is an integral part of the visual language of design.

The ability to *communicate visually* defines design as capable of revealing and explaining patterns and simplifying complex phenomena to their fundamental essence (Owen, 2007). Frascara (2004) describes visual communication as arising from the necessity to communicate specific messages and obtain desired responses. Within the strategic management context, Turner and Topalian (2002) highlight the fundamental role of visual communication in providing a practical link between boardrooms discussions and the everyday activities of the company. Indeed, design through visual communication makes tangible companies' strategic intent to stakeholders, thus allowing for the intent realization. Similarly, the IIT Institute of Design of Chicago (2020) emphasizes that visual communication in design focuses on understanding and speaking the language of stakeholders across all levels, disciplines, and functions of the company so that everyone is motivated in the intent realization. Therefore, visual communication provides the means for enabling collective action around a shared vision.

While making abstract concepts tangible facilitates discussions and motivates collective action, new patterns of relationships between objects and system components can arise (Dunne & Martin, 2006; Owen, 2007). When the connections between intangible concepts can be visualized, design can frame systems components in a functional way for assessing the value of arrangements. *Framing*, or the ability to order systems and synthesize patterns (Conley, 2013; P. H. Jones, 2014b; Paton & Dorst, 2011), allows for representing information and data structures so that the current context reality can be explained, assessed, and questioned toward new valuable directions.

If design contributes to assessing purposeful relationships between the solution and its context, the fundamental ability to identify new paths among the identified relationships allows for widening the solution space and informing new valuable directions. Schön (1983) states that the primary value of design for new product development consists of design solving problems without handling problems as given. Under this perspective, design set new problems by defining the decision to make, the ends to achieve, and the means to choose for the achievement of the ends. Therefore, design is a reflective practice that combines the perception of the problematic situation with a way of reasoning that allows for developing alternative actions. The *reframing* capability of design defines the reflective practice as it allows for widening the solution space by repositioning a concept, solution, or option in different contexts where a new capacity for interaction or use might emerge (Buchanan, 1992; Johns, 2009; Paton & Dorst, 2011). Hence, solving problems through design capabilities embeds an initial problem setting by reframing the initial statements (Meroni, 2008).

Reframing allows for *envisioning* alternative future possibilities as it opens new spaces of intervention. Within the strategic management literature, Turner and Topalian (2002) define envisioning as the design's ability to extend the implementation of the company's vision. Therefore, design is considered a strategic resource for companies' competitiveness as it critically influences the conception and delivery of products that closely reflect customers' needs and desires. By imagining and representing scenarios, design provides tangible alternatives for companies when making decisions (e.g., see Joziasse, 2011; Miller & Moultrie, 2013; Topalian, 2011).

Although envisioning in creative problem-solving is driven by the process of idea generation, Verganti (2009) takes a different position by stating that envisioning results from a process of different understandings interpretation. Indeed, interpretation allows for imagining experiences that are still not asked for, rather than answering existing needs (Verganti & Öberg, 2013). When interpretation rather than idea generation drives envisioning, companies are provided with a new vision rather than a new idea for product development. For this purpose, Verganti (2016) defines *criticism* as a fundamental design capability in contexts of diversity interpretation. Criticism is the ability to questioning assumptions by interpreting the network partners' perspectives so that the current situation can be criticized and moved toward outlandish endorsements. "Things to use" (i.e., sketches, mock-ups, storyboards, and prototypes) or a broad perspective on a given situation that derives from preliminary research (Verganti, 2016) provide the means for partners to externalize different perspectives on a topic and for designers to challenge assumptions.

Although criticism did not characterize the traditional approach to solving problems in design, it is today acknowledged as a relevant design capability in the evolved competitive contexts within which design operates (Magistretti et al., 2019). When diverse kinds of knowledge inform new product development directions, different perspectives participate in defining the direction to take. Jones (2014a) describes that when diversity is involved in new product development, a purpose that informs actions must be defined. Therefore, design is responsible for determining agreement toward a purpose identification for a more definition of the problem. This *negotiation* capability allows for creating a shared understanding of the problem and fostering a joint commitment to possible resolution actions (Ito & Howe, 2016). Conducting brainstorming sessions, holding retreats to encourage sharing perspectives, running focus-group, and involving users in developing future scenarios support companies to build a shared understanding of new product development (Camillus, 2008).

Design develop new products by embedding diverse perspectives and insights into experiments. Design *experimentation* capability is defined as the ability to "learning through iterative forms, prototyping and trials that test a range of possible solutions with end-users" (Beverland et al., 2016, p. 593). Brown (2008) defines experimentation in design as allowing for learning about the strengths and weaknesses of ideas. Accordingly, Micheli et al. (2018) emphasize that experimentation contributes to superior product development as it provides a way for experimenting and developing new concepts through learnings gained from diverse perspectives. Hence, the competitive value of design experimentation resides not in validating products but in acquiring updated product information over iterative trials.

Design capabilities for superior products development focus on solving companies' problems toward competitive advantage (Table 2. 1). Companies rely on the consumer as the primary force influencing their economic profit. When companies adopt a consumer-centric perspective for new product development, design capabilities support profitability by synthesizing and manifesting distributed and diverse knowledge within and outside an organization toward consumer satisfaction. Although consumer-centered perspectives are still valid in many circumstances, successful new product development conditions become less predictable in times of rapid technological and social change.

STRATEGIC DESIGN CAPABILITIES FOR NPD	DEFINITION	CAPABILITIES FINALITY	OBSERVABLE ITEMS	AUTHORS
Building empathy	The ability to take the perspective of another	Understanding what users regard as meaningful	Ethnographic observations Qualitative interviews	Carlgren et al., 2016; Connel and Tenkasi, 2015; Micheli et al., 2018
Knowledge brokering	The ability to access the implicit understanding of products' function and meaning that are shared inside the users' cultural community	Envisioning potential/ emerging cultural changes	Participatory observations	Bertola and Teixeira, 2003;
Knowledge integration	The ability to codify and communicate different perspectives	Facilitating shared agreements on products criteria	Formal representations of abstract concepts (e.g., models, metaphors, and synthetic images)	Bertola and Teixeira, 2003; Celaschi et al., 2009
Visualization	The ability to make ideas and insights visual and tangible and to represent abstract concepts	Bringing a common view to concepts	Sketches, drawings, mock-ups, prototypes, and in general physical artifacts	Carlgren et al., 2016; Dell'Era et al., 2020 Micheli et al., 2018 Owen, 2007
Visual communication	The ability to reveal and explain patterns and simplify complex phenomena to their fundamental essence	Enabling the initial intent realization	Text, drawings, slides, posters, reports, models in hardware, photo, video, CAD drawings, diagrams, demonstrations	Frascara, 2004 IIT Institute of Design, 2020 Owen, 2007 Turner and Topalian, 2002
Framing	The ability to order systems and synthesize patterns	Assessing the value of arrangements in current contexts	Afinity diagramming Mindmapping Customer journey mapping	Beckam, 2020 Conley, 2013; Jones, 2014; Paton and Dorst, 2011
Reframing	The ability to reposition a concept, solution, or option in different contexts	Widening the solution space; Identifying new interaction paths	Future workshops Counter-briefs	Buchanan, 1992; Johns, 2009; Paton & Dorst, 2011 Schön (1983)
Envisioning	The ability to imagine and represent alternative future possibilities	Extending the implementation of the company's vision	Scenario representations Storyboards	Joziasse, 2011; Miller & Moultrie, 2013; Topalian, 2011
Criticism	The ability to interpret the network partners' perspectives	Envisioning new directions	Providing "things to use"; Providing broader perspectives	Verganti, 2016; Verganti & Öberg, 2013
Negotiation	The ability to create a shared understanding of the problem and foster a joint commitment to possible resolution actions	Deepening the problem definition	Brainstorming sessions, Holding retreats; Focus groups; Future workshops;	Camillus, 2009; Ito & Howe, 2016; Jones, 2014
Experimentation	The ability to learn through iterative forms, prototyping and trials that test a range of possible solutions with end-users	Acquiring updated product information over iterative trials	Prototypes, A/B test	Beverland et al., 2016; Brown, 2008; Carlgren et al, 2016; Micheli et al., 2018

Table 2. 1 Summary of design capabilities for competitive new product development retrieved from the literature review. The summary shows design capabilities' definitions, finalities, and observable items

2.3. The evolving meaning of NPD in design

The definition of new product development is strictly dependent on different meanings of efficiency, as each definition of efficiency influences companies' competitive actions. Therefore, organizations develop new products by following competition rules related to the definition of what efficiency is. The neoclassical theory of the nineteenth century defines economic activity as strictly dependent on markets (i.e., see Friedman, 1962). In this context, efficiency relies on minimizing input and maximizing output. Coherently, companies develop new products at the lowest possible prices and new product development aims to increase profitability by reducing tasks that do not generate income. Conversely, the economic-growth theory explains the economy as drawing on innovation (i.e., see W. B. Arthur, 1996; Romer, 1992). Under this perspective, efficiency depends on the ability of companies to develop new products by accessing and employing human capital as a source for invention and continuous growth (Romer, 2016).

Hence, different meanings of efficiency influence the definition of new product development as different purposes determine the company's actions. When the new product development purpose relies on profitability, new product development has been defined as a phase of a process where technical and financial feasibility allows companies to produce a new product (e.g., see Dibb et al., 2005). Similarly, new product development has been defined as a cost that determines a product budget by turning development activities into items to be cut or raised (e.g., see Dibb et al., 2005).

Whereas profitability allows for increased productivity in an industry, the rules that determine profitability often are challenged by the changing rules of competition. And when the rules change, companies often face uncertainty about the strategy to adopt toward economic profit (Porter & Kramer, 2011; Whitney, 2015). In this context, complementary knowledge coming together to understand and apply the next moves for producing new products can lead to innovation and economic growth (Schumpeter, 1942).

Under this perspective, Buchanan (2004) defines new product development as a strategy for creating new interaction paths. Therefore, new product development becomes an active agent for change as it allows for exploring products opportunities in the context where valuable knowledge is available. When the context where new products are developed represents a space for identifying and implementing product opportunities, new product development becomes a relationship-building activity. Although Buchanan (2004) is not the only one who defines new product development as a strategy, the acknowledged definitions see the strategy aiming to "increasing sales by improving present products or developing new products for current markets" (i.e., see Kotler & Armstrong, 2010). Consequently, the realms of activities for new product development are still limited to pre-determined financial issues.

Junginger (2008) states that design exploits its true potential when companies consider new product development assuming an active role. Under this perspective, design can focus on designing the participation of the human capital available for producing new products. When human capital rather than financial capital provides new exploration possibilities, design focuses on accessing people's knowledge for enabling new products production and consequently innovation and economic growth. Buchanan (2015, p. 20) emphasizes that "the purpose of a company is to provide goods and services in society." Whereas profitability is traditionally regarded as the primary purpose of companies, and design has often served this intent, the author states that "profit is best understood as a necessary element to sustain the organization and strengthen its ability to innovate in changing circumstances" (Buchanan, 2015, p. 20).

Hence, design can focus on actions and activities that determine collective interactions for new product development toward innovation as the leading company's purpose.

By expanding the design profession from graphic and industrial design to interaction design and then to the design of organizations, Buchanan (2001a) positions the design role within the broader system of the company by affirming that design can bring a degree of cohesiveness to every human undertaking. Indeed, design can frame a shared vision of the company's purpose to achieve and establish the organization of resources needed to achieve the purpose. Under these terms, design becomes strictly related to organizational design concepts raised within the management field. Simon (1945) defines the goal of design as the one to devise actions, processes, or physical structures that support some defined purpose. Senge (1990) affirms that the design role lies in understanding internal and external forces driving change and designing the learning processes that lead managers in a company to understand those forces. Therefore, adopting design to organize knowledge within the internal community of a company supports innovation management for producing new products in rapidly changing environments (R. Boland & Collopy, 2004).

Although new product development as an active agent of change allows design to intervene in broader contexts of collective interactions, the influential contributions in design research (e.g., see Buchanan, 2015; Junginger, 2009) limit the design profession within the specific company's boundary. In entrepreneurial ecosystems, companies let new product development explore product opportunities by searching in the organizational context of the ecosystem's available knowledge (Spigel, 2017a; Spigel & Vinodrai, 2020). Nevertheless, the active role of new product development as the ability of design to accessing and utilizing people knowledge represents a valid direction for investigating the organization of systemic network knowledge by employing design capabilities.

2.4. The organizational role of design capabilities

Linking design capabilities to open innovation practices

Acha (2008) defines design capabilities relevant for open innovation as design can organize knowledge interfaces through task partitioning. Therefore, design can specify the tasks allowing companies to coordinate collaboration activities among internal and external expertise. Dodgson et al. (2005) describe design particularly falling within task partitioning as its ability to decompose problems makes design an enabler for innovative activities. Simon (1996) emphasizes that problem decomposition represents an efficient way for solving complex problems. Although the design role in open innovation did not receive the same attention as other innovation practices (Tether, 2009), problem decomposition can make design relevant when organizing complex knowledge flows is the basis for effective problem-solving (Dodgson et al., 2005).

Von Hippel (1990) introduces the concept of task partitioning by describing innovation projects as “partitioned” into several tasks that are then distributed among individuals and firms. Therefore, specifying how different expertise can perform tasks means understanding the interdependencies between tasks and their management. Accordingly, Sanchez and Mahoney (1996) highlight that product development and production strongly depend on coordination tasks' design as they determine the product feasibility. Brusoni and Prencipe (2006) argue that knowledge designs organizations, not products. Hence, in the context of open innovation, design enables new product development by translating and integrating tasks for coordinating distributed knowledge (Acha, 2008).

Task partitioning clearly positions design capabilities into the organizational dimension of new product development. However, the organizational principles of distributed knowledge flows in open innovation rely on the specific characteristics of complex products and systems (Acha, 2008). Complex products and systems are described by a central authority (i.e., the leading company) that coordinates new product development tasks across its value chain (e.g., see Davies et al., 2011; Davies & Brady, 2000; Hobday et al., 2000). In complex products and systems, new product development depends on the close collaboration between companies that share technical and market knowledge under established confidential agreements. In this context, problem-solving tasks are partitioned among network partners once the problem has been identified (Davies et al., 2011). Consequently, the complexity of new product development is solved by the ability of the leading company to efficiently and effectively integrate the project tasks among participants.

Entrepreneurial ecosystems differ from complex products and systems as self-organizing mechanisms of coordination characterize them. When a central authority does not direct the activities, new product development emerges from micro-interactions among ecosystems stakeholders (Roundy et al., 2018). Brownlee (2007) describes self-organization as a property of complex adaptive systems in terms of dispersed interaction. In complex adaptive systems, as in entrepreneurial ecosystems, new product development emerges from heterogeneous and dispersed actions of agents acting in parallel. Dispersed interaction determines that no leading entity controls the interactions as interactions are governed by competition and collaboration between agents. Consequently, the ability to engage with ecosystem stakeholders produces the continual adaptation of actions and products, thus resulting in a continuous change of interactions configurations (Schindehutte & Morris, 2009).

The adaptability of entrepreneurial ecosystems represents a primary benefit for companies to innovate as changes introduced by adaptation create continuous new exploration opportunities (Brownlee, 2007). Under this perspective, entrepreneurial ecosystems differ from complex products and systems. Entrepreneurial ecosystems provide companies with continuous knowledge support when sensing and seizing opportunities and when reconfiguring assets around the new opportunity are needed (Roundy, 2020; Roundy & Fayard, 2019). Although both the models aim to develop new products, complex products and systems focus on new product development as a process defined by predetermined phases and related tasks. Differently, entrepreneurial ecosystems see new product development as an output of entrepreneurial social activity (Stam & Spigel, 2017).

In this context, design capabilities might support companies searching for the diverse and distributed entrepreneurial knowledge required for identifying and scaling a new opportunity. However, if non-disclosure agreements of knowledge sharing represent the necessary condition that enables new product development in complex products and systems, in entrepreneurial ecosystems, companies must adopt the “simple rules” (Roundy, 2020) that allow entrepreneurial engagement. Simple rules define the willingness of companies to participate in interactions toward a mutual sharing of entrepreneurial knowledge for mutual benefit. From the perspective of capabilities, companies adopt the simple rules of entrepreneurial ecosystems when they are able to search for entrepreneurial knowledge through a relational approach (Theodoraki et al., 2018).

In this context, the link between design capabilities and open innovation still relies on the organizational dimension of new product development but differs in the practices and related capabilities required for developing new products through a multi-actor interface. In entrepreneurial ecosystems, new product development reflects the interactive entrepreneurial activity embedded in the sensing, seizing, and reconfiguring organizational dimensions. However, interaction and engagement are enabled by relational approaches.

Hence, design capabilities can support boundary-spanning search of open innovation to identify valuable knowledge while sensing, seizing, and reconfiguring through a relational approach. Consequently, a deeper investigation of the relationships between network-level design capabilities for new product development in contexts of open innovation and network-level capabilities of entrepreneurial ecosystems is required.

The necessary conditions for relating design capabilities to EEs

Theodoraki et al. (2018) adopt a social capital approach to explore the complex dynamics of new product development through entrepreneurial ecosystems. Specifically, the authors emphasize that investing in the relational dimension of social capital enhances complementarity. When symbiosis and interdependence between ecosystem stakeholders are required to define entrepreneurial ecosystems, establishing relationships allows companies to gain advantage through the assets of the ecosystem's participants for new product development.

Although companies in entrepreneurial ecosystems strongly rely on searching heterogeneous stakeholders to expand their knowledge base, heterogeneity alone does not support complementarity (Godley et al., 2021; Theodoraki et al., 2018). For this purpose, companies must establish relationships for accessing heterogeneous knowledge and strengthening stakeholders' interconnections (Spigel, 2017b). When complementarity is a constraint to develop new products, companies satisfy the relational dimension of entrepreneurial ecosystems while searching for heterogeneous knowledge. Consequently, complementarity is supported by the ability of companies to span the knowledge boundaries through a relational approach.

Lopez-Vega et al. (2016) describe how boundary-spanning practices occur when companies search for external knowledge. The authors provide a helpful classification of the ways companies search heuristics, or external data and information that expand the company's knowledge base. In their study, cognitive and experiential search represent the two dimensions that inform search practices in open innovation contexts (Lopez-Vega et al., 2016). Gavetti and Levinthal (2000) describe cognitive and experiential dimensions as two distinctive ways of searching information. Cognitive search refers to the modalities through which the company and its environments are conceptualized. Cognition allows companies to simplify the complexity of knowledge relationships and the interactions among actors through representations of their problem space (Simon, 1991). Conversely, experiential search is defined by the mechanisms that shape what a company actually does (Gavetti & Levinthal, 2000). In these terms, experiential search is defined by actions derived from feedback on current activities (Zollo & Winter, 2002). Although the authors refer to cognitive and experiential dimensions as supports to improving the absorptive capacity of companies, they provide a clear definition of the concepts that Lopez-Vega et al. (Lopez-Vega et al., 2016) expand to open innovation.

The open innovation literature does not focus on relational considerations related to boundary-spanning practices. However, cognitive and experiential dimensions represent the necessary conditions to consider when classifying the design capabilities required for new product development in a multi-actor interface as they provide possibilities for engagement over searching. By assuming cognitive and experiential dimensions as the necessary conditions for enabling companies' engagement with entrepreneurial ecosystems stakeholders, it will be possible to investigate how design capabilities can support the relational finalities of entrepreneurial ecosystems capabilities for new product development.

3. METHODOLOGY

3.1. Research setting

The food industry ecosystem as a favorable context

The food industry is undergoing profound changes as technological advancements influence its structure and competitive environment. Therefore, new products and new technologies provide new consumption trends and food habits as well as market opportunities and companys' strategies. However, as Galizzi and Venturini (2012) highlight, the empirical and theoretical literature on the influence of technological change on companies' strategies for new product development mainly concerns research-intensive industries, where radical innovation outputs drive the description of new product development processes. Freeman (1994) emphasizes that as it happens for research-intensive industries, systematic analyses of the external context of change become a necessary requirement in low R&D industries in times of fast changes. As far as the food industry is characterized by low R&D intensity (G. Galizzi & Venturini, 2012), it becomes interesting to understand how food industry companies react to changes and compete to develop new products.

The food industry represents a complex and adaptive ecosystem with a high number of interacting and co-evolving agents. The modern food industry is inseparable from consumers' daily lives as only a tiny fraction of people do not rely on it. As consumer demand is constantly high, the food industry shows a strong marketing orientation (Giovanni Galizzi & Venturini, 1996). When demand satisfaction does not necessarily require companies to develop radically innovative products, the industry focuses more on developing marketing skills than technological ones. Schifferstein (2016) describes the food industry as aiming to satisfy consumers' trends and new habits by focusing on branding strategies, packaging, and advertising. Hence, the food industry supports the view that new product development mostly relies on linking complex interactions between consumers' needs and scientific and technological developments (G. Galizzi & Venturini, 2012). Consequently, new product development in the food industry does not rely on food offerings as much as on the products that lead to the sale of food offerings, namely packaging.

In this context, new product development competition is characterized by a vertical configuration between packaging manufacturers and retailers. As retailers are the primary touchpoint between production and consumption, they benefit from developing own-labeled products, thus creating direct competition with manufacturers' brands (Caldentey, 2012). The differentiation of products becomes the primary indicator of competitive advantage, often benefiting more retailers than manufacturers. Consequently, vertical competition is relevant for packaging manufacturers that react by adopting non-price strategies, such as customer loyalty (Traill, 2012). However, although marketing strategies primarily support packaging manufacturers in creating horizontal relationships for new product development, it is often challenging to understand consumer needs in times of fast technological changes (Whitney, 2015).

Galizzi and Venturini (2012) emphasize that a characteristic of the food industry that can determine new directions in new product development resides in the large amount of heterogeneous knowledge that the food industry imports from different sectors and resources. When new product development can be informed by heterogeneous and dispersed knowledge, packaging manufacturers can engage with a broader set of actors. The authors outline how engaging with diverse knowledge can inform packaging manufacturers about new technologies and related packaging techniques. Sarkar and Costa (2008) expand the level of engagement by emphasizing that many diverse actors participate in the food supply together with their challenges to meet customers' requirements individually. Hence, the search for human capital that informs new product development toward cross-collaboration is acknowledged as a promising direction in packaging manufacturing for the food industry (i.e., see also Costa & Jongen, 2006; Mikkelsen et al., 2005).

Under this perspective, considering the development of new products in terms of organizational change is described as a promising direction from several authors in the field (Costa & Jongen, 2006; G. Galizzi & Venturini, 2012; Mikkelsen et al., 2005; Sarkar & Costa, 2008). When the link between production and consumption requires a broader level of engagement for new product development, organizational change, and specifically, the neo-Schumpeterian approach is suggested. It allows for expanding the focus from the single firm and industry to inter-firm relationships. However, the ability to search and engage with the human capital available represents a critical aspect in this context. As Galizzi and Venturini (2012) outline, packaging manufacturing companies scarcely approach this direction as they lack the capabilities to enable organizational change due to their focus on marketing strategies. Consequently, although the approach is acknowledged as valid by the theoretical exponents in the field, a scarce competence in organizational change constrains new product development to marketing-related activities.

Given the potentialities of design capabilities to support an expanded level of engagement for new product development, the next section analyzes the current design positioning in the food industry. Specifically, design current interventions and possibilities in the packaging sector are outlined.

Packaging manufacturing as a favorable sector

New product development in the food industry is primarily related to packaging products and related services, as packaging in the food industry represents the primary marketing medium for product differentiation. In this context, design intervention is reported as relatively limited to packaging design and related consumption experiences (Schifferstein & Hekkert, 2011). Therefore, design supports the functional and communicative properties of products toward the improvement of food offers preparation, their service modalities, and the ways they are experienced. In this context, packaging design aims to increase the performance of packaging products that act as food barriers from external contamination factors, such as moisture, air, and light (Robertson, 2013). Moreover, packaging design supports the communication of information about the food ingredients, their origins, mode of use, etc. (Dekker, 2011).

Rundh (2009) defines packaging design as a fundamental asset of marketing strategy in manufacturing companies due to its ability to integrate external changing factors into attractive users' solutions. The author outlines how several conditions of change influence packaging design beyond consumers' demographic and lifestyles factors, such as environmental, international, logistics, and technological factors. However, the design intervention for packaging design in the food industry is fairly limited to product-oriented approaches that relate to the development of products through materials, shape, size, color, texture, and graphics selection and application (e.g., see Schifferstein, 2016).

Although the current design interventions in packaging manufacturing undoubtedly provide a competitive advantage in product differentiation in the food industry, packaging companies deal with complex issues on a daily basis (Rundh, 2009). In this context, design could provide superior support due to its strategic capabilities for new product development (Stevens & Moultrie, 2011). Involving design capabilities in the development of wider systems of food production and consumption to support environmental issues (AlphaBeta, 2017), new logistics solutions, technological advancements (McKinsey&Company, 2019) are some examples for unleashing the design potentialities toward system-level goals.

By considering the food industry ecosystems as a favorable context for investigating how design capabilities can engage system-level entrepreneurial knowledge for new product development, the research focuses on product development projects in packaging manufacturing companies to provide a broader understanding of design potentialities in this sector.

The following chapter outline the research methodology adopted in conducting the investigation.

3.2. Research objectives

This research investigates the relationships between design capabilities and the capabilities of entrepreneurial ecosystems for new product development in manufacturing and was structured around the question:

How can design capabilities support packaging manufacturing companies to co-create entrepreneurial ecosystems for new product development?

The research question sets the following sub-questions:

- Which are the design capabilities that might enable the co-creation of entrepreneurial ecosystems?
- What is the relationship between design capabilities and the organizational dimensions of new product development in entrepreneurial ecosystems?
- Which are the impacts of design capabilities when co-creating entrepreneurial ecosystems?

The literature review shows that design capabilities for new product development intervene at the network level for codifying external knowledge and synthesizing it for providing companies with new business directions. Therefore, design capabilities are employed for serving internal companies strategies of new product development. In this context, their strategic intervention is observed when technical and market knowledge in the network are involved. Indeed, accordingly with territorial models of innovation, technical and market knowledge are the wellspring of entrepreneurial innovation as they support the formation of dominant designs. Under this perspective, design capabilities represent a strategic resource for companies, that invest in design as a mediator between the internal and external contexts for developing new products that reflect social changes and the expertise of diverse technical knowledge in the final output.

Given the ability of design capabilities to intervene at the network level for new product development, it becomes interesting to investigate how they might support entrepreneurial knowledge interactions between the company and the network actors. This research interest draws on current technological and social evolutions, which rapid advancements often challenge the readiness of production systems to respond. Therefore, in a context where dominant design as the standard driving companies' productivity and performance are continuously disrupted, new models of competitive advantage arise. Specifically, competitive advantage derives from the ability of companies to access and strengthen diverse and distributed entrepreneurial knowledge that informs new product development directions. Hence, ties and relationships rather than efficiency become the primary driver to innovate in contexts of continuous uncertainty.

In this context, the entrepreneurial ecosystems research focuses on actors' actions for accessing and strengthening diverse and distributed knowledge. The literature reports specific entrepreneurial capabilities of knowledge access and strength when companies sense, seize and reconfigure new opportunities in the context of entrepreneurial ecosystems. If one analyses the finalities of entrepreneurial ecosystems capabilities, she/he can notice that they focus on relational aspects of participation. Indeed, continuous relational interactions lead to the emergence and sustainment of a repository of entrepreneurial knowledge available to companies thanks to the climate of trust deriving from the general commitment of participants to realize shared ecosystems goals (i.e., supporting the development of entrepreneurial activity). Therefore, new product development relies on sensing, seizing, and reconfiguring opportunities by becoming involved in the entrepreneurial knowledge process by sharing information.

Under this perspective, new product development becomes a co-creation process as it results in systemic entrepreneurial activity. When opportunities are sensed, seized and reconfigured through systemic entrepreneurial knowledge, new product development results from relationship-building activities. And as far as the actors involved in co-creation produce benefits, co-creation in entrepreneurial ecosystems is defined as a co-production process through entrepreneurial knowledge sharing. Consequently, new product development under a relational lens reflects the ability of companies to access and strengthen entrepreneurial knowledge by adopting an open innovation approach.

Specifically, the investigation of the relationship between design capabilities and entrepreneurial ecosystems capabilities considers open innovation as a theoretical bridge that defines engagement at the network level and informs the engagement dimensions of design capabilities. Therefore, classifying design capabilities under the engagement dimensions of open innovation makes it possible to create a connection between design and entrepreneurial ecosystems that today is lacking (Figure 3. 1).

The investigation of the relationships between design capabilities and entrepreneurial ecosystems capabilities supports the identification of the design capabilities that nurture entrepreneurial knowledge interactions when sensing, seizing and reconfiguring opportunities in entrepreneurial ecosystems. By focusing on packaging manufacturing for the food industry as the primary context of the inquiry, the research findings will highlight the design capabilities that support the relational perspective of new product development over sensing, seizing and reconfiguring, and their impacts on new product development projects in food packaging manufacturing companies.

Research findings will inform both managers in packaging manufacturing companies and designers. Findings can support managers in food packaging manufacturing companies to be aware of the design strategic contribution when new dynamics of competitions focused on relationships can provide a competitive advantage for new product development. Furthermore, findings can show managers how design capabilities result in relational ways for sensing, seizing, and reconfiguring opportunities. Under a design perspective, findings can inform designers with new application directions of design capabilities when developing new products entails relational activities of entrepreneurial knowledge access and strength. This can support product design practice to challenge the modernist vision of design to manufacturing products of demands toward manufacturing solutions through multi-actor entrepreneurial knowledge.

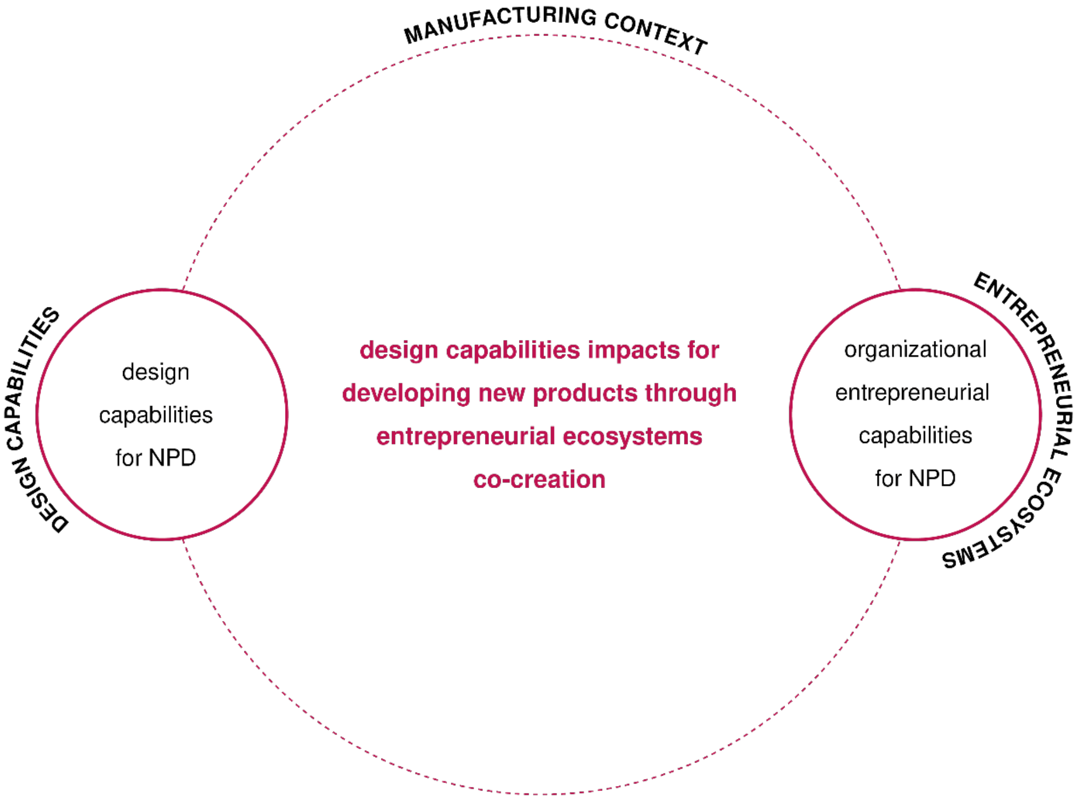


Figure 3. 1 Research positioning and gap

3.3. Research assumption

The co-creation of entrepreneurial ecosystems for new product development draws on accessing and strengthening entrepreneurial knowledge in the system. The theory assumes that companies that pursue a systemic shared goal can sense, seize, and reconfigure opportunities for new product development by relying on systemic entrepreneurial knowledge. Consequently, the entrepreneurial ecosystems theory focuses on the ability of companies to engage with systemic knowledge as a necessary condition for new product development. This research investigates this ability from a design capabilities perspective, as described in the design literature, as able to codify and synthesize network-level knowledge for new product development.

Under this perspective, the research is driven by the assumption that *if design capabilities engage with systemic knowledge to serve internal companies' new product development strategies, they can engage with systemic knowledge to co-create entrepreneurial ecosystems for new product development.*

By relying on the literature review, the co-creation of entrepreneurial ecosystems might be primarily influenced by two factors or conditions of change:

a) The logic of competition served by the new product development project
b) The complexity of the technology that drives the new product development project

Therefore, this research investigates the relationship between design capabilities and capabilities of entrepreneurial ecosystems in terms of which design capabilities can nurture those entrepreneurial capabilities that enable systemic knowledge access and strength under the different conditions of change.

Entrepreneurial ecosystems capabilities represent the capabilities that enable opportunity identification (i.e., capabilities under the sensing dimension), resources mobilization (i.e., capabilities under the seizing dimension), and actions adaptation (i.e., capabilities under the reconfiguring dimension). In the research, they are considered the dependent variables that can eventually result from design capabilities (i.e., dependent variables).

The research assumption will be investigated and interpreted to create a new knowledge contribution.

3.4. Research design and methods

Research design

The research has been designed to qualitatively inform the research assumption (see Figure 3. 2). Given the interest in investigating the relationships between capabilities that belong to two different domains, it was deemed necessary to integrate knowledge to develop a new taxonomy of design capabilities so that design capabilities that can enable the co-creation of entrepreneurial ecosystems have been outlined and classified. Then, the taxonomy has been integrated within a framework that frames both design and entrepreneurial ecosystems capabilities retrieved from the literature review (see Chapter 4.2 for the detailed framework description). The framework enabled the investigation and was intended to guide the analysis and interpretation of the case studies results. The research was structured around two investigations to explore and describe the relationships between design and entrepreneurial ecosystems capabilities for new product development in manufacturing and explain how design capabilities supported packaging companies in engaging with entrepreneurial ecosystems. The investigations examined the phenomena by considering the two conditions of change.

Specifically, the first investigation examined if design capabilities nurtured the capabilities of entrepreneurial ecosystems over the new product development projects and how this nourishment resulted in terms of impacts under the influence of the logic of competition followed by the projects. The examination was initially conducted within a case study of six new product development projects that explored capabilities relationships for describing the differences that characterize the support of design capabilities under a certain logic of competition. Then, the same exploration was conducted within another case study of four new product development projects for validating the differences between the two logics of new product development retrieved from the first case study. While the first case study resulted from a self-contained research activity within an academic course, the second case study derived from the engagement of packaging companies. This allowed for comparing results between the cases by considering different settings of the new product development projects under the same change condition. Furthermore, the diversity of cases setting resulted in different data collection techniques and related data analysis procedures for cross-case comparison. The generalization of case studies results could then be related to the background theory for the analytical generalization.

The second investigation focused on the four projects examined over the second case study. The engagement of packaging companies for the description and explanation of the projects supported the understanding of the influence of the driving technologies' complexity on capabilities relationships. This understanding was deemed relevant to interpreting if the possibilities of intervention of design capabilities in entrepreneurial ecosystems are more or less influenced by the logic of new product development adopted in the project or if they show completely different interventions when the complexity of technology is considered. Like in the first investigation, data were generalized and compared to the background theory for the assumption testing.

The qualitative investigations were intended to test the research assumptions by analyzing and interpreting data collected through different procedures and techniques. It is important to note that the research assumptions informed the research sampling strategy. The research question could be answered by considering the influence of the conditions of change as reported by the cases' evidence. Therefore, answering the research question contributed to new knowledge creation through the in-depth study of the lessons learned from the cases.

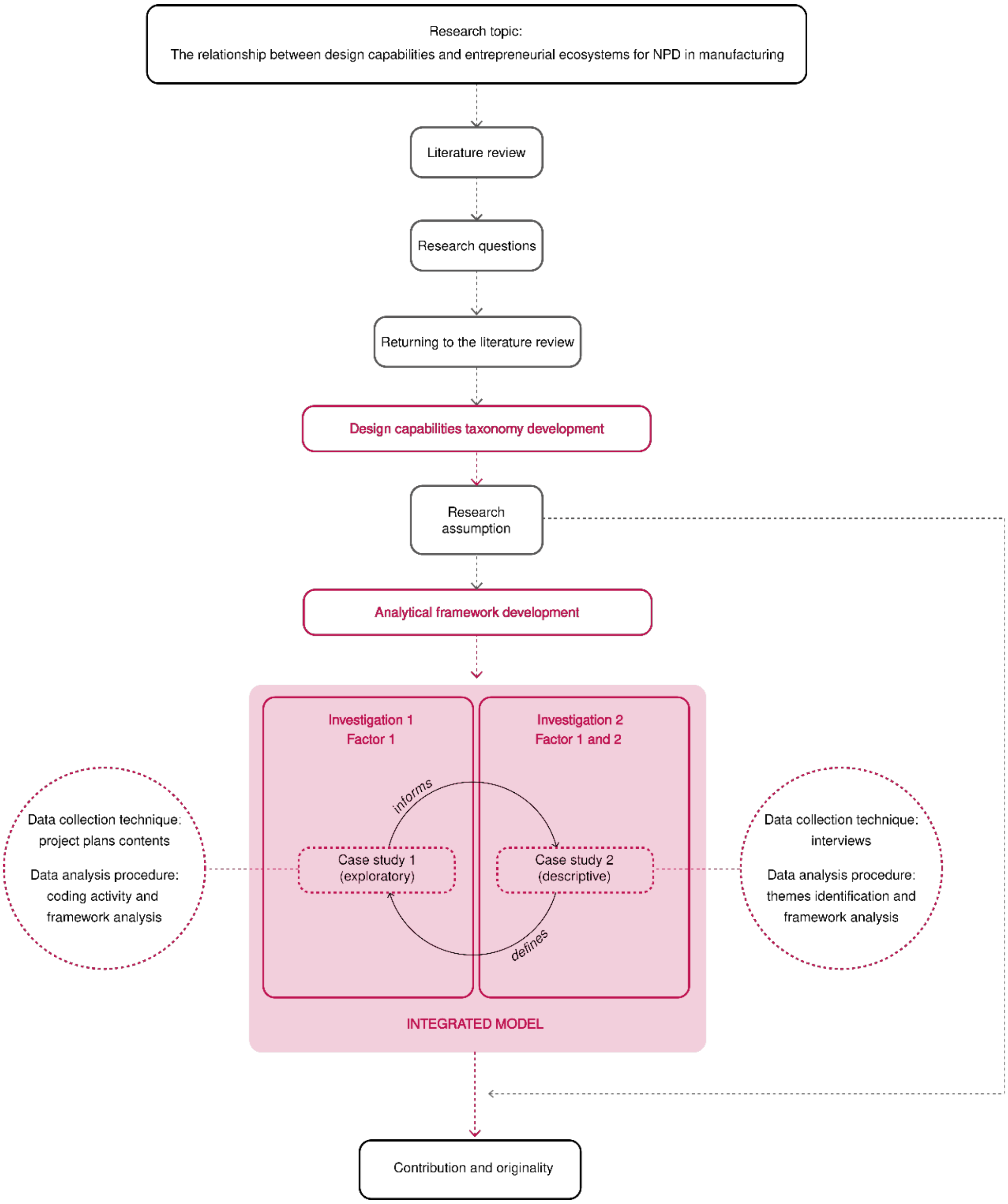


Figure 3. 2 Research design

Research method

This qualitative research has been carried out case study research method. Case study is a method for doing research that studies a contemporary phenomenon within its context, particularly when the boundaries between the phenomenon and the context are not clearly evident. The method has its foundations on the work of Robert K. Yin, including his post-positivistic perspective to the analysis of the field of investigation (Yin, 2009). Unlike the positivist quantitative approach, case study research adopts inductive investigation procedures that explore a certain phenomenon when immersed in its natural condition. The employment of multiple methods for collecting, interpreting, understanding, explaining, and eliciting data allows for deriving the phenomenon's meaning (Denzin & Lincoln, 2011). Since researching through case studies investigations brings within itself speculative analysis as one of the primary means through which explaining a phenomenon, and therefore a systemic approach to the field of inquiry, case study researchers recognize that the design of the research project assumes a fundamental role in supporting the validation of the background theory. Researchers carefully select the cases that prove what is sustained and argued in theoretical terms. This allows them to analytically generalize the selected cases by relying on the pieces of evidence that recall to theoretical propositions.

Case study research focuses on generalizing theories. Yin (2009) describes the “analytical generalization” of research findings as to the procedure of qualitatively comparing the results deriving from similar variables in different operating models. Unlike analogical generalization in action research, the standpoint of analytical generalization is that the adoption of a background theory not only supports the definition of the research project and data collection, but it becomes the primary means to generalize the case study results. Therefore, the theory that has been developed before the research started serves to calibrate the empirical results of the case study. Instead of relying on “learning by doing” activities for collecting and interpreting data, case study researchers conduct what Nagel defined as "controlled investigation" (Nagel, 1962). Researchers search for conflicting opportunities where the examined phenomenon is manifested in identical or different modalities. Consequently, researchers retrieve from the existing theory the factors that might influence change in case study results so that it becomes possible to generalize change as a function of specific conditions (Rihoux & Lobe, 2012).

The generalizability of results refers to the external validity of the research (Yin, 2009). Malterud (2001) describes external validity in qualitative research as the extent to which findings can be transmitted to other settings. Therefore, the external validity of the research is achieved if the same results of a case study are achieved in other case studies. Although a high number of case studies support the repeatability of the investigation procedure over the research project, Yin (2009) emphasizes that it is sufficient to repeat the investigation procedure within two or three case studies as long as they serve the same objective within the general scope of the investigation. This leads to identifying the elements that are repeated under certain conditions, thus allowing for the repeatability of the investigation in different settings.

While analytical generalization supports the logical repetition of investigations, thus providing external validity, consistency refers to the internal validity of the research (Yin, 2009). Within case study research, internal validity is defined as the determination of causal links between two events under the influence of a third factor. Therefore, case study researchers use to analyze cases results by deducing the effects from the explored events. Yin (2009) outlines that the main strategy for analyzing cases results toward internal validity is the qualitative comparison between empirical configurations of the dependent and/or the independent variables and the theory. The comparison draws on the theoretical assumptions that drive data collection and provide guidance for the theorical comparison of achieved results.

3.5. Sampling strategy

Unit of analysis

The unit of analysis of the case studies is the new product development project, or the different types of activities performed by professionals when the development of the new product requires the engagement of systemic knowledge. Therefore, new product development projects over the case studies were considered a relationship-building activity and not as design and implementation process's phases. This decision relies on the fact that in entrepreneurial ecosystems, new product development is defined at the organizational level of engagement rather than at the design and implementation level. Consequently, the research investigated those activities that supported the sensing and seizing of an opportunity and the eventual reconfiguration of the resources.

Although the projects were not explicitly set under the rules of entrepreneurial knowledge engagement defined by entrepreneurial ecosystems, namely focusing on knowledge access and strength over sensing, seizing, and reconfiguring, the investigations focused on those activities that corresponded to the entrepreneurial ecosystems finalities for new product development. Consequently, those activities were considered the observable items of the design capabilities that nurtured entrepreneurial ecosystems capabilities' finalities for knowledge access and strength.

The underlying assumption was that: if design capabilities engage with systemic knowledge to serve internal companies' new product development strategies, they can engage with systemic knowledge to co-create entrepreneurial ecosystems for new product development.

Considering the interest to investigate the relationships between design capabilities and entrepreneurial ecosystems, the logic of competition and the complexity of the technology driver in the examined projects are critical factors to consider to describe the new potential space of intervention for design capabilities. Otherwise, the level of engagement in which design capabilities intervene will still report to the internal companies' strategies for new product development.

For this reason, the selections of the projects that will constitute each case study will rely on the logic of competition adopted and on the complexity of the driving technology as the characteristics that define the projects for the investigations.

NPD projects selection

The first investigation focused on testing the assumption by considering the logic of competition as the differentiator between new product development results. It was concerned with conducting and examining one case study built on several new product development projects. Specifically, the case study was described by six projects. The investigation adopted the result perspective as the guide for selecting the projects. The result perspective argues that projects can be defined by the variation in their goal and intended effects (E. S. Andersen, 2008; J. R. Turner & Müller, 2003). Therefore, the project activities are influenced by the project goal and the expected outcome, which influence the organization of activities in the project coherently with the logic of competition they serve (e.g., see Jansson & Ljung, 2013). The adoption of the result perspective for the selection of the projects was deemed fundamental for investigating the relationships between design capabilities and entrepreneurial ecosystems under the two logic of competition of interest, namely the dominant design and the adaptive logics.

The case study drew on six projects developed within the "Organizational Models for Innovation" course at IIT Institute of Design (Chicago, Illinois) over the 2019 fall semester (Dastoli et al., 2021). The course teaches professional designers enrolled in the master program to strategically integrate skills, techniques, sensibilities, practices, processes, and strategies institutionally and geographically dispersed. The course aims to prepare professional designers to plan, implement, and manage complex collaborative projects using design capabilities.

The course projects were deemed consistent with the investigation scope as they were informed by theoretical concepts that are widely acknowledged in the entrepreneurial ecosystems literature. Specifically, the projects explore the engagement with systemic knowledge by relying on concepts of knowledge diversity and proximity, network relationships, platforms, and technology affordances. Professional designers put these concepts into practice in the form of visual models of systemic knowledge interactions and design experiments for new product development by drawing on selected packaging companies they were assigned to. It was interesting to note that although the theoretical imprinting of the projects relied on systemic knowledge engagement for new product development, the projects followed different goals that influenced the project activities (Table 3. 1). Therefore, the examination of the first case study related to comparing capabilities relationships in the projects under this condition of change.

CASE STUDY 1

NPD PROJECTS	PROJECTS GOALS	PROJECTS EXPECTED OUTCOMES	ADOPTED LOGIC OF COMPETITION
PROJECT A1	Increased packaging functionality	Dark kitchen model	DOMINANT DESIGN
PROJECT B1	Sustainable packaging development	Food packaging hub	DOMINANT DESIGN
PROJECT C1	Packaging solutions for new food typologies	Food packaging laboratory	DOMINANT DESIGN
PROJECT D1	Incubation platform design for natural food production	Creation of profitable companies with sustainability values and goals	ADAPTIVE
PROJECT E1	Hybrid model of sustainable manufacturing and distribution	Local circular economy	ADAPTIVE
PROJECT F1	Micro-factory of food production and consumption	Local production and consumption	ADAPTIVE

Table 3. 1 New product development project's classification for case study 1

The second investigation focused on a case study described by four projects of four packaging companies that develop new products for innovating in the food industry. Although the selection of the companies and related projects was made based on opportunities presented to the researcher, all of them showed an interest in the research topic. The interest shown was considered a relevant criterion of selection as it can indicate that companies are informed and representative of the topic of interest under investigation (P. Jones, 2018).

The participants involved in the case studies are enrolled in the top management category of the companies, covering roles of innovation managers, executive technology director, executive marketing director, and executive office director. They were first contacted via email, where a cover letter introducing the researcher's profile and affiliation, the research topic, and the scope was attached. Furthermore, the email informed them about their role in the research and the procedure of investigation. Once they showed interest in participating, they were asked to select a new product development project they could tell about by briefly describing the project goal and expected output. Moreover, companies were asked to indicate the technology that drove the project for new product development. As in the first case study, this step was fundamental for selecting the projects to investigate by focusing on the competition logic adopted for developing the new product (Table 3. 2). Indeed, only projects that was developed by engaging local resources of production and consumption were selected. When the projects were selected and classified under the two logics, participants were informed about the contents of the interview, selected as the procedure of investigation. Thus, they received the interview protocol in advance so that they could be prepared for the day of the interview.

CASE STUDY 2

NPD PROJECTS	PROJECTS GOALS	PROJECT EXPECTED OUTCOME	ADOPTED LOGIC OF NPD
PROJECT A2	High-performance and sustainable packaging	Increased shelf-life through sustainable materials	DOMINANT DESIGN
PROJECT B2	High-functional packaging development	Improved food delivery experience	DOMINANT DESIGN
PROJECT C2	Packaging customization platform development	Highly personalized B2C food packaging service	ADAPTIVE
PROJECT D2	Business model for local vegetable dairy production and consumption	Local production and consumption hub of vegetable-based dairy	ADAPTIVE

Table 3. 2 New product development project's classification for case study 2

The second case study also focused on testing the assumption by considering the complexity of the driving technology as influencing new product development projects results. The decision to consider technology complexity exclusively in the context of the second case study was derived from three reasons. First, the first case study was intended as a self-contained study conducted at the IIT Institute of Design. Therefore, given the academic setting of the study, the researcher involved professional designers within the lasting course period. Second, the second investigation aims to test capabilities relationships by considering the influence of the technology's complexity on the project activities. This requires that participants developed the projects by perceiving the driving technology as a constraint given its technology affordances. Consequently, the researcher found that the top management in real company settings can provide informed descriptions of the project activities due to the technology's complexity. Third, and most important for the investigation's objective, the selected projects were driven by technologies with different complexity. As explained in Chapter 4.4, the measurement of the technology complexity requires that a specific technology drives the project's development. Hence, relying on people who work in real projects can provide the necessary information for the measure.

As described in the next section, technology complexity was measured by following the method used by Broekel (2018) that identifies the technology age. The younger the age, the higher is the technology's complexity. Starting from this point, projects were classified in terms of the complexity of their driving technology (Figure 3. 3). This allowed interpreting interview results under the perspective of technology as influencing the organization's engagement activities organization over sensing, seizing, and reconfiguring within the two competition logics (Figure 3. 4)

Then, results from the first and second parts of the case study were qualitatively compared to explain the influence of the two conditions of change on capabilities relationships.

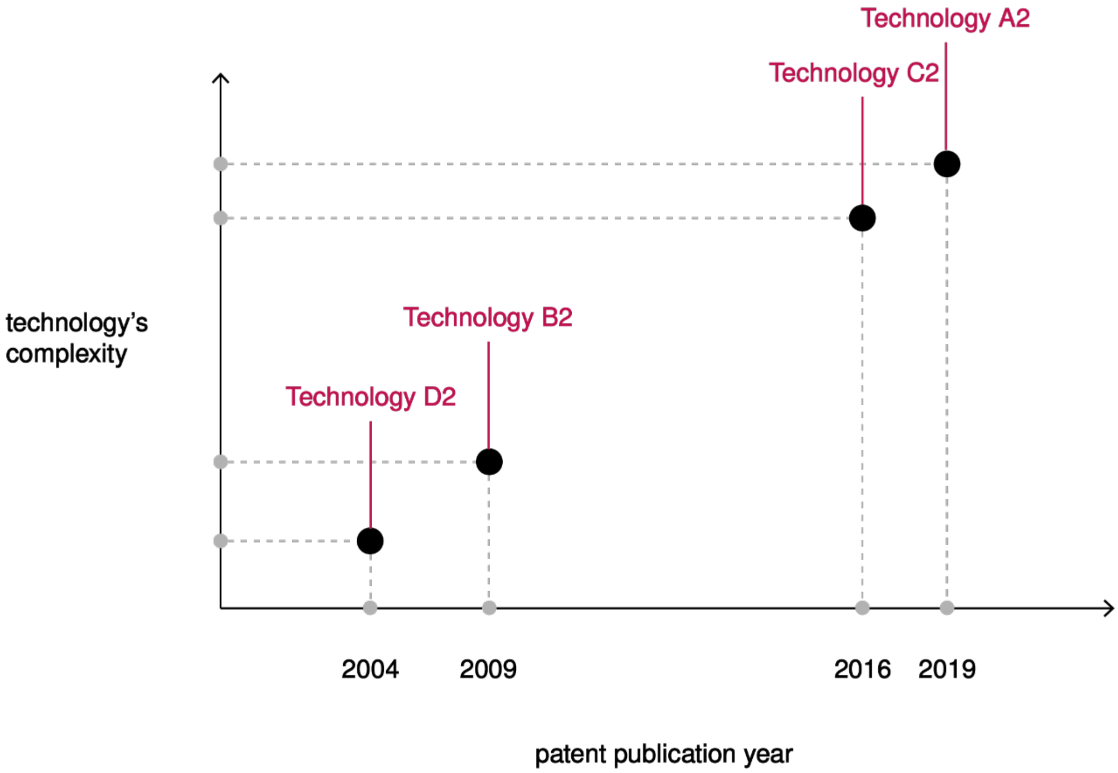


Figure 3. 3 The complexity of the projects' driving technologies based on their patent publication year

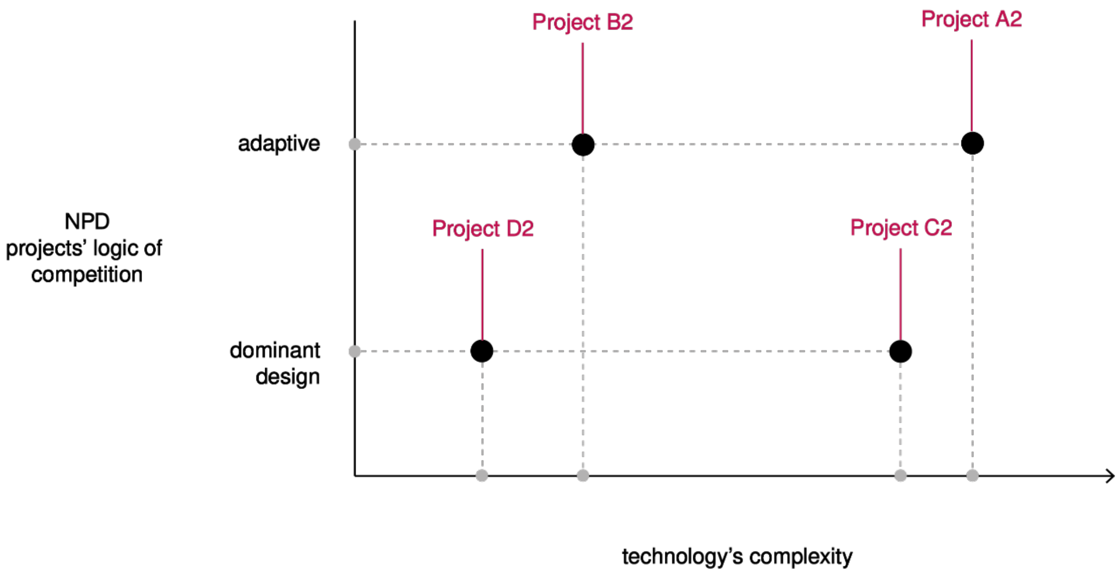


Figure 3. 4 NPD projects classification based on the logic of competition they reflect and the complexity of the projects driving technology

Below, the explanation about how the collected data were organized can guide readers in understanding the design of the research investigations.

Datasets

Two datasets were created as a partial representation of the information collected throughout the two investigations. They were structured by integrating the separate and different data collected over the case studies so that it would have been possible to interpret them as a unit to answer the research questions.

The first dataset relates to the first case study and reports the exploration of capabilities relationships throughout six new product development projects. The second dataset reports the description of capabilities relationships retrieved from the four new product development projects of the second case study.

The datasets have been integrated under the two investigations, which refer to investigating the assumption under the two primary conditions of change. Specifically, the first dataset serves the investigation of the first condition of change, or the logic of competition, while the second dataset serves the investigation of the second condition of change, or the complexity of the technology, by integrating it within the different logics of competition in new product development. Figure 3. 5 illustrates the final structure of the datasets.

The next section describes the research investigations that relied on the datasets' structure over their development.

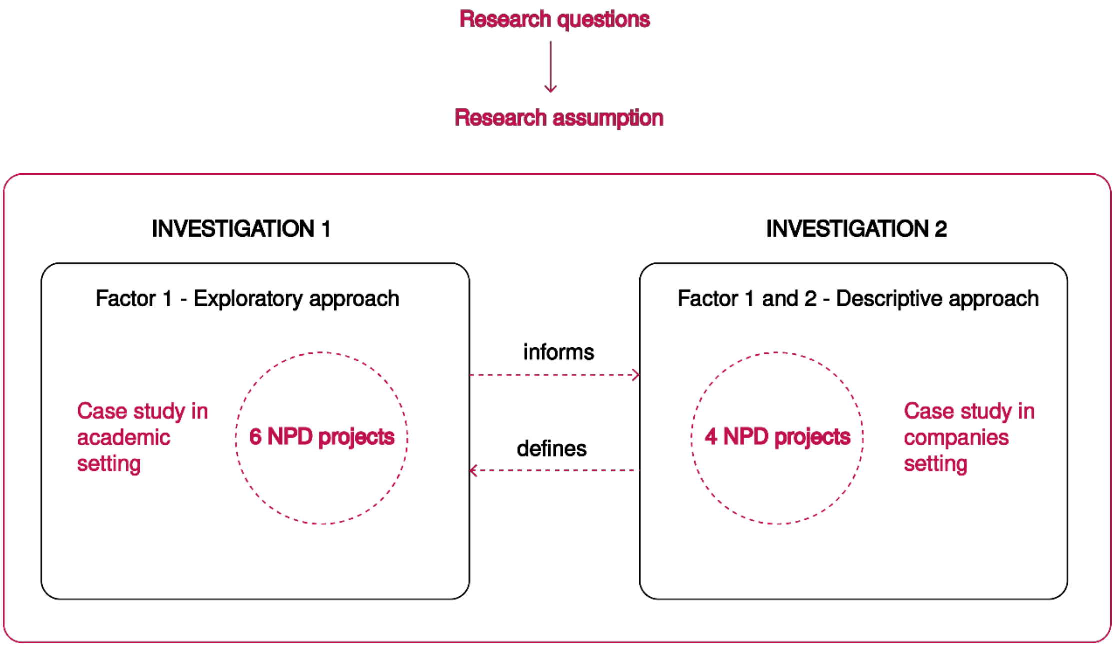


Figure 3. 5 Research datasets

4. INVESTIGATING THE RELATIONSHIP

4.1. Integrating knowledge

Developing an engagement-driven taxonomy

Developing a new taxonomy of design capabilities was deemed fundamental for relating design capabilities for competitive new product development to organizational capabilities of entrepreneurial ecosystems as the current classifications of design capabilities for competitive new product development focus on firm-level scopes (i.e., increasing performance) and categorization dimensions (i.e., strategic contribution to company's profitability). When the context of intervention of design capabilities for new product development is the multi-actor interface of entrepreneurial ecosystems, the connection between design and entrepreneurial ecosystems capabilities refers to establishing relationships and is enabled by the engagement dimensions of design capabilities. By reframing the categorization dimensions of design capabilities for competitive new product development, it is possible to widen the lenses that define design capabilities at the network level of intervention of entrepreneurial ecosystems.

In this context, the scope of classifying design capabilities draws on accessing knowledge and strengthening relationships, while the categorization relies on the engagement dimensions of design capabilities. Specifically, the literature review that defines engagement in multi-actor interfaces refers to open innovation practices as a form of collaboration (Loureiro et al., 2020). This perspective distinguishes the cognitive and experiential dimensions as engagement enablers when the company aims to compete through establishing relationships (Lopez-Vega et al., 2016; Loureiro et al., 2020). Therefore, classifying design capabilities under cognitive and experiential dimensions of open innovation practices of collaboration might allow for investigating how design capabilities can support the company’s engagement with the multi-actor interface of entrepreneurial ecosystems. Engagement enables companies to access knowledge and strengthen relationships for new product development. Hence, the design capabilities support to engagement finalities of entrepreneurial ecosystems capabilities allows for co-creating interactions that enable new product development through network-level entrepreneurial knowledge.

Under these premises, the new taxonomy of design capabilities integrate multiple theoretical concepts: (a) the scope refers to the logic of competition of entrepreneurial ecosystems (i.e., efficiency in terms of accessing knowledge and strengthening network-level knowledge relationships), (b) the categorization criteria concerns the dimensions of engagement of cognitive and experiential practices of open innovation for boundary-spanning (i.e., simplify complexity and driving actions), (c) design capabilities for competitive new product development are the categorized elements.

The taxonomy has been developed by categorizing design capabilities under an ontological criterion (Blaikie & Priest, 2019; Corbetta, 2015). Therefore, design capabilities have been classified by considering their intrinsic form in relation to the defined categorization dimensions. By deriving from the literature review what constitutes design capabilities that simplify complexity and drive actions, it has been possible to classify design capabilities for competitive new product development under a different lens. Rather than providing their strategic role for companies' profitability, the taxonomy shows the design capabilities that refer to engagement in open innovation contexts thanks to their ontological characteristics (see Table 4. 1).

Design capabilities that simplify complexity

Simplifying complexity is the first taxonomy category and represents the cognitive dimension enabling engagement in entrepreneurial ecosystems. When cognitive search support engagement through practices that simplify complexity, design capabilities that ontologically belong to those practices have been reported. As Simon (Simon, 1991) described, cognition refers to the simplification of complex problems space through the representation of concepts. Gavetti and Levinthal (2000) relate cognition to those mechanisms that support the conceptualization of the company in relation to its environment. Lopez-Vega et al. (2016) define cognitive heuristics as the knowledge achieved through mechanisms of knowledge codification. Hence, simplifying complexity can be defined as the dimension that categorizes design capabilities that synthesize and make knowledge tangible through cognitive learning.

Weil and Mayfield (2020) refer to *visualization* as the capability that simplifies framing and communicating complex systems. Therefore, designers can make intangible insights and concepts workable by recurring to physical artifacts like sketches, mock-ups, storyboards, and prototypes that embody and communicate abstraction. Remarkably, the design practice emphasizes the role of prototypes in concretizing and externalizing conceptual ideas (Lim et al., 2008). Under this perspective, prototypes are "filters that traverse a design space" (Lim et al., 2008, p. 5) or "embodiments of critical elements of the intended design" (Lauff et al., 2018). Although prototypes for new product development are often intended as a means for formal evaluation, their characteristic of simplifying complexity is widely acknowledged in design practice (Houde & Hill, 1997).

Prototypes and other kinds of representations represent the ability of design to *integrate knowledge* and thus act as a medium for simplifying the communication and negotiation of different perspectives (Celaschi et al., 2009). Dorst (1997) defines the visual dimension of knowledge integration as fundamental for establishing a network of decisions related to a topic while considering heterogeneous contents. Therefore, design codifies the knowledge embedded in the individuals and products interactions over collaboration for new product development (Bertola & Teixeira, 2003).

Consequently, the communication among distributed perspectives is enabled by visual artifacts that embed the knowledge complexity of new product development (Andreasen et al., 2015). *Visual communication* creates and consolidates the requirements to develop new products, such as understanding tasks, the conditions for synthesis, and choices (Henderson, 1998). By creating a shared understanding of product requirements through tangible means, visual communication simplifies sharing norms and values and codifies tacit knowledge (Beckman & Barry, 2009).

The dialogue embedded in visual communication enables the inquiry, divergence, and convergence over the design process. Under this perspective, Beckman (2020) positions *framing* and *reframing* capabilities in the cognitive dimension of learning as they involve inquiry to uncover assumptions and acknowledge the limitation in perspectives for seeing alternative frames. While framing supports the legitimacy of alternative perspectives, reframing sustain the common understanding of a situation. Consequently, framing and reframing represent the ability to connecting different and collective narratives thus simplifying the complex problem space through the communication of the guides for decision making (Beckman & Barry, 2009).

Making decisions for new product development implies that different perspectives negotiate a shared vision. Jones (2014a) defines *negotiation* as the design capability to generate agreement between different perspectives. However, in heterogeneous context of participation designers "move towards practices where differences and controversies are allowed to exist, and dilemmas are raised and possibilities explored" (E. Björgvinsson et al., 2012). The participatory design literature acknowledge conflicts as an opportunity to explore possibilities that might eventually lead to alignment (e.g., see S. Pedersen & Clausen, 2017; Storni et al., 2015). Therefore, in complex contexts of participation, negotiation is defined as the ability to enable the conditions of diversity participation around matters of concern (Andreasen et al., 2015; Dindler & Iversen, 2014; Signe Pedersen, 2020; Wilson & Zamberlan, 2015). Hence, negotiation simplifies the complexities involved in providing a shared vision within a landscape of multiple actors and relations, in terms of establishing and transforming personal and professional relationships around a shared vision (Bødker et al., 2017; Dindler & Iversen, 2014).

While negotiation allows for exploring new possibilities given different perspectives and expertise, *envisioning* as the ability to imagine and represent alternative futures supports new products development by helping teams holding new frames together (Beckman, 2020). When scenario representations embed connections among different frames, the understanding of the complex construction of concepts is simplified. Liedtka (Liedtka, 2020) highlights that making connections tangible support the seizing of opportunities when preventing error represents a barrier to new product development and innovation. Consequently, the simplification of new concepts through representations supports decision-making.

Design capabilities that drive action

Driving action is the second category of the taxonomy and represents the experiential dimension enabling engagement in entrepreneurial ecosystems. When experiential search support engagement through practices that drive action, design capabilities that ontologically belong to those practices have been reported. Gavetti and Levinthal (2000) describe experiential mechanisms of knowledge search relying on direct feedback on current activities. Experience allows trying actions and experiencing outcomes for improvements (Levitt & March, 1988; Zollo & Winter, 2002). Hence, driving action can be defined as the dimension categorizing design capabilities that involve the partial implementation of alternatives for informing new actions through experiential learning.

In this context, the design literature reports *experimentation* for new product development as the ability to learn through iterative forms for acquiring updated products information (e.g., see Beverland et al., 2016; Micheli et al., 2018). Experimentation is related to obtain early feedbacks about the new product with minimum investments in the up-front phase of new product development (Lisa Carlgren et al., 2016; Micheli et al., 2018). Iteration, trial and error and prototyping make experimentation a low risk opportunity to fail and learning through failures (Schrage, 2014). Hence, by eliciting the product requirements through prototypes, experimentation capability drives the new actions to be performed for new product development.

Beltagui et al. (2019) highlights that iteration, trial and error and prototyping are well suited to complexity and uncertainty as they provide information to overcome initial ambiguity of new product development projects. Traditionally, consumers provide the input to improving actions (Thomke, 1998). However, Verganti (2009) argues that providing an exclusive reliance on customers inputs leads to limiting the innovation possibilities. Therefore, the author introduces *criticism* as the ability to learning from the collection and interpretation of information gained by network partners in new product development (Verganti, 2016; Verganti & Öberg, 2013). Elder and Paul (2013) emphasizes that criticism is the ability to absorb the deep life experiences of systemic users so that new frames for new product development are enabled. In these terms, criticism drives new actions by submitting early products to a broader set of inputs.

Accordingly, Hargadon and Sutton (1997) find a community of users as the broader context from which translating signals toward internal resources mobilization. Throughout participatory observations of the product usage within community of users, *knowledge brokering* expands the possibilities for collecting feedbacks and insights about new product development. Bertola and Teixeria (Bertola & Teixeira, 2003) highlight that knolwegde brokering provides companies the helpful information for adapting business processes to emerging social and cultural change, thus driving new actions for new product development.

Within a context of expanded participation, the collection of diverse input toward effective actions is driven by the design ability of *sampling*. As far as new product development becomes a complex social domain, Jones (2018) argues that a user base cannot inform design decisions for new product development as the design team may not know enough the final target. Therefore, selecting the idoneous participants in information collection activities represent a fundamental ability of design in order to drive strategic actions (Andreasen et al., 2015). Under this perspective, Jones (2018) suggests sampling models and frames in estimating the population characteristics. Through social systems models, sampling drives new actions by collecting social system's current interests and interactions.

DIMENSIONS OF OPEN INNOVATION SEARCH	DESIGN CAPABILITIES FOR NPD	DESIGN CAPABILITIES ONTOLOGICAL DESCRIPTION	OBSERVABLE ITEMS	AUTHORS
COGNITIVE SEARCH: SIMPLIFYING COMPLEXITY Engaging through synthesizing and making knowledge tangible (Gavetti and Levinthal, 2000; Lopez-Vega et al., 2016; Simon, 1991)	Visualization	Simplification of framing and of the communication of complex systems	Sketches, drawings, mock-ups, prototypes, and in general physical artifacts	Houde & Hill, 1997 Lauff et al., 2018 Lim et al., 2008 Weil and Mayfield (2020)
	Visual communication	Creation and consolidation of the requirements to develop new products, such as understanding tasks, the conditions for synthesis, and choices	Text, drawings, slides, posters, reports, models in hardware, photo, video, CAD drawings, diagrams, demonstrations	Andreasen et al., 2015 Beckman & Barry, 2009 Henderson, 1998
	Framing	Generation and acknowledgment of the legitimacy of alternative viewpoints	Affinity diagramming Mindmapping Customer journey mapping	Beckman, 2020 Beckman & Barry, 2009
	Reframing	Negotiation of meaning, shared mental models and common understanding of a situation	Future workshops Counter-briefs	Beckman, 2020 Beckman & Barry, 2009
	Negotiation	Establishmen and transformation of personal and professional relationships around a shared vision	Brainstorming sessions, Holding retreats; Focus groups; Future workshops;	Andreasen et al., 2015; Bødker et al., 2017; Dindler & Iversen, 2014; Pedersen, 2020; Wilson & Zamberlan, 2015
	Envisioning	Holding new frames together	Scenario representations Storyboards	Beckman, 2020 Liedtka, 2020

(continued)

DIMENSIONS OF OPEN INNOVATION SEARCH	DESIGN CAPABILITIES FOR NPD	DESIGN CAPABILITIES ONTOLOGICAL DESCRIPTION	OBSERVABLE ITEMS	AUTHORS
EXPERIENTIAL SEARCH: DRIVING ACTION Engaging through experiential learning (Gavetti and Levinthal, 2000; Lopez-Vega et al., 2016; Zollo and Winter, 2002)	Experimentation	Elicitation of the product requirements	Prototypes, A/B test	Beltagui et al., 2019 Beverland et al., 2016 Carlgren et al., 2016 Micheli et al., 2018 Schrage, 2014 Thomke, 1998
	Criticism	Absorbtion of the deep life experiences of systemic users	Providing "things to use"; Providing broader perspectives	Elder and Paul, 2013 Verganti, 2009 Verganti, 2016 Verganti and Öberg, 2013
	Knowledge integration	Codification of the knowledge embedded in the individuals and products interactions	Formal representations of abstract concepts (e.g., models, metaphors, and synthetic images)	Bertola & Teixeira, 2003 Celaschi et al., 2009 Dorst, 1997
	Knowledge brokering	Translation of signals about social and cultural changes	Participatory observations Focus groups	Bertola and Teixeira, 2003 Hargadon and Sutton, 1997
	Building empathy	Self-identification in others' perspectives	Ethnographic observations Qualitative interviews	Carlgren et al., 2016 Connel and Tenkasi, 2015 Micheli et al., 2018

Table 4. 1 The engagement-driven taxonomy of design capabilities for NPD as informed by open innovation

4.2. Framework development

The logic behind framework structuring

The logic adopted for the framework structure development aimed to create an investigation space that visually could relate capabilities belonging to two different domains: design and entrepreneurial ecosystems. Specifically, each domain reports the level of engagement within which capabilities intervene for new product development. Therefore, the area for the visual investigation of relationships arises from two primary and distinct axes, each reporting the domain capabilities of interest and the related dimensions. Specifically, visual investigation of relationships draws on a grid structure that originates from individual capabilities along the two primary axes (Figure 4. 1). Each capability of one domain can potentially intersect with all the capabilities of the other domain, and intersections nodes indicate this possibility within the investigation space.

The capabilities differ in their classification criteria along the two domain axes. While design capabilities are reported in terms of ontological definitions, the capabilities of the entrepreneurial ecosystem have been classified by considering their employment finalities. This choice in differentiating design capabilities by ontology and capabilities of entrepreneurial ecosystems by finality is driven by the necessary conditions that define entrepreneurial ecosystems' interactive new product development process, namely sensing, seizing, and reconfiguring. In order to sense, seize and reconfigure, each capability of entrepreneurial ecosystems supports a specific finality under each new product development dimension. When new product development is a strategy to create new interaction paths, design capabilities need to serve the specific interactive finalities of entrepreneurial capabilities. As far as design capabilities for new product development report different finalities (see Chapter 2.1), their possibility of intervention can be investigated by considering a different classification criterion. Consequently, design capabilities can intervene in new product development if their ontology supports entrepreneurial ecosystems capabilities finalities over sensing, seizing, and reconfiguring.

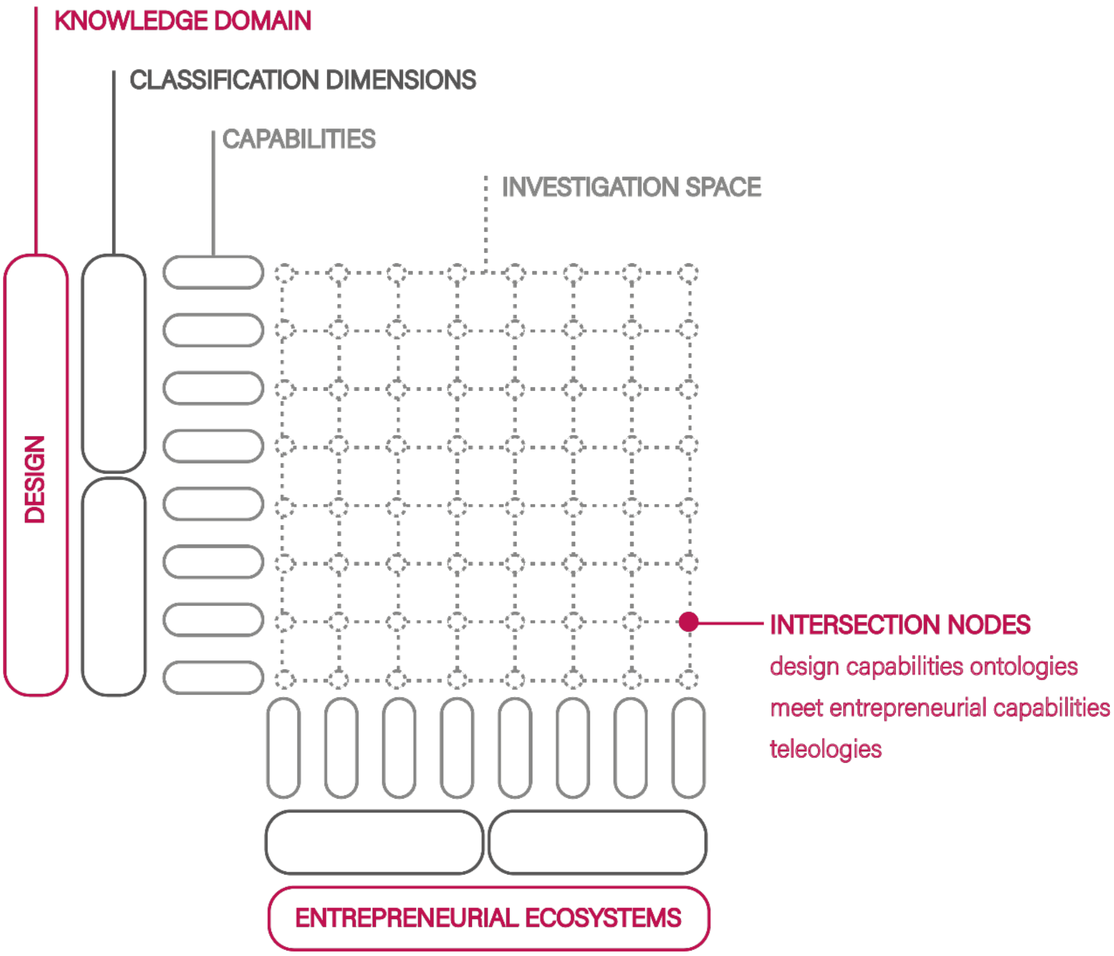


Figure 4. 1 Framework structure for investigating capabilities relationships

Framework description

The framework displays the capabilities identified over the literature review process and clusters them under the defined dimensions along the two axes (Figure 4. 2). On the vertical axis, two design capabilities dimensions enable the engagement at the organizational level of new product development in entrepreneurial ecosystems: simplifying complexity (the cognitive dimension) and driving action (the experiential dimension). The open innovation literature defines the two dimensions as the necessary conditions for engaging with system level knowledge to satisfy system-level goals. Therefore, as described in the previous section (see Chapter 4.1), design capabilities have been ontologically classified under the two dimensions to investigate their intervention possibilities along the horizontal axis.

Hence, the design capabilities that ontologically simplify complexity are:

- Visualization
- Visual communication
- Framing
- Reframing
- Negotiation
- Envisioning

The design capabilities that ontologically drive action are:

- Knowledge integration
- Experimentation
- Criticism
- Knowledge brokering
- Building empathy

The horizontal axis displays the dimensions and related capabilities of new product development in entrepreneurial ecosystems. Specifically, new product development in entrepreneurial ecosystems is described as enabled by three necessary conditions, which refer to the clustering dimensions of entrepreneurial ecosystems capabilities, namely sensing (or identifying opportunities), seizing (or mobilizing resources), and reconfiguring (or adapting actions). Each dimension clusters capabilities with different finalities that support the dimension attainability.

The entrepreneurial ecosystems capabilities that describe sensing are:

- Building legitimacy
- Transactive memory
- Vicarious learning

The entrepreneurial ecosystems capabilities that describe seizing are:

- Proactiveness
- Mentoring
- Framing diversity
- Interactive expertise

The entrepreneurial ecosystems capability that describes reconfiguring is:

- Reflectiveness

The next section describes how the framework has been intended and employed as an analytical and interpretative tool of the research investigations.

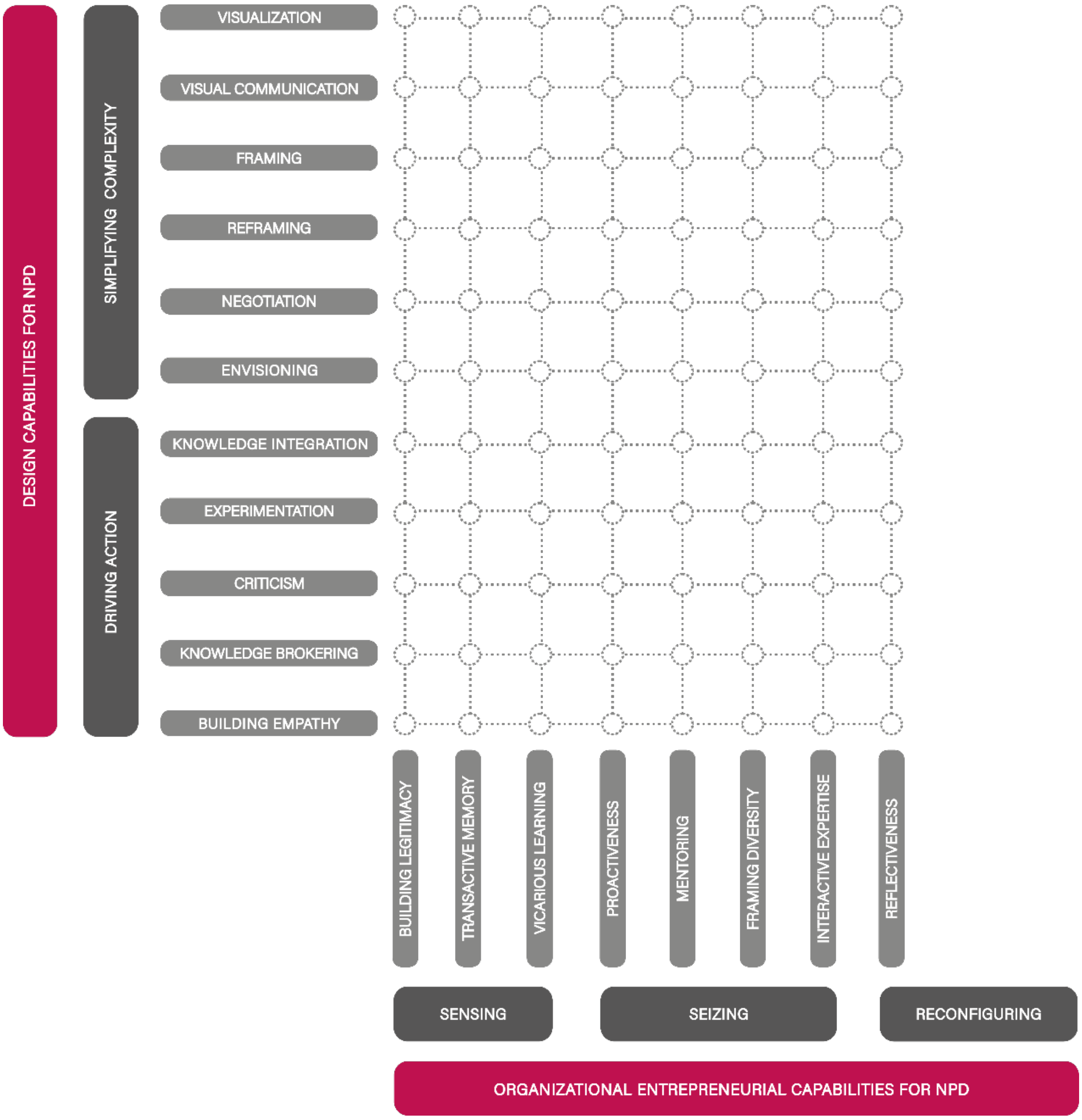


Figure 4. 2 The developed framework

The framework as an analytical and interpretative tool

The framework considers the dimensions and the capabilities of entrepreneurial ecosystems as dependent variables, which finalities results eventually satisfied by specific design capabilities under the different conditions of change.

By reporting the collected results within the grid structure in the form of intersection nodes, the framework allows for visualizing both the *quantity and uniqueness* of capabilities relationships for each investigated project. Quantity and uniqueness as data analysis and interpretation criteria resulted supportive in the analysis and interpretation of the projects at the individual level, and in the following generalization of results when the projects where compared under the conditions of change.

The visualization of the quantity of satisfied entrepreneurial ecosystems capabilities finalities at the individual level of the project informed the limited or expanded possibilities of intervention of design capabilities under the factors of change. Moreover, the position of the capabilities relationships informed the intervention of design capabilities in the sensing, seizing and reconfiguring dimensions of entrepreneurial ecosystems.

The visualization of the uniqueness of satisfied entrepreneurial ecosystems capabilities finalities at the individual level of the project enabled a deeper interpretation of the projects under the condition of change under examination. Specifically, the definition of the condition of change as enabler of different entrepreneurial knowledge engagement modalities, as supporter of specific purposes and as driver of specific design capabilities impacts over the sensing, seizing and reconfiguring dimensions allowed for understanding the uniqueness of capabilities relationships, as it will be show over the next sections.

4.3. The influence of the logic of competition

Case study setting and data collection

The first case study was conducted within the academic context of IIT Institute of Design, by employing the “Organizational Models for Innovation” course as the investigation platform. The course theme guided the preliminary activity of companies' selection and profiling for the enablement of projects development. The course focused on the local assembly in manufacturing as the driving topic for guiding the organization and integration of collaborative practices among distributed expertise for new product development in the food industry context.

Although new product development in manufacturing for the food industry strongly relies on the implementation of mass customization paradigms of production and consumption that satisfy consumers demand on a global scale (Jovane et al., 2003), it is widely acknowledged that the globalization of food production has increasingly distanced consumers, both geographically and socially, from producers and production areas. Meanwhile, consumers increase their awareness of environmental, ethical, and health-related issues when consuming food, reflecting their preferences on customized offers on a local scale (Autio et al., 2013). In this context, manufacturing companies can cover this gap by leveraging new actions possibilities informed by the technologies they exploit for new product development. Therefore, companies can take advantage of involving heterogeneous knowledge that can participate in the development of new products as informed by technology affordances. Consequently, being able to structure and organize the collaboration and integration of diverse and distributed expertise represents a necessary condition for manufacturers; here is where design capabilities might provide significant new support.

Starting from this objective, the researchers selected and profiled packaging manufacturing companies in the Chicago region so that professional designers could explore local know-how to develop the projects. Specifically, six companies were taken into account as six working teams were established in the course. In line with the course theme, selected companies were selected as they showed signals of local production and consumption (Table 4. 2). The researchers searched the information mainly through the companies' websites and published projects reports. This also allowed for outlining the companies primary production purposes so that the working teams could develop projects inspired by the companies characteristics. Once the companies were selected and profiled, they were assigned randomly to the working teams.

CASE STUDY 1

SELECTED COMPANIES	PRODUCTION PURPOSES	SIGNALS OF LOCAL PRODUCTION AND CONSUMPTION
COMPANY A1	Packaging functionality	Packaging for distributing milk in local vending machines; Customizable packaging filling equipment
COMPANY B1	Sustainable packaging development	Virtual packaging assistant for local guidelines on packaging materials restrictions; Sustainable packaging materials for food delivery
COMPANY C1	Contract packaging	Flexible filling packaging machinery; Custom packaging for local food manufacturers
COMPANY D1	Healthy nutrition	Co-packaging for local and organic food; "Meet the farmer" events for increasing local production of organic food
COMPANY E1	Hybrid packaging supply	Large network of manufacturers and distributors around the world; Custom and value added services
COMPANY F1	High-efficiency filling	Packaging machinery innovation for custom packaging applications; Upstream and downstream equipment for local farm-fresh food packaging

The development of projects lasted seven weeks and consisted of two different phases: the first six weeks of the semester were intended to inform professional designers of the main concepts supporting new product development in open innovation models. Specifically, the teams were provided with theoretical readings explaining concepts of diversity and proximity, networks, technology affordances, and platforms for new product development. The acquisition of the concepts was primarily intended as an extra-class activity so that their absorption through principles extrapolations could be improved within the weekly class appointment. Indeed, each class was organized around the discussion and speculation about main questions such as: “In what ways design capabilities can be integrated into local manufacturing systems of production?”; “What organizational models are most effective in integrating design capabilities into innovation districts, such as in the city of Chicago?”; “What new capabilities are necessary for design to be a fundamental know-how in shaping the development of local and inclusive economies?.”

Meanwhile, the teams were assigned to develop a visual model starting from the assigned company. Each model reported the visual organization of dispersed regional know-how and its integration by explicit enabling design strategies. Therefore the first six weeks led to the development of six organizational maps that incorporated the concepts learned and articulated the relationships between dispersed know-how from a design perspective. The visual models visually explained the relationship between agents, capabilities, and the idealized open innovation system. Although the models displayed an abstract idealization of the open innovation system for each company, they evidenced the relevant aspects of the chosen context of abstraction. Hence, the evidence retrieved from the situated context of idealization justified the appropriateness of the design strategies being recommended by the working teams.

The last course week was intended for the new product development planning by taking advantage of the diverse know-how displayed in the models. Project planning for developing a new product or service required the working teams to proper resourcing, sequencing, and scheduling design activities. It involved working teams to understand the function of design practices and the affordances of production systems in new product development while promoting local and diverse economies.

The plans were based on multiple cycles of quick and cheap experiments that integrate exploration, co-creation, prototyping, and stakeholders engagement. The working teams were informed about the procedure of project planning by Schrage's 5x5x5 framework described in his book The Innovator's Hypothesis (2014): give diverse teams of five people up to five days to come up with portfolios of five business experiments costing no more than $5,000 each and taking no longer than five weeks to run. Although the business experiments omitted the cost part of the framework, they reported a comprehensive list of activities over the new product development projects that were then considered the main informative data for design capabilities identification.

The next section reports the detailed description of the projects before describing the data collection phase of the case study.

Projects description

As outlined in the sampling strategy, the six projects were selected and classified under the two different logics of new product development: the dominant design and the adaptive logic. While the projects' expected outcomes informed the researcher that the projects involved the engagement of systemic knowledge for new product development, and therefore that they could be valid resources for the research investigation, what primary made the distinction between the two competition logics referred to the projects' goals. When new product development projects in manufacturing aim to engage in collective efforts for improving or radically designing new product solutions, they reflect a dominant design logic of competition. Conversely, when they aim to engage in collective efforts to support entrepreneurial activity development, they reflect an adaptive logic that embeds activities of incremental collaboration for new product development. Simply put, the goals of a dominant design logic refers to developing new product solutions (radical or incremental), while the goals of an adaptive logic reflect collaboration as a fundamental approach enabling new product development.

Three projects were classified under the dominant design logic, and three under the adaptive logic (see Chapter 3.5). Table 4. 3 outlines the comprehensive list of experiments for each project.

CASE STUDY 1

LOGIC OF COMPETITION	NPD PROJECTS	PROJECTS EXPECTED OUTCOMES	PROJECTS GENERAL GOALS	PROJECTS DESIGN-LED BUSINESS EXPERIMENTS	PROJECTS TOTAL ACTIVITIES ANALYZED
DOMINANT DESIGN	PROJECT A1	Dark kitchen model	Increased packaging functionality	EXP 1: Co-design a shared kitchen space EXP 2: Personalizing packaging for direct-to-consumer (D2C) orders EXP 3: Producing short-runs of packaging for specialized and local events EXP 4: Engaging consumers in developing packaging products for sustainable recycling EXP 5: Engaging supermarkets in using new packaging products for sustainable recycling	78
	PROJECT B1	Food packaging hub	Sustainable packaging development	EXP 1: Collecting wasted packaging and reuse it in the clothing industry EXP 2: Building a "transparent plant" for showing consumers sustainable packaging manufacturing processes EXP 3: Developing reusable delivery containers EXP 4: Co-designing the sustainable packaging of the future with customers EXP 5: Prototyping nature-inspired packaging	34
	PROJECT C1	Food packaging laboratory	Packaging solutions for new food typologies	EXP 1: Consumer-driven co-design workshop EXP 2: Policy-makers co-design workshop EXP 3: Retailers co-design workshop EXP 4: Matchmaking workshop between local farmers and start-ups EXP 5: Pop-up packaging laboratory running in local events	60
ADAPTIVE	PROJECT D1	Creation of profitable companies with sustainability values and goals	Incubation platform design for natural food production	EXP 1: Engaging employees in continuous improvement processes EXP 2: Providing employees with instructions EXP 3: Feeding the incubation EXP 4: Connecting local farmers with food manufacturers through speed dating EXP 5: Seeding sustainable knowledge and practices with academia.	87
	PROJECT E1	Local circular economy	Hybrid model of sustainable manufacturing and distribution	EXP 1: Experimental partnership cycle of design sprints EXP 2: Simulation of co-ownership patent development EXP 3: Hackathon for activating collaborative partnership between production and consumption actors EXP 4: Matchmaking event between local start-ups and investors EXP 5: Assessment of a waste prediction platform	48
	PROJECT F1	Local production and consumption	Micro-factory of food production and consumption	EXP 1: Prototyping the micro-factory concept EXP 2: Assessing the concept through a hackathon event EXP 3: Testing the concept in a grocery store EXP 4: Open a pop-up store for testing the concept EXP 5: Stakeholder workshop for defining the base infrastructures and machine modules for the concept realization	97

Table 4. 3 Case study 1: projects description and classssification on the basis of the logic of competition they reflect

The projects that reflected a *dominant design* logic of competition were: Project A1, B1, and C1.

Project A1 was developed as an explorative project informing new product development possibilities for company A. The project developed and tested a "dark kitchen" model, which represents a growing concept in line with the exponential rise of food delivery. The company currently has expert capabilities in packaging design, food manufacturing, insights and product development, Just-In-Time manufacturing, and circular supply thinking. By combining company A's core competencies toward a scalable dark-kitchen model design, a customized, low-cost, efficient, and flexible direct-to-consumer business was hypothesized. The project was developed through five design-led business experiments that aimed at engaging with systemic actors by focusing on increasing packaging functionality over the different phases of the dark-kitchen model design and testing. Specifically, Project A1 was described by design activities that allowed for: co-design a shared kitchen space, personalizing packaging for direct-to-consumer (D2C) orders, producing short-runs of packaging for specialized and local events, engaging consumers in developing packaging products for sustainable recycling, and engaging supermarkets in using new packaging products for sustainable recycling.

Project B1 explored new product development opportunities for company B. The primary characteristics of the company relate to the production of packaging products by using sustainable materials. The project focused on expanding the company intervention within the sustainable context of production and consumption by planning experiments that explored the company's collaborative work with diverse actors. The project aimed to expand sustainable practices throughout the food packaging supply chain, thus including packaging materials manufacturing, production, delivery, disposal, reuse, and repurpose. The design-led experiments focused on: collecting wasted packaging and reuse it in the clothing industry, building a "transparent plant" for showing consumers sustainable packaging manufacturing processes, developing reusable delivery containers, co-designing the sustainable packaging of the future with customers, and prototyping nature-inspired packaging.

Project C1 was developed as an explorative project informing new product development possibilities for company C. The company is a local co-packaging and co-manufacturing reference point for packaging processing in the region. The project focuses on the company's difficulty when clients demand the packaging of innovative food products. By hypothesizing that a packaging innovation laboratory could contribute to innovative and flexible packaging solutions, the project plan outlines the following five design-led business experiments: a consumer-driven co-design workshop, a policy-makers co-design workshop, a retailers co-design workshop, a matchmaking workshop between local farmers and start-ups, and a pop-up packaging laboratory running in local events.

The projects that reflected an *adaptive* logic of competition were: Project A1, B1, and C1.

Project D1 explored new product development opportunities for company D, which has experience in the natural food industry and strategic business operations. The project aimed to leverage the company's capabilities towards the development of an incubation platform that could accelerate the growth of entrepreneurial activity and strengthen the regional food industry. By identifying, investing in, and growing startups, the project supported a bottom-up approach to changing the landscape of the food industry toward the adoption of natural, healthy, and sustainable practices. Through the sharing of expertise, the creation of profitable companies that support building a collaborative ecosystem for societal improvement was expected as the project's outcome. Specifically, the project focused on planning the following design-led business experiments: engaging employees in continuous improvement processes, providing employees with instructions, feeding the incubation, connecting local farmers with food manufacturers through speed dating, and seeding sustainable knowledge and practices with academia.

Project E1 explored new product development opportunities for company E. The company is a worldwide acknowledged supplier of hybrid packaging solutions. The company first introduced the idea of taking the best and dispersed know-how of packaging manufacturing and distribution to build a hybrid value chain. The project aims to develop a sustainable and local hybrid model of production and distribution by engaging with the local actors of the Chicago region. Being been hypothesized as led by the competencies of the company's Future Department, the project planned the following design-led business experiments: an experimental partnership cycle of design sprints, a simulation of co-ownership patent development, a hackathon for activating collaborative partnership between production and consumption actors, a matchmaking event between local start-ups and investors, and the assessment of a waste prediction platform.

Project F1 was developed as an explorative project informing new product development possibilities for company F. The company is a local package machinery company based in Chicago, who develops packaging machinery solutions for clients within the food industry. The project expanded the possibilities of intervention of the company within a systemic context by repositioning company E from an upstream machine-producing company to a member of a micro-factory platform in Chicago. Specifically, the project envisioned a future system of local production and consumption that incorporates several infrastructures at the basis of the platform. For this purpose, the project was planned by the following design-led business experiments: prototyping the micro-factory concept, assessing the concept through a hackathon event, testing the concept in a grocery store, open a pop-up store for testing the concept, and a stakeholder workshop for defining the base infrastructures and machine modules for the concept realization.

The described projects were defined by a comprehensive list of activities that were collected and then analysed as explained in the next section.

Data interpretation strategy

Each project plan provided a comprehensive list of activities (seeTable 4. 3). The research identified design capabilities by drawing on the activities that inform them as observable items (Fleurbaey, 2006). Specifically, each activity was tagged when reflected a specific design capability coherently with the observable items retrieved from the literature review and reported within the taxonomy. Consequently, capabilities relationships over the investigation derived from identifying those observable items of design capabilities that supported the finalities of entrepreneurial ecosystems capabilities.

An example is here provided for explaining the adopted strategy. Each new product development project plans described the activities conducted over the process when system-level knowledge had to be involved. Each activity over the project refers to one or more observable items of design capabilities retrieved from the literature. For instance, experimentation capability as the elicitation of product requirements in design refers to prototyping as the observable items. From the entrepreneurial ecosystems perspective, prototyping serves to recognize and work with what matters for others and informs the interactive expertise capability. However, the design activities might have employed prototyping for different finalities, such as identifying useful knowledge (i.e., transactive memory capability's finality in entrepreneurial ecosystems). Hence, prototyping can potentially support both interactive expertise and transactive memory, but the situated context of the projects reported the activity as satisfying the transactive memory finality. Consequently, the relationship arises when the observable design item or activity (i.e., prototyping) satisfies entrepreneurial ecosystems capabilities finalities.

This strategy was applied to all the data collected from the course projects plans.

Once the potential capabilities relationships between the two domains were identified within the project plans, they were reported within the developed framework. As explained in Chapter 4.2 the framework was intended as an analytical and interpretative tool of results. Framework results were interpreted by considering the logic of competition as the main differentiator between the projects so that its influence on capabilities relationship could be interpreted.

For each logic of competition, the interpretation of the results focused on the analysis of individual projects frameworks and then on the comparison between them. The individual analysis identified the prevailing *number of entrepreneurial ecosystems capabilities finalities* served by design capabilities when a capabilities relationship over entrepreneurial ecosystems' sensing, seizing, and reconfiguring dimension was displayed. This allowed for understanding the major intervention of design capabilities over the relationship-building finalities of entrepreneurial ecosystems. Then, each project framework was compared with the others under the same logic, and consequently the comparison continued by considering all the projects under the different logic. The comparison also concerned with the identification of which entrepreneurial ecosystems dimensions were involved when the two domains' capabilities displayed a relationship in the framework.

To understand the differences between capabilities relationships when the same dimensions were covered, the researcher focused on interpreting the results under four lenses that supported the unpacking of the influence of the logic of competition on the projects' capabilities relationships (Figure 4. 3). Specifically, for each project were defined what the logic of competition enabled when entrepreneurial knowledge was engaged over the projects; what it led design capabilities to support; how the engagement with entrepreneurial knowledge was conducted through design capabilities; the impact of design capabilities on the project when entrepreneurial knowledge was engaged.

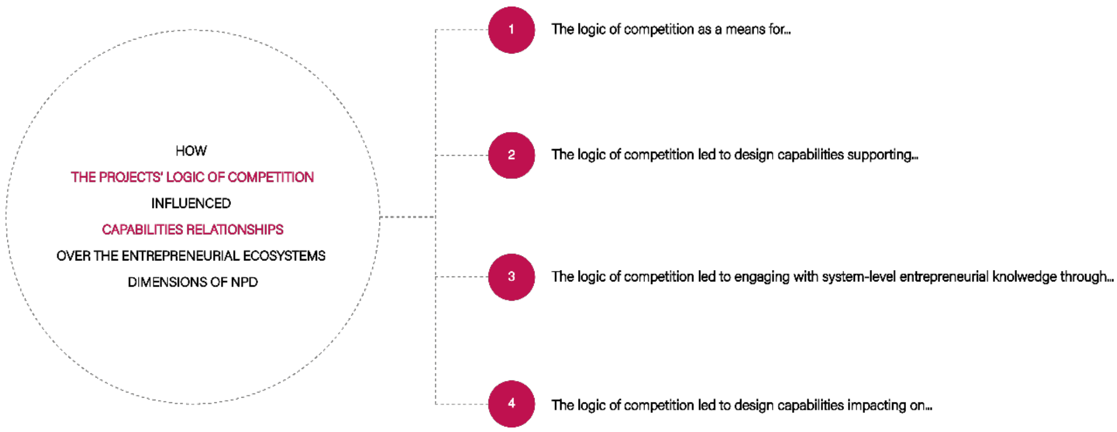


Figure 4. 3 Case study 1: the four lenses for evaluating the influence of logic of competition on capabilities relationships

This in-depth analysis led to the generalization of the influence of the different logic of competition on capabilities relationships over the entrepreneurial ecosystems dimensions in terms of project purpose and design capabilities impacts.

Projects results and interpretation

Each project plan resulted in a framework that showed capabilities relationships between the design and entrepreneurial ecosystems domain when the new product development project involves systemic knowledge. Specifically, capabilities relationships resulted when design capabilities satisfied the finalities of entrepreneurial ecosystems capabilities. Below, framework results and interpretations are reported for the projects classified under the two logics of competition.

Dominant design logic of new product development

Project A1: The activities collected in project A1 resulted in the capabilities relationship reported in Figure 4. 4. The framework visually displays the support of design capabilities in the seizing dimension of entrepreneurial ecosystems. Few design capabilities are reported to support the sensing dimension, while no capabilities relationships are displayed in the reconfiguring dimension. Together with the analysis of the project plan activities, this proportion led to the interpretation that design mostly supported the sensing of opportunities at the firm level. Therefore, opportunities were sensed primarily by employing design capabilities in internal activities of opportunity identification without involving system-level knowledge.

Although design capabilities in the sensing dimension scarcely support entrepreneurial ecosystems capabilities' finalities in proportion to the sensing dimension, the framework displays two design capabilities relationships with the vicarious learning capability. Specifically, experimentation and knowledge brokering nurtured the entrepreneurial learning of the company. By performing co-design activities with consumers and observing signals of cultural and social change through participatory observations, experimentation and knowledge brokering informed the company about new business directions that were internally elaborated.

The internal conceptualization of new sensed opportunities might explain the higher support of design capabilities to the interactive expertise finality: recognizing and working with what matters for others. After the sampling capability of design supported the strategic selection of stakeholders toward productive collaboration, the company was required to mobilize resources for collaboratively implement it toward the dark kitchen model testing once they sensed and conceptualized the opportunity. In this phase, activities were enabled by the design abilities to framing and reframing the opportunity with stakeholders by negotiating different perspectives, integrating the stakeholders' perspectives and know-how, and experimenting the proposed solution. Then visual communication supported the sharing of experimentation results.

Although the experimentation of the shared solution went through several iterative cycles, no capabilities relationships were found in the reconfiguring dimension. Due to the focus of sensing and responding to change signals through the involvement of lead users and serial entrepreneurs, reflectiveness in entrepreneurial ecosystems was not supported by design capabilities. The company focused on iterating toward the final solution by engaging with sampled stakeholders who did not represent the lead user or the serial entrepreneur categories.

Project A1 displayed relationships concerning both cognitive capabilities of simplifying complexity and experiential capabilities of driving action. While the former exclusively supported the capabilities of the entrepreneurial ecosystems in the seizing dimensions, the latter nurtured the capabilities of both the seizing and the sensing dimensions. Project A1 strongly relied on ideating and implementing the dark kitchen model through simplifying complexity capabilities when engaging with systemic knowledge. At the same time, the cognitive dimension was not considered as relevant for identifying the opportunity: the project relied on experiential capabilities for driving the identification of new business directions. Furthermore, the project did not show any interest in engaging lead users or serial entrepreneurs over the projects but focused on iterating by following the perspectives of initially engaged stakeholders.

Project B1: The activities collected in project B1 resulted in the capabilities relationship reported in Figure 4. 4. The framework displays a similar configuration to the one achieved from Project A1. However, a proportion of capabilities relationships is not so evident as for the previous project.

While the sensing dimension reports the same capabilities relationships, thus explaining the same firm-level intervention of design capabilities, the seizing dimension seems poorly populated.

By analyzing the project's activities, the seizing of the opportunity was conducted by engaging with knowledge in the system only in the reframing and experimentation of alternative solutions. However, the solutions derived from internal activities of ideation that referred to a previously sensed opportunity. Therefore, reframing and experimentation support recognizing and working with what matters for others in the way systemic knowledge can provide useful directions for the internal implementation of the solution.

Similar to Project A1, the reconfiguring dimension did not show capabilities relationships due to the internal cycles of iteration over the project.

As in Project A1, Project B1 displayed capabilities relationships guided by both the design dimensions. Cognitive and experiential design capabilities populate the same entrepreneurial ecosystems dimension of the previous project, even if in similar proportion as explained before.

Project C1: The activities collected in project C1 resulted in the capabilities relationship reported in Figure 4. 4. The framework displays a similar configuration to the one achieved from Project A1 and a similar proportion of design capabilities relationships over entrepreneurial ecosystems' sensing, seizing, and reconfiguring dimensions. As in Project A1, the framework displays higher support of design capabilities in the seizing dimension of entrepreneurial ecosystems. Few design capabilities are reported to support the sensing dimension, while no capabilities relationships are displayed in the reconfiguring dimension.

Although the two projects show similarities in the general configuration of framework relationships, Project C1 shows several differences. First, design capabilities support the mentoring capability of entrepreneurial ecosystems over the seizing dimension. Through visual communication, it was envisioned that company C could communicate to investors the findings achieved from startups over the matchmaking workshop. Visual communication supported the negotiation between investors and startups toward future support. Second, the project was described by five workshops that involved heterogeneous participants over each workshop activity. In addition to framing, reframing, negotiation, and experimentation, the project focused on envisioning shared solutions at the end of each workshop. This led to five envisioned solutions shared among different categories of participants for each workshop. However, conversely to Project A1, knowledge integration did not support the criteria definition toward a comprehensive solution implementation. The lack of interest in integrating diverse knowledge at the end of the project can also be confirmed by the design capability of sampling. Unlike in Project A1 and B1, sampling shows a relationship with interactive expertise, which means that collaboration over an integrated solution did not reflect the interest of the project. Although different participants collaborated within each workshop, their collaboration under an integrated lens was not the project goal. Indeed, it aimed to create a laboratory built on heterogeneous knowledge for new packaging products development.

Considering the design capabilities support to the mentoring capability as the main differentiator between Project C1 and the previous projects, it derives that only cognitive design capabilities of simplifying complexity were employed. Therefore, Project C1 resulted in a similar proportion of design capabilities relationships under the two design dimensions, which describes cognitive capabilities employed not only for recognizing and working with what matters for others but also for offering entrepreneurial learning when startups and investors were involved in the project.

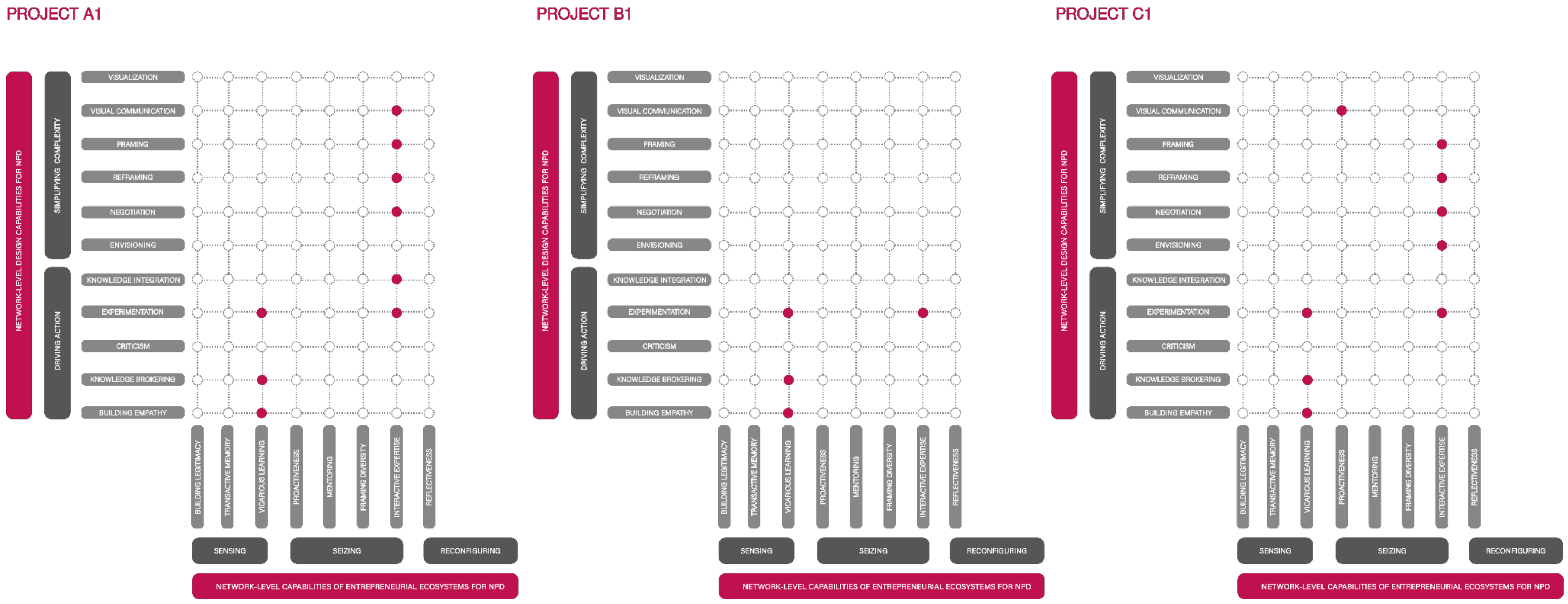


Figure 4. 4 Case study 1: The framework relationships resulted from projects that followed a dominant design logic of competition for NPD

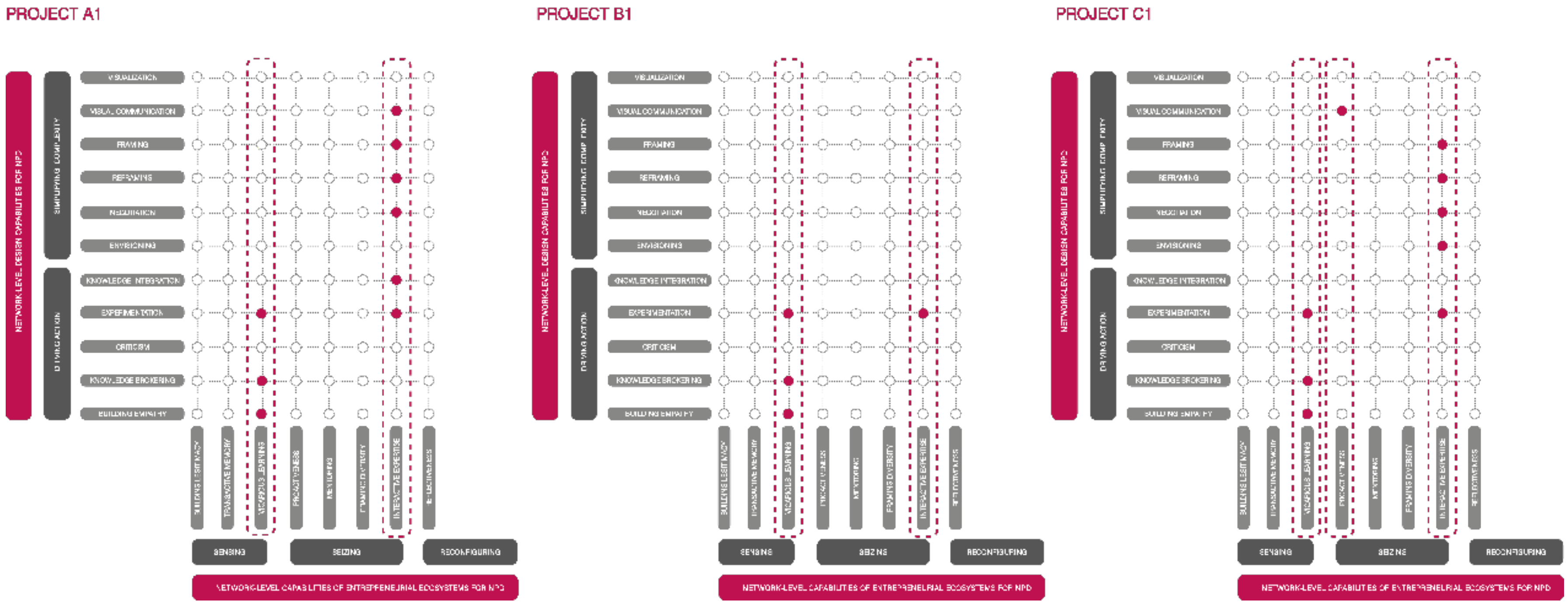


Figure 4. 5 Case study 1: The entrepreneurial capabilities finalities satisfied by design capabilities in the projects that followed a dominant design logic of competition for NPD

Project D1: The activities collected in project D1 resulted in the capabilities relationship reported in Figure 4. 6. The framework displays higher support of design capabilities in the seizing dimension of entrepreneurial ecosystems, while no capabilities relationships are displayed in the reconfiguring dimension. It is interesting to note that the sensing dimension displayed several capabilities relationships that populate the framework. Although design capabilities also supported the sensing of opportunities at the firm level, the project plan's activities informed the design capabilities participation in finalities of legitimacy building, transactive memory, and vicarious learning capabilities of entrepreneurial ecosystems.

Specifically, the project envisioned that company D might establish its legitimacy in accessing systemic knowledge of entrepreneurial ecosystems by organizing a cycle of open webinars where the company's history and future intentions were shared while participants were involved in framing and reframing the intentions from their perspective. This could allow the company to sense new opportunities to pursue. Moreover, participating in entrepreneurship-oriented open webinars supported identifying actors that might possess the helpful knowledge to implement eventually sensed opportunities. In this context, design sampling capability supported the transactive memory capability of entrepreneurial ecosystems by framing samples of possible collaborations. Finally, Project D supported the vicarious learning capability through knowledge brokering and visualization. While knowledge brokering corresponded to participatory employees' observations of an entrepreneurship improvement framework, visualization allowed for representing informational contents over entrepreneurship training activities. In the seizing dimension, visualization also supported the finalities of mentoring. The project envisioned that the company prototyped an entrepreneurship improvement framework for training startups in setting the opportunity presentations to capture investors' attention and thus foster future support. Thanks to the ability to visually communicate the training contents, the company could train startups and then support their presentations over the dedicated event with the investors.

While the incubation platform development focused on involving startups, the project envisioned the collaboration between the company and other actors in the system. The sampling capability of design supported the establishment of productive collaboration (i.e., framing diversity). Together with knowledge integration, it allowed for establishing partnerships and deals for the incubation platform development. The incubation platform was developed through the broad support of design capabilities, which is evident from the framework results. Different actors collaborated due to the design ability to framing, reframing and negotiating different perspectives toward a shared incubation platform vision.

Project D1 did not employ the experimentation capability as a driver of action. No project iterations have been planned in participation with the different involved actors. Conversely, the project planned a strong support of cognitive design capabilities that simplified complexity when using a multi-actor interface over sensing and seizing. However, no capabilities relationships in the reconfiguring dimension resulted in the framework. The author interpreted this result as related to the project focus on the conceptualization phase of the incubation platform.

Project E1: The activities collected in project E1 resulted in the capabilities relationship reported in Figure 4. 6. The framework results show a higher proportion of capabilities relationships over the seizing dimension. In the sensing dimension, only the design capability of framing supported the vicarious learning capability of entrepreneurial ecosystems. Specifically, potential materials suppliers for creating sustainable packaging were explored through several interviews to identify a preliminary direction for opportunity identification.

The seizing dimension resulted in visual communication supporting the collaboration between startups and investors (i.e., proactiveness) in similar matchmaking activities observed in Project D1. However, while in Project D1 the startups-investors collaboration was also supported by prototyping an entrepreneurship improving framework, in Project E1 only visual communication through slides presentations supported the entrepreneurial learning of startups for capturing the investors' attention. As in Project D1, the project plan envisioned two main parallel activities: the startups support and the engagement of potential partners to develop the sustainable and hybrid model of manufacturers and distributors. Indeed, the model implementation steps were framed together with the selected manufacturers and distributors, thus establishing productive collaboration.

The design capabilities that supported the finality of interactive expertise followed the same proportion of cognitive design capabilities that also intervened in Project D1. In Project E1 this aspect was even more emphasized by criticism as the unique experiential capability in the framework. By providing manufacturers and distributors with "things to use," the company and its partners could envision new solutions implementation directions.

Project F1: The activities collected in project F1 resulted in the capabilities relationship reported in Figure 4. 6. The framework reports very similar capabilities relationships and proportions of Project E1. The main differences are related to the sensing dimension, which shown visual communication as the design capability that supported the company building of legitimacy in the systemic knowledge context. Indeed, the project plan envisioned a kick-off meeting where narratives about the entrepreneurial history of the company and entrepreneurial participants were shared. Furthermore, the project employed the knowledge brokering capability when a shared developed prototype was developed to observe potential users' usage and capture insights.

Over the seizing dimension, it is interesting to note that the company was envisioned as a mentor for startups, and framing and reframing capabilities supported the mentoring finality of offering entrepreneurial learning. Specifically, the hackathon focused on supporting framing and reframing activities of startups by providing them with training and facilitation.

As in the previous projects, Project F1 resulted in higher and almost total cognitive design capabilities relationships of simplifying complexity over the collaboration through a multi-actor interface.

Figure 4. 7 highlights the dimensions of intervention of design capabilities in the projects frameworks.

The next section reports the results interpretation that derived from the qualitative comparison of the projects under the two logics of new product development.

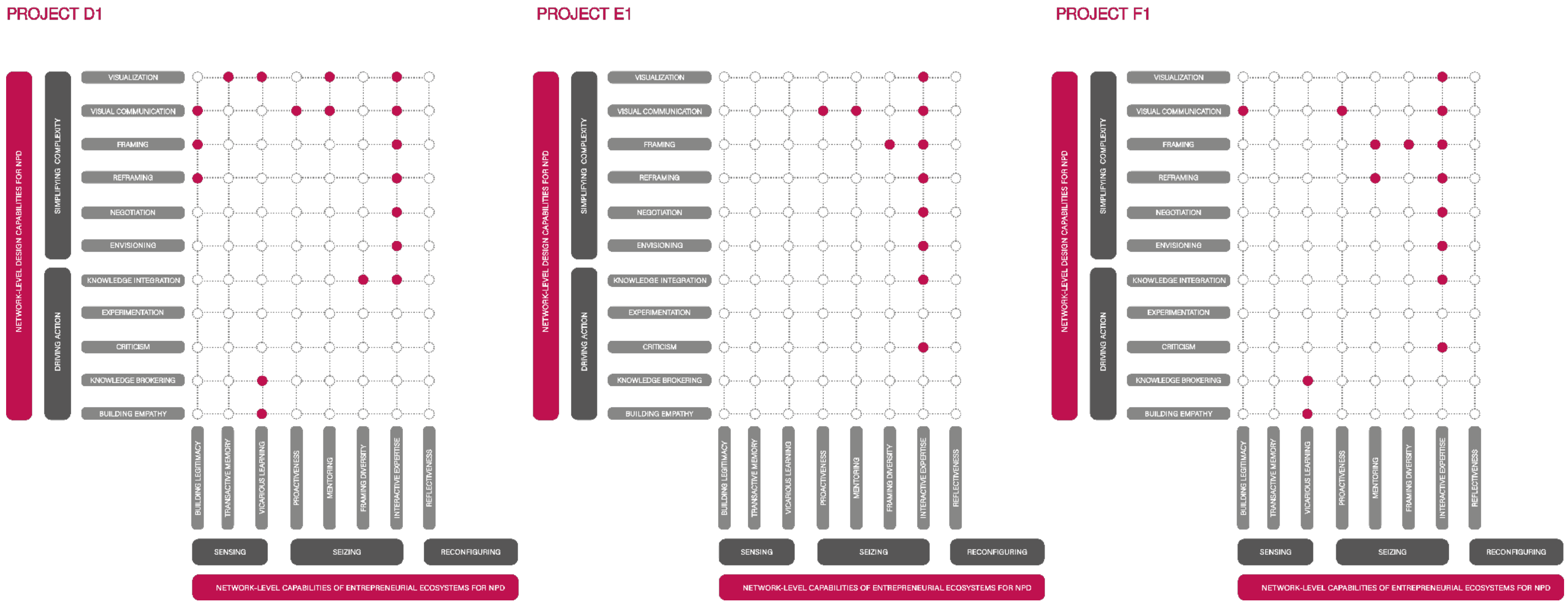
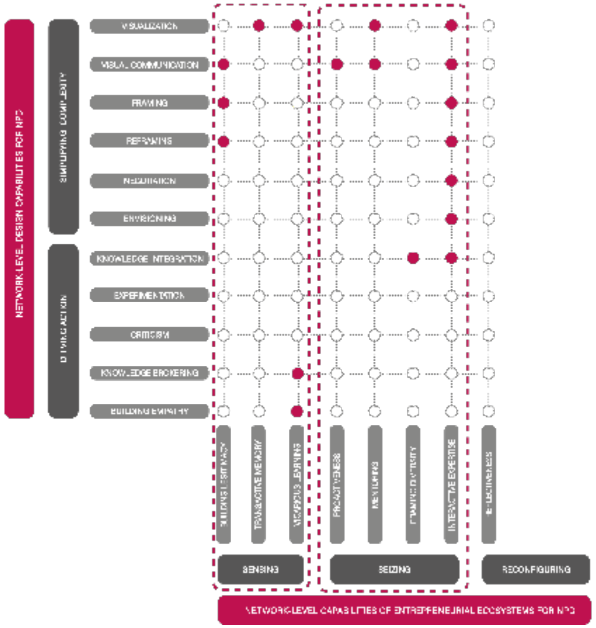
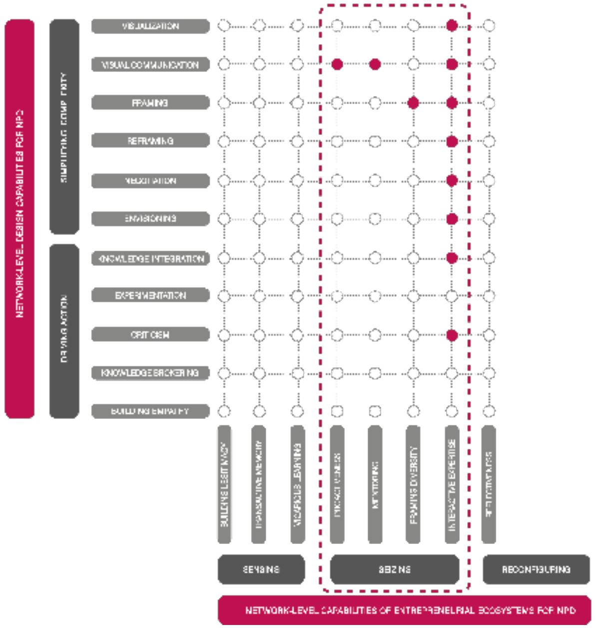


Figure 4. 6 Case study 1: the framework relationships resulted from projects that followed an adaptive logic of competition for NPD

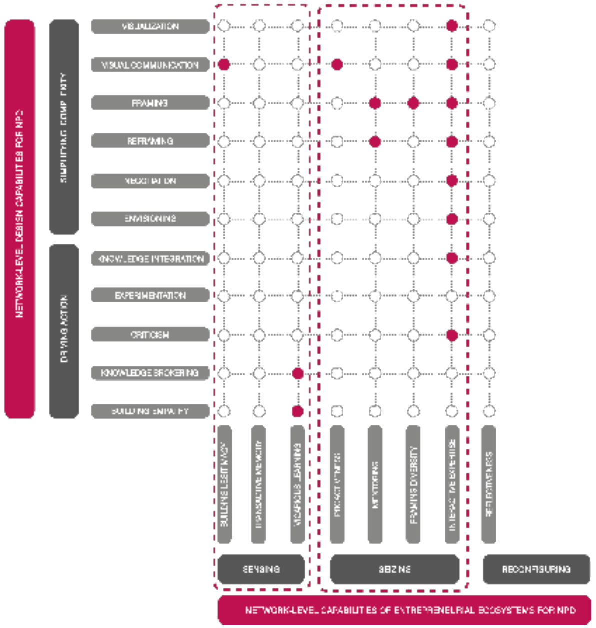
PROJECT D1



PROJECT E1



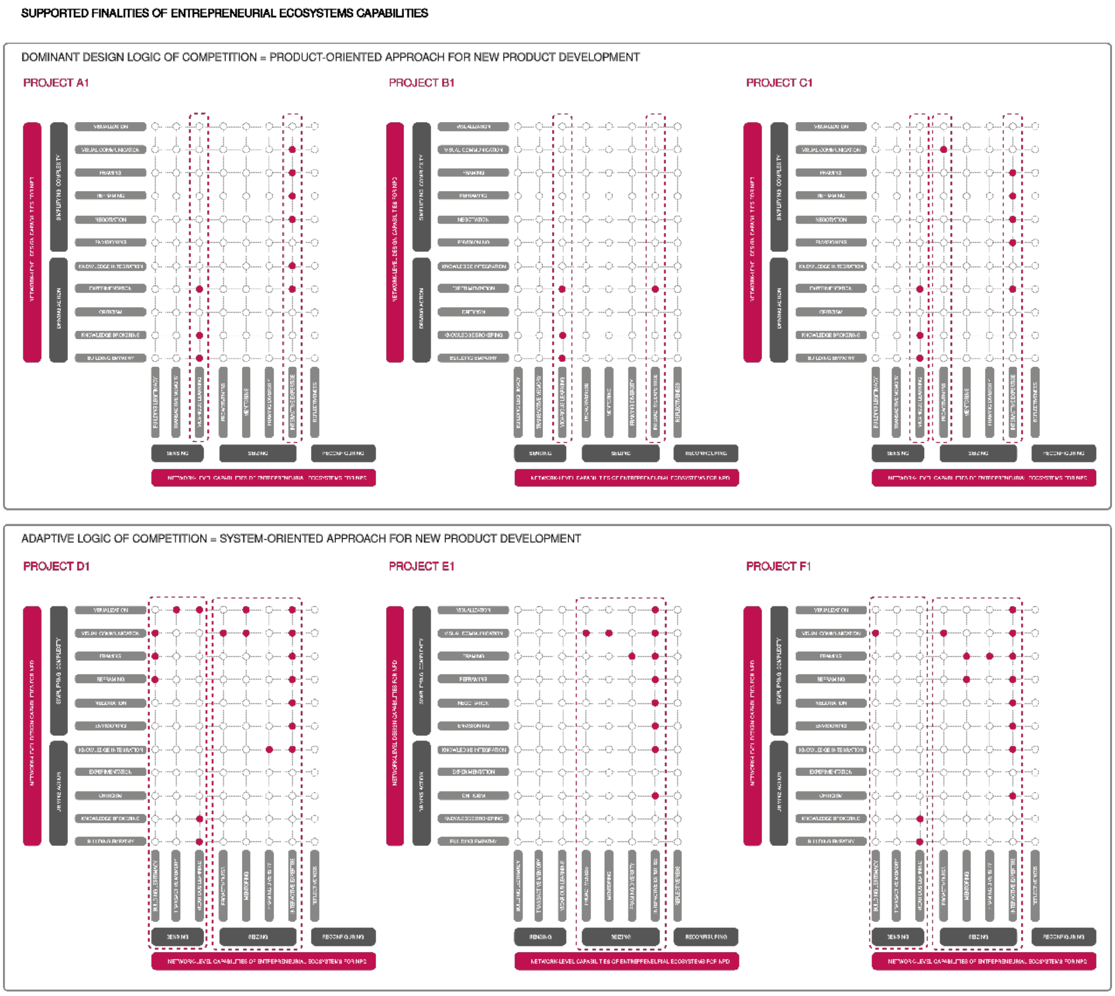
PROJECT F1



Comparing the projects under the two logics of competition

The projects that showed a dominant design and an adaptive logic of competition were all concerned with engaging systemic knowledge to develop the project plans' goals and achieve the expected outcomes. However, dominant design projects relied on systemic knowledge to develop products and services functionality toward the outcomes, while adaptive projects focused on creating the knowledge system to achieve the outcomes. Therefore, the two competition logics differ as they showed a *product-oriented approach* and a *system-oriented approach* for new product development. While dominant design projects aimed to reach the planned goals as the primary effort when engaging with systemic knowledge, the adaptive logic aimed to create ecosystems through systemic knowledge engagement. Hence, although the functionality of products interested both the logics of new product development, the adaptive logic considered products' functionality in terms of building actionable systemic relationships for long-term new product development.

The shift from achieving product functionality to building actionable systemic relationships resulted in more entrepreneurial ecosystems capabilities finalities satisfied by design capabilities in the adaptive projects' frameworks. Figure 4. 8 shows that the proportion of capabilities relationships over different finalities of entrepreneurial ecosystems capabilities is unbalanced. When co-creation refers to engaging with a multi-actor interface toward productive entrepreneurship, design capabilities support knowledge access and strength by serving more finalities of entrepreneurial ecosystems capabilities.



Despite the unbalanced proportion of served finalities of entrepreneurial ecosystems capabilities, all the investigated projects displayed capabilities relationships in sensing and seizing dimensions of entrepreneurial ecosystems. In contrast, no relationships were reported in the reconfiguring dimension (Figure 4. 9).

Figure 4. 9 Case study 1: the entrepreneurial ecosystems dimensions of intervention of design capabilities in each investigated project

Specifically, in Projects A1, B1, and C1, the satisfaction of sensing capabilities finalities found the support of design capabilities that drive action, while in Projects D1, E1, and F1, design capabilities that simplify complexity were also involved. When new product development involved the multi-actor interface of entrepreneurial ecosystems for sensing in projects that serve a dominant design logic of competition, design supported the engagement with entrepreneurial knowledge through entrepreneurial learning capabilities. Conversely, design capabilities engaged with system-level entrepreneurial knowledge through entrepreneurial learning and knowledge codification and synthesis in projects that served an adaptive logic of competition. This emphasizes that when new product development involved the multi-actor interface of entrepreneurial ecosystems, design capabilities also focused on accessing system-level knowledge by relying on the actors' knowledge sharing.

Similarly, design capabilities that supported the finalities of entrepreneurial ecosystems over the seizing dimensions relied on engaging with entrepreneurial knowledge through the design and implementation of heterogeneous collaboration. Although collaboration in seizing was also pursued by projects that served a dominant design logic of competition, it is evident from the framework that those projects did not aim to establish deals and partnerships or engage with startups and investors to build a system of diversified relationships supporting the long-term project development.

To understand the uniqueness of capabilities relationships over the frameworks, the researcher focused on interpreting the results under four lenses that supported the unpacking of the influence of the logic of competition on the projects' capabilities relationships (Figure 4. 3). Specifically, for each project were defined what the logic of competition enabled when entrepreneurial knowledge was engaged over the projects; what it led design capabilities to support; how the engagement with entrepreneurial knowledge was conducted through design capabilities; the impact of design capabilities on the project when entrepreneurial knowledge was engaged.

As Table 4. 4 shows, the logic of competition enabled different modalities of knowledge engagement over the sensing and seizing dimensions (see Lens 1 in the table). While in the projects that served a dominant design logic of competition, entrepreneurial knowledge was engaged in knowledge access in the sensing and seizing dimensions, in projects that served an adaptive logic of competition, entrepreneurial knowledge engagement modalities differed over the two dimensions. Entrepreneurial knowledge access drove the project activities in the sensing dimension, and entrepreneurial knowledge strength drove the activities in the seizing dimension. It is interesting to note that iteration over collaboration in seizing was intended as the main reconfiguration process in all the case study’s projects.

Consequently, design capabilities employed in the projects focused on sensing and seizing opportunities by supporting different projects purposes (see Lens 2 in the table). If design capabilities in sensing supported product proposals generation in Projects A1, B1, and C1, they were primarily intended to support accessing heterogeneous entrepreneurial knowledge in Projects D1 and F1. While the same purpose was not identified in Project E1, the adaptive logic of competition led the three projects to intend design capabilities as supporting knowledge interdependence strength over the seizing dimension. When collaboration is intended to implement the degree to which projects participants' goals and tasks depend on other participants, design capabilities had more possibilities of intervention through knowledge codification and synthesis over different entrepreneurial ecosystems capabilities seizing finalities.

This was evident from the unbalanced frameworks relationships in seizing. If the synthesis and development of consumer insights primarily involved participants collaborating toward a shared goal in Projects A1, B1, and C1, focusing on implementing participants' interdependence supported creating an infrastructure that could pursue the long-term goals of Projects D1, E1, and F1. Lens 3 in TABLE reports the interventions of design capabilities in the project purposes support.

The expanded engagement of entrepreneurial knowledge through design capabilities allowed to satisfy different finalities of entrepreneurial ecosystems capabilities. When entrepreneurial knowledge engagement represents the primary wellspring for developing new products, the finalities of entrepreneurial ecosystems have more possibilities to be satisfied.

Consequently, the capabilities relationships over the projects differed over the two logic projects as the purposes of the projects enabled limited or expanded possibilities of entrepreneurial knowledge engagement for design capabilities. Therefore, the intervention of design capabilities led to different impacts on the projects (see Lens 4 in the table). It is interesting to note that design capabilities engaged with different types of entrepreneurial knowledge by impacting in different ways. Specifically, consumers were scarcely involved in projects' sensing and seizing phases that served an adaptive logic of competition. This emphasizes that new opportunities emerge from productive collaboration rather than local consumers' needs in projects that focus on engaging with an entrepreneurial multi-actor interface.

1 The logic of competition as a means for...

NPD PROJECT LOGIC OF COMPETITION	NPD PROJECTS	SENSING CAPABILITIES RELATIONSHIPS	SEIZING CAPABILITIES RELATIONSHIPS	RECONFIGURING CAPABILITIES RELATIONSHIPS
DOMINANT DESIGN	Project A1	system-level entrepreneurial knolwedge access	system-level entrepreneurial knolwedge access	X (iterative cycles of product changes)
	Project B1	system-level entrepreneurial knolwedge access	system-level entrepreneurial knolwedge access	X (iterative cycles of product changes)
	Project C1	system-level entrepreneurial knolwedge access	system-level entrepreneurial knolwedge access	X (iterative cycles of product changes)
ADAPTIVE	Project D1	system-level entrepreneurial knowledge access	system-level entrepreneurial knowledge strength	X (iterative cycles of product changes)
	Project E1	X (firm-level opportunity identification)	system-level entrepreneurial knowledge strength	X (iterative cycles of product changes)
	Project F1	system-level entrepreneurial knowledge access	system-level entrepreneurial knowledge strength	X (iterative cycles of product changes)

2 The logic of competition led to design capabilities supporting...

NPD PROJECT LOGIC OF COMPETITION	NPD PROJECTS	SENSING CAPABILITIES RELATIONSHIPS	SEIZING CAPABILITIES RELATIONSHIPS	RECONFIGURING CAPABILITIES RELATIONSHIPS
DOMINANT DESIGN	Project A1	internal product proposals generation	insights synthesis and development	X (iterative cycles of product changes)
	Project B1	internal product proposals generation	internal insights synthesis and development	X (iterative cycles of product changes)
	Project C1	internal product proposals generation	insights reframing and development	X (iterative cycles of product changes)
ADAPTIVE	Project D1	knowledge diversity access	knowledge interdependence strength	X (iterative cycles of product changes)
	Project E1	internal product proposals generation	knowledge interdependence strength	X (iterative cycles of product changes)
	Project F1	knowledge diversity access	knowledge interdependence strength	X (iterative cycles of product changes)

3 The logic of competition led to engaging with system-level entrepreneurial knolwedge through...

NPD PROJECT LOGIC OF COMPETITION	NPD PROJECTS	SENSING CAPABILITIES RELATIONSHIPS	SEIZING CAPABILITIES RELATIONSHIPS	RECONFIGURING CAPABILITIES RELATIONSHIPS
DOMINANT DESIGN	Project A1	Experimentation, knolwedge brokering and building empathy for direct observations of local customers	Visual communication, framing, reframing, negotiation, knolwedge integration and experimentation for conducting business experimentation workshops with stakeholders	X (iterative cycles of product changes)
	Project B1	Experimentation, knolwedge brokering and building empathy for direct observations of local customers	Experimentation for testing business experiments with stakeholders	X (iterative cycles of product changes)
	Project C1	Experimentation, knolwedge brokering and building empathy for direct observations of local customers and stakeholders	Framing, reframing, negotiation and envisioning for synthesizing and testing business experiments with stakeholders	X (iterative cycles of product changes)
ADAPTIVE	Project D1	Visual communication, framing and reframing for sharing future oriented narratives; Visualization for identifying "who knows what"; Visualization, building empathy and knowledge brokering for directly observing employees and stakeholders	Knowledge integration for establishing stakeholders partnerships; Visualization, visual communication, framing, reframing, negotiation and envisioning for conducting business experimentation workshops with employees, stakeholders and startups; Visual communication for providing direct advice to startups; Visual communication for fostering collaboration between startups and investors	X (iterative cycles of product changes)
	Project E1	X (firm-level opportunity identification)	Framing for establishing stakeholders partnerships; Visual communication for providing direct advice to startups; Visualization, visual communication, framing, reframing, negotiation, envisioning and criticism for conducting business experimentation workshops with stakeholders and startups; Visual communication for fostering collaboration between startups and investors	X (iterative cycles of product changes)
	Project F1	Visual communication for sharing future-oriented narratives; Knowledge brokering and building empathy for directly observing customers and stakeholders	Framing for establishing stakeholders partnerships; Visual communication for providing direct advice to startups; Visualization, visual communication, framing, reframing, negotiation, envisioning knolwegde integration and criticism for conducting business experimentation workshops with stakeholders, startups and consumers; Framing and reframing for providing startups with direct advice; Visual communication for fostering collaboration between startups and investors	X (iterative cycles of product changes)

4 The logic of competition led to design capabilities impacting on...

NPD PROJECT LOGIC OF COMPETITION	NPD PROJECTS	SENSING CAPABILITIES RELATIONSHIPS	SEIZING CAPABILITIES RELATIONSHIPS	RECONFIGURING CAPABILITIES RELATIONSHIPS
DOMINANT DESIGN	Project A1	consumers engagement in consumers' needs discovery	consumers and stakeholders enagement in synthesizing and testing insights	X
	Project B1	consumers engagement in consumers' needs discovery	consumers and stakeholders enagement in testing synthesized insights	X
	Project C1	consumers and stakeholders engagement in users' needs discovery	consumers, startups and stakeholders enagement in reframing and testing insights	X
ADAPTIVE	Project D1	employees and stakeholders engagement in knolwedge sharing	employees, startups, investors and stakeholders engagement in relationship building	X
	Project E1	X (firm-level opportunity identification)	stakeholders and startups engagement in relationship building	X
	Project F1	consumers and stakeholders engagement in knolwedge sharing	consumers, startups and stakeholders engagement in relationship building	X

Considerations

The findings from the interpretation of the first case study's projects led to the consideration that both the logic of competition made design capabilities supporting the co-creation of entrepreneurial ecosystems for new product development. However, the support was strongly unbalanced in favour of those projects that employed design capabilities under an adaptive logic of competition, as they reported design capabilities impacts that strongly reflect the intention of building a system of actionable relationships over the projects purposes (Figure 4. 10).

Table 4. 4 described that the logic of competition served by the projects led to design capabilities supporting different projects purposes over the sensing and seizing dimensions of entrepreneurial ecosystems. By engaging with entrepreneurial knowledge in the system, design capabilities supported the generation of product proposals within the company when the projects' logic was dominant design. Differently, in projects that served an adaptive logic of competition, design capabilities supported the access to heterogeneous entrepreneurial knowledge in the system. Although design capabilities required to access entrepreneurial knowledge also when generating new product proposals was required, they did not took full advantage from the relational activities enabling knowledge access. Indeed, experimentation, knowledge brokering and building empathy provided significant impacts only when they supported the acquisition of companies' entrepreneurial learning through consumer engagement for needs discovery. This means that when the projects logic was dominant design, the co-creation of entrepreneurial ecosystems was not intended as a primarily advantage for the projects to succeed.

Conversely, projects that served an adaptive logic of competition, invested on design capabilities for accessing different types of entrepreneurial knowledge as the projects required engaging with an entrepreneurial community for new product development.

This led to design capabilities impacting on heterogeneous knowledge sharing through the satisfaction of building legitimacy, transactive memory and vicarious learning capabilities' finalities of entrepreneurial ecosystems. Hence, new product development strongly relied on design capabilities that simplified the complexity of the multi-actor entrepreneurial interface of the sensing projects' phase.

Over the seizing phase of the new product development projects, different design capabilities impacts were reported as, again, the logic of competition determined different purposes when system-level entrepreneurial knowledge had to be mobilized. In dominant design driven projects, entrepreneurial knowledge engagement was intended as a way for insights deduction and development. Therefore, different types of entrepreneurial knowledge (i.e., stakeholders, consumers and startups) were involved in co-design activities for new product development. Specifically, design capabilities impacted on insights synthesis and iteration toward the final solution development. Although heterogeneous entrepreneurial knowledge was engaged also in projects that served an adaptive logic of competition, the focus of engagement was implementing the degree to which projects participants' goals and tasks depend on other participants. Therefore, by impacting on relationship building, design capabilities supported entrepreneurial knowledge interdependence.

Hence, while dominant design logic projects considered entrepreneurial knowledge engagement as a means for making consumers current or future needs tangible, adaptive logic projects took advantage from entrepreneurial knowledge engagement in building relationships of productive collaboration for new product development.

The projects under the two different logic of competition shared the absence of design capabilities impacts over the reconfiguring dimension of new product development in entrepreneurial ecosystems. As the role of design for new product development reconfiguration in manufacturing is traditionally reported as related to evaluating the qualities of a design product and the effects emerging from the design process, design capabilities of framing and reframing were primarily employed over the seizing phase of the projects. However, new product development in entrepreneurial ecosystems defines reconfiguration as a phase where the evaluation and implementation of products emerges from the engagement with specific entrepreneurial actors (i.e. lead users and entrepreneurs) for sensing and implementing signals of change.

Hence, the logic of competition influenced different design capabilities impacts over the sensing and seizing dimensions of entrepreneurial ecosystems but no effect was reported over reconfiguring.

These findings informed the researcher about possible expectations from the subsequent case study investigation.

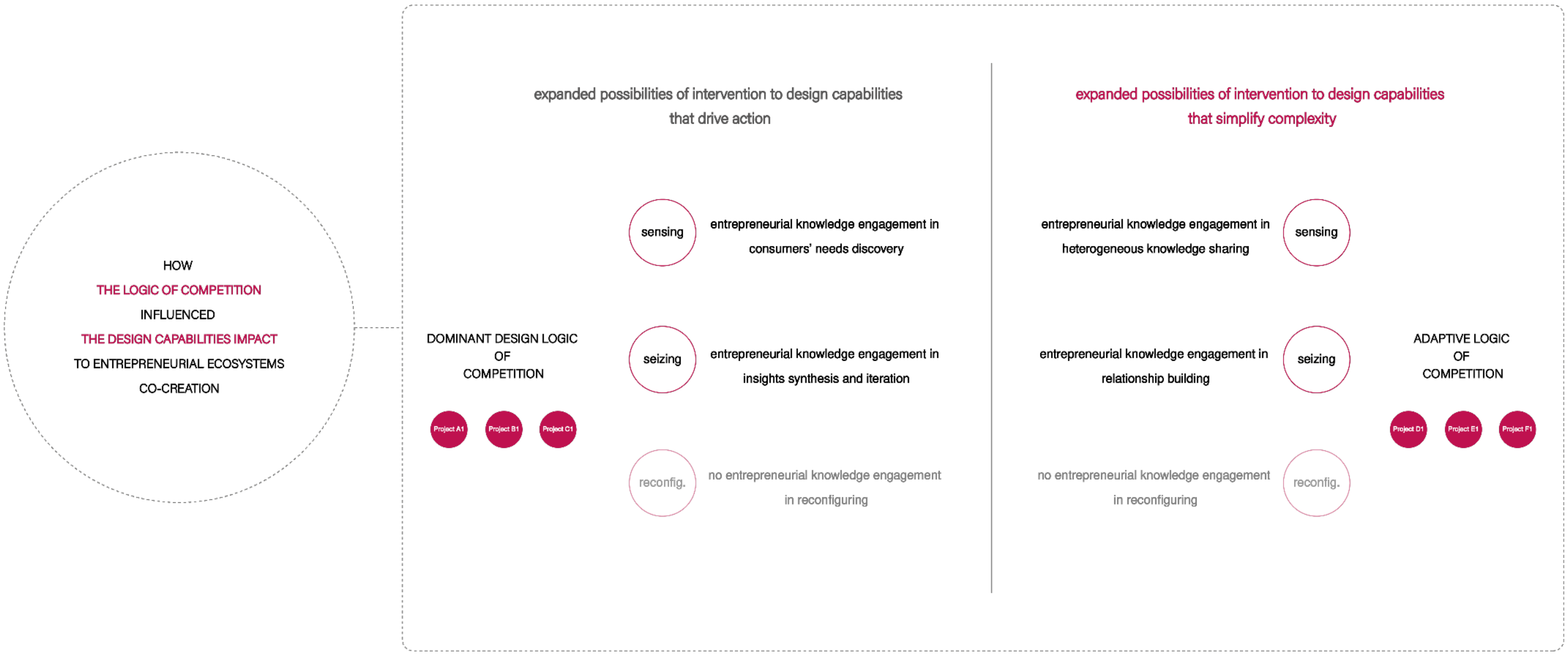


Figure 4. 10 Case study 1: the influence of the logic of competition on the design capabilities support to entrepreneurial ecosystems co-creation

4.4. Including the factor of technology complexity

Case study setting and data collection

The second case study was conducted by engaging four packaging manufacturing companies participating in the food industry innovation. The case study aimed to describe the capabilities relationships that allowed for accessing and strengthening systemic knowledge over the companies' new product development projects. Like in the previous investigation, the case study focused on new product development projects differentiated by the adopted logic of competition in the projects (Table 4. 2). Therefore, the case study first focused on describing the influence of the logic of competition on achieved results from real companies' projects. A qualitative comparison was derived by considering both the case studies' results.

Then results of the second case study were analyzed and interpreted by considering the second condition of change as the focus of the investigation: the complexity of the technology driver of the projects. By reviewing the extant literature on technological complexity, Broekel (2018) outlines several factors that define the ability of a company to engage in complex activities and technologies for products and economic development. Collaborative R&Ds for combining diverse and distributed knowledge, co-authored patents publications resulting from a heterogeneous collaboration, and the density and the proximity of systemic knowledge for knowledge transfer are described as the main factors that distinguish the technological complexity of a company toward successful systemic knowledge engagement. Although the factors represent an important reference for measuring technological complexity, they were found challenging to be collected in the form of informational data for investigating new product development projects in the contained time of the doctoral research.

Consequently, the researcher followed Broeker's technique (Broekel, 2018) that draws on measuring the complexity of the driving new product development project technology.

Specifically, the author reports that the porssibility to engage with the broader external company knowledge toward productive entrepreneurship is influenced by the age of the employed technology in the new product development projects. The younger the technology, the higher is its complexity. This condition results from the larger amount of knowledge previously required for growing the technology's range of functions (Broekel, 2018). Therefore, new product development projects that employ younger technologies are distinguished by expanded possibilities of systemic knowledge engagement (see also Hausmann et al., 2014).

Within its study, Broekel (2018) relied on patent data for approximating the age of technologies. By following the same technique, the researcher used the IHS Markit database for retrieving the age of each technology employed by the company in the selected new product development project. The database is the main provider of global information about industry' sectors technologies. The database allowed for identifying the technologies age by relying on the patents' publication year. Moreover, the patents showed the antecedents technologies that informed about the improved functions. Then, when technologies show similar ages, their complexity can also be informed by the number of antecedents technologies patented (Broekel, 2018).

By taking technology complexity as the differentiator of the selected new product development projects, in the second part of the investigation capabilities relationships were interpreted by considering the influence of technology complexity within the two logics of competition. This analysis was deemed fundamental to understanding the limits and possibilities of a certain technology for new product development through entrepreneurial ecosystems knowledge. Figure 4. 4 reports the classification of the companies' projects driven by higher or lower technology complexity.

The previous case study collected data by relying on the new product development projects resulting from the academic course as an investigation platform. In this case study, the researcher developed a semi-structured interview protocol to engage with the involved companies (see APPENDIX). The protocol was structured in four main sections, namely the participant information (i.e., educational background and current employment position in the company), the new product development project information (i.e., project goal and expected outcome, the driving technology), a preliminary assessment of the design capabilities employed over the project, and the interview' semi-structured questions relating to the sensing, seizing and reconfiguring phases of the project.

After the first two sections of the protocol were answered, participants indicated the design capabilities employed over the project as the superior skills that supported the new product development. This preliminary assessment was considered fundamental for interpreting results in terms of acknowledgment of design as a strategic investment for new product development. For this purpose, participants were provided with an additional attachment that reported the definition of each design capability and the related observable items retrieved from the previously developed taxonomy. Participants were then asked to organize in decreasing order the design capabilities employed over the project before the fourth interview's section started.

Over the fourth section, each participant described the selected new product development project through narratives. The interviews developed around main questions that focused on understanding if the project satisfied the entrepreneurial ecosystems finalities over the three new product development phases of sensing, seizing, and reconfiguring. When affirmative responses were obtained, the researcher prompted the project's narration in understanding specific design activities (or observable items in the taxonomy) that were eventually performed to serve the indicated entrepreneurial ecosystems' finalities. The researcher prompted the narrative to understand why the project did not satisfy certain entrepreneurial ecosystems finalities when negative responses were obtained. Moreover, the researcher focused on questioning if specific design capabilities that displayed a framework relationship over the first case study could have supported those entrepreneurial ecosystems capabilities' finalities.

Each interview lasted about two hours, and results were transcribed to analyze and interpret data, as described later in the chapter.

Projects description

Although the semi-structured interviews did not focus on technical product issues, two companies on four expressed their preference in remaining anonymous within the current dissertation. Therefore, the researcher decided to refer to all the companies and related projects using capital letters like in the first case study. To distinguish the first and the second case studies companies and projects in the final qualitative comparison, the number of the case study follows the capital letters of the second case study companies and projects. Hence, Projects A2, B2, C2, and D2 of companies A2, B2, C2, and D2 are described below.

The projects were all developed recently from Italian companies and over one or two years. Specifically, project A2 was developed over 2020, while projects B2, C2, and D2 started in 2018 and ended early in 2021.

As in the previous case study, the projects are first described by following the logic of competition that was followed for developing new products. The projects that followed a **dominant design logic** were Projects A2 and B2.

Project A2 was developed with the primary goal of achieving a high-barrier and sustainable packaging for increasing the packaging shelf-life in grocery stores. Company A2 is acknowledged as a leading Italian company in the development of high-barrier food packaging coatings. However, the company lacked knowledge about sustainable materials for packaging to be integrated into a single coating. Driven by a water-based copolymer that supports the integration of different materials, the company decided to engage with systems actors to integrate entrepreneurial, market, and technical knowledge for goal achievement.

Project B2 aimed to achieve a high-functional food packaging that could improve the food delivery experience of customers. This means that both the aesthetical and functional characteristics of the packaging need to be integrated within a single solution. A packaging vacuum skin technology drove the project. The technology makes it possible to perfectly conserve fresh food in its organoleptic properties and in the packaged original position. Moreover, the technology provides a polymeric skin that covers the food, thus making the food visible and touchable in its three dimensions when it is still unpacked. However, the company lacked entrepreneurial knowledge about integrating the technology functions into a valuable customer experience when delivering packaged food products.

The projects that followed an **adaptive logic** were Projects C2 and D2.

Project C2 aimed to develop a packaging customization platform that could deliver highly personalized food packages to support the visibility of local restaurants. The initial assumption was that if local restaurants could offer a packaging customization service while selling food, their visibility in terms of sales would have grown. The company's core business relies on a packaging printing technology that enables highly personalized packages production through high-speed throughput. However, the company lacked knowledge about developing a service based on a platform model of heterogeneous collaboration. Therefore, the company focused on integrating heterogeneous system knowledge for the platform development.

Project D2 focused on developing a B2C packaging production and distribution hub for enhancing the local production and consumption of vegetable-based dairy. The company is an acknowledged manufacturer of sterilized packages for versatile food dairy. However, the main challenge for the company was to understand the local culture in terms of production and consumption dynamics and trends of vegetable-based food. By creating a local production and consumption hub for vegetable-based dairy the company can participate in reducing sustainability issues and expand its business.

Through the interviews, the researcher could collect comprehensive verbal descriptions of the projects that were analyzed and interpreted as described below.

Data interpretation strategy

The first procedure adopted for analyzing and interpreting the data collected over the semi-structured interviews referred to the thematic analysis of the transcribed texts. The "reflexive thematic analysis approach" proposed by Braun et al. (2019) was adopted to manually coding the collected data. Although the employed approach describes the researcher as having an active role in producing new meanings and knowledge, the text coding phase in the research served to identify themes in the text that could be compared with the theoretical background. Specifically, themes that could be related to the conditions of change over the new product development project were identified. Hence, coherently with the case study method of data analysis, the themes were referred to theory so that new theoretical lessons learned from the case study could inform the frameworks' findings (Yin, 2009).

When the logic of competition were considered as the factor of change taken into consideration over data analysis and interpretation, the same procedure of reporting identified capabilities relationships in the framework was adopted. Indeed, while performing the thematic analysis of the texts of the interviews, the researcher populated the framework for each company project with the retrieved capabilities relationships. This allowed to identifying the prevailing number of entrepreneurial ecosystems capabilities finalities served by design capabilities and to identify which design capabilities dimension prevail on the other. As in the previous case study, the comparison between the projects also concerned with the identification of which entrepreneurial ecosystems dimensions were involved when the two domains' capabilities displayed a relationship in the framework.

To understand the differences between capabilities relationships when the same dimensions were covered, the researcher focused on interpreting the results under four lenses that supported the unpacking of the influence of the complexity of the technology on the projects' capabilities relationships (Figure 4. 11). Specifically, for each project were defined what the technology complexity enabled when entrepreneurial knowledge was engaged over the projects; what it led design capabilities to support; how the engagement with entrepreneurial knowledge was conducted through design capabilities; the impact of design capabilities on the project when entrepreneurial knowledge was engaged.

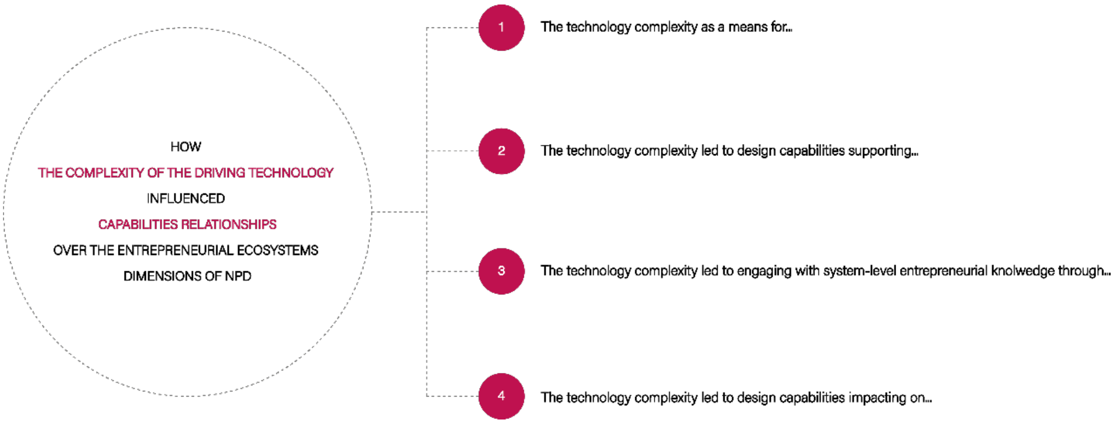


Figure 4. 11 Case study 2: the four lenses for evaluating the influence of technology complexity on capabilities relationships in the investigated projects

The following section describes the new product development projects that were the focus of the interviews.

Projects results and interpretation

The first preliminary assessment of the design capabilities that were employed over the projects reported the results shown in Table 4. 5. This assessment informed the general design capabilities intervention over the projects. Starting from this information, the researcher could prompt the interviewees to specify if the design capabilities employed over the project could have supported specific entrepreneurial ecosystems finalities when they missed.

PRELIMINARY ASSESSMENT

DESIGN CAPABILITIES	PROJECT A2	PROJECT B2	PROJECT C2	PROJECT D2
VISUALIZATION	✓ (black)	✓ (black)	✓ (red)	✓ (red)
VISUAL COMMUNICATION	✓ (black)	✓ (black)	✓ (red)	✓ (red)
FRAMING	✓ (black)	✓ (black)	✓ (red)	✓ (red)
REFRAMING		✓ (black)	✓ (black)	✓ (red)
NEGOTIATION				✓ (red)
ENVISIONING		✓ (black)	✓ (black)	✓ (black)
KNOWLEDGE INTEGRATION	✓ (black)	✓ (black)	✓ (black)	✓ (black)
EXPERIMENTATION	✓ (red)	✓ (red)	✓ (red)	✓ (red)
CRITICISM		✓ (black)	✓ (black)	✓ (red)
KNOWLEDGE BROKERING				
BUILDING EMPATHY		✓ (red)		

✓ (red) System-level engagement support for NPD

✓ (black) Internal strategies support for NPD

Table 4. 5 Case study 2: the preliminary assessment of design capabilities employed over the projects

Capabilities relationships under the two logics of competition

As in the previous case study, data collected from each interview resulted in a framework that displayed capabilities relationships between the design and entrepreneurial ecosystems domain when the new product development project involved system-level entrepreneurial knowledge. Specifically, capabilities relationships resulted when design capabilities satisfied the finalities of entrepreneurial ecosystems capabilities. As explained in the data collection section of the case study, the interviews focused on identifying capabilities relationships by relying on both effective and potential activities the project could have performed. Therefore, each project's framework reports both current and potential capabilities relationships. Below, framework results and interpretations are reported for the projects classified under the two logics of competition.

The projects that reflected a dominant design logic of competition were Project A2 and B2. As described in Chapter 3.5, the two projects differed in the complexity of the technology driver. Specifically, Project A2 was driven by a more complex technology than the one employed by Project B2.

Project A2: The activities performed in Project A2 resulted in the capabilities relationship reported in Figure 4. 12. The framework visually displays the support of design capabilities exclusively in the sensing dimension of entrepreneurial ecosystems. Specifically, only the vicarious learning finality was satisfied with the support of design capabilities. The framework displays only one effective capabilities relationship resulting from the project's performed activities and one potential capabilities relationship. The design capability of experimentation effectively supported vicarious learning finalities as the project outlined the engagement with consumers through prototypes for gaining entrepreneurial learning. However, the interviewee also found it possible to deepen the consumer engagement through ethnographic observations for the same finality.

The scarce design intervention over the sensing activities was reported as the consequence of the downstream position of the company in the supply chain:

“We rarely identify new opportunities as we traditionally integrate our technology for new application finalities that serve the client needs. Project A2 started from the client requesting compostable and high-barrier packaging for increasing the packaging shelf-life.”

And continued: “As we did not possess the know-how about compostable materials processing, we started a collaboration with several partners to develop the final product.”

Therefore, the project involved several collaborations that resulted due to a formal non-disclosure agreement. When the interviewee was prompted about possible design capabilities supporting the helpful identification of “who knows what,” the answer was:

“We have a solid network of specialized expertise about packaging manufacturing, so we relied on the cluster’s know-how for engaging partners.”

Consequently, legitimacy building was not found as necessary for the project development as the company strongly relies on the industrial community within which it developed new products over the years. However, when the questions focused on understanding alternative possibilities of collaboration that not involved non-disclosure agreements, such as open webinars for exploring shared visions about possible solutions, the interviewee emphasized that the lack of trust among industrial companies would represent the main barrier:

“We participated in entrepreneurial events where each attendee was asked to reframing together a specific concern. However, these events often represent a waste of time as everyone stops participating actively at a certain point. The self-interest in protecting knowledge is the main barrier that limits the success of the event.”

Moreover, the costs of making changes, especially in projects driven by high complex technologies like Project A2, represent a constraint to exploring collaboration opportunities:

“We traditionally follow clients' requests as the risk cost of making changes in our way of developing products is too high. Starting from the client request, we pool the know-how we already trust.”

It is interesting to note that design capabilities were employed over the new product development project. However, they did not support system-level engagement but were concerned with marketing activities for the product design and commercialization.

Project B2: The activities performed in Project B2 resulted in the capabilities relationship reported in Figure 4. 12. Like in Project A2, the framework visually displays the support of design capabilities exclusively in the sensing dimension of entrepreneurial ecosystems. Only the vicarious learning finality was satisfied with the support of design capabilities. Experimentation and building empathy supported system-level knowledge engagement for gaining entrepreneurial knowledge. Specifically, experimentation in design allowed for engaging with consumers through prototypes to gain feedback about the delivery experience. Building empathy was identified as the design capability that supported the consumers' engagement through ethnographic observations. The interviewee also found it possible to deepen the consumer engagement through participatory observations that supported internal strategies for new product development.

When the interview focused on the sensing dimension, the interviewee emphasized that several design capabilities supported the opportunity identification phase. The company internally produced sketches, mock-ups, and prototypes that followed the framing, reframing, and envisioning of the delivery experience conceptualization phase. However, only internal resources participated in sensing through trend and data analysis of the external market:

“We strongly believe that the ability to imagine and representing new future scenarios allows for saving time, costs, and resources toward the customers' needs satisfaction. In the project, we needed to foresee market trends and data over the next years and integrate them into a standardized, scalable and replicable scenario of use.”

While sensing involved customers for gaining entrepreneurial learning, the seizing dimension of the project involved the mobilization of resources that the envisioned scenario informed. However, once the idea was internally defined, the project only engaged with packaging materials suppliers for the delivery experience:

“Once the final prototype of the delivery experience was realized, we started contacting the most idoneous suppliers over the food supply chain that allowed for our packaging to be delivered coherently with the previously imagined scenario.”

Therefore, no productive collaboration characterized the project over the initial opportunity implementation.

Consequently, the project went straight to the end once the delivery experience was put into reality. Possible reflections about the reconfiguration of activities through lead users and local entrepreneurs were not considered, and only consumers were involved in iterative feedback collections through improved prototypes.

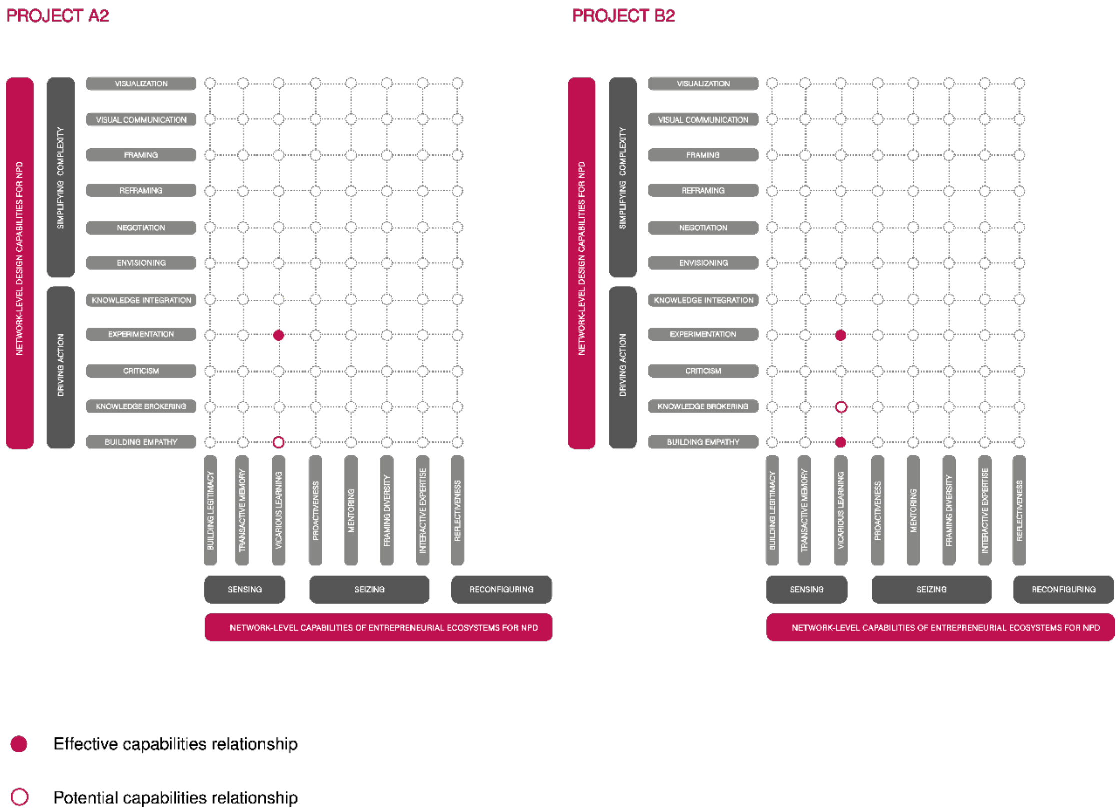


Figure 4. 12 Case study 2: the framework relationships resulted from projects that followed a dominant design logic of competition for NPD

As in the previous case study, the framework results of Project A2 and B2 were interpreted by following the proportion criterion. The prevailing proportion of capabilities relationship within one or more entrepreneurial ecosystems dimensions informed the effective and potential interventions of design capabilities for specific finalities of entrepreneurial ecosystems capabilities.

Figure 4. 13 reports the data interpretation of the two projects. By analyzing the proportion of capabilities relationships, both the projects shown a prevailing intervention of design capabilities in the sensing dimension of entrepreneurial ecosystems. Only experiential design capabilities of driving action provided support to entrepreneurial ecosystems capabilities finalities. Specifically, both the projects focused on engaging system-level entrepreneurial knowledge through design

capabilities by involving consumers to collect feedbacks that informed iteration activities toward the product's final design.

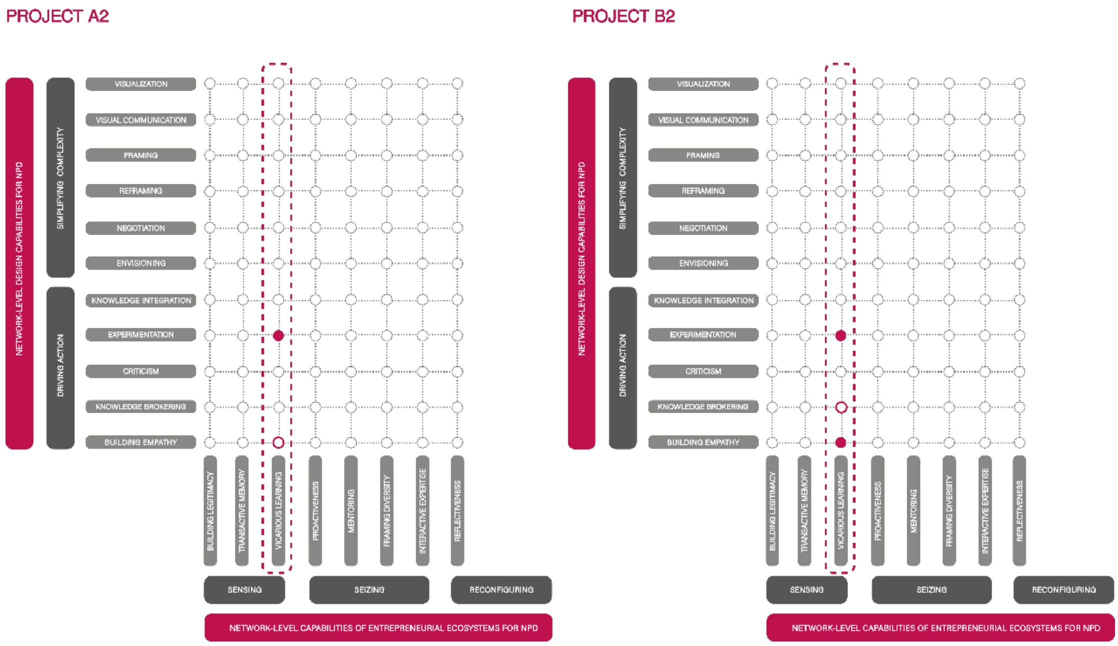


Figure 4. 13 Case study 2: the entrepreneurial capabilities finalities satisfied by design capabilities in the projects that followed a dominant design logic of competition for NPD

The projects that reflected an adaptive logic of competition were Project C2 and D2. As described in Chapter 3.5, the two projects differed in the complexity of the technology driver. Specifically, Project C2 was driven by a more complex technology than the one employed by Project D2.

Project C2: The activities performed in Project C2 resulted in the capabilities relationship reported in Figure 4. 14. The framework visually displays similar support of design capabilities in the sensing and the seizing dimensions of entrepreneurial ecosystems. However, if one considers only the effective capabilities relationships reported by the project interview, the sensing dimension strongly prevails on the seizing dimension. The development of a website mockup supported the sharing of future-oriented narratives about the project when the company initially engaged with the local entrepreneurial community. This enabled the company to identify and engage with restaurants, agencies, and e-commerce experts through framing. Specifically, in the initial stage of the project, the development of an initial opportunity map allowed for identifying the industry participants that could support the opportunity implementation. Consequently, the company's participation in a local entrepreneurship event allowed it to engage with specific actors to start an eventual collaboration.

The development of the packaging customization platform relied on the design capability of visualization for satisfying the finality of both vicarious learning and interactive expertise. The former was served by engaging with restaurants by developing a website mockup for collecting suggestions about consumer current needs. The latter was served by engaging with restaurants and agencies through the website mockup for ideas exchange about packaging customization issues.

However, before the website mock-up was implemented into a functioning platform of B2B online packaging customization, the interest of restaurants in the company proposal was tested through experimentation. Indeed, the company launched a Google Ads campaign that collected restaurants feedback by analyzing the number of website mock-up impressions, clicks, and information requests. Once the company collected positive interest feedback, restaurants, advertising agencies, and e-commerce experts established deals for collaborating on the project.

Although deals establishment confirmed participants' interest in working together, no collaboration activities were performed over the project. The company lacked the internal design capabilities to show participants how to work on the same project in a collaborative fashion.

“We never developed projects in a real collaborative manner. Traditionally, we develop a packaging customized proposal and then we test it with the final users. However, this project has been set under a completely different lens even if we do not have integrated competences that could have supported critical collaboration phases.”

While the website mock-up supported ideas sharing, their integration was up to the company. Consequently, the project needed several meetings where different perspectives emerged in conflicts due to the lack of communication among one project milestone development and the next.

Moreover, self-interest prevailed in the effort to collaborate. Then, each participant seemed interested in participating in the project development as long as it could provide them monetary benefits.

“The main point was that advertising agencies shown reticence in sharing information about possible new restaurants clients and graphic studious that could be integrated into the platform. They perceived information sharing as a way for cut them off from the platform.”

The company perceived the lack of productive collaboration as the main barrier in the project development. Furthermore, it showed interest in deepening the design perspective on collaboration about the project.

“I think we need new competences that focus on stakeholder collaboration if we start undertaking systemic projects goals and expectations. However, the company is concerned about the risk that collaboration activities could bring in terms of time and costs. Meanwhile, if those activities started to be performed within the internal company context to show employees how they function, it might be interesting to try their implementation in systemic knowledge contexts."

Therefore, the researcher prompted the interview by focusing on several design capabilities that could inform the interviewee about possible collaboration directions. Specifically, the establishment of deals could have been reinforced toward productive collaboration by engaging with restaurants, agencies, and e-commerce expertise through framing, reframing, negotiation, and envisioning to enable the sharing of different perspectives over the organization of future collaborative activities. This could have been reassured participants that collaboration can lead to shared views that accomplish different interests. Furthermore, the same design capabilities could have strengthened the connection between participants by developing business experiments that organized the project activities for each milestone development.

Although collaboration between stakeholders was not effectively performed, the company defined the project direction toward a system creation due to the past trials in engaging consumers for informing new sustainable business directions of the packaging printing technology. While the consumer engagement supported only a marginal increment of the technology application revenues related to custom packaging prints for spot events, the B2B packaging customization platform aimed to provide a sustainable service for ongoing restaurant activities.

Project D2: The activities performed in Project D2 resulted in the capabilities relationship reported in Figure 4. 14. Unlike Project C2, the prevailing proportion of capabilities relationships in Project D2 resulted in the seizing and reconfiguring dimensions of entrepreneurial ecosystems. In developing the B2C packaging production and distribution hub, the company driving technology is already widely acknowledged by the stakeholders and consumers community. Therefore, the company already engages with food dairy stakeholders for new product development and knows consumer feedback about its packaging products. Consequently, the company did not need to sense the opportunity by engaging with stakeholders and consumers' knowledge in the project's initial phase. Instead, the project development strongly relied on lead users engagement:

“We aimed at developing a solution that focused on sustainable production and consumption under a long-term perspective, and we decided to focus on the local production and consumption of vegetable-based dairy as influencers in social networks are very sensitive to sustainability issues in this historical time.”

Therefore, the company set the project by aiming at reconfiguring the new product development activities they traditionally perform in projects starting from influencers engagement. The interviewee emphasized:

“It is hard to predict consumers' needs when you are developing new products for the long-term. Especially in a production and consumption sector that is not completely new, as vegetable-based food is.”

As the company developed strong internal design capabilities for innovation over the years, they engaged with lead users through business experiments prototyping while providing different perspectives on the topic derived from the R&D department. Therefore, the project involved the visualization and criticism design capabilities for sensing change signals in the vegetable-based production and consumption panorama. Sensing change was also supported through framing and reframing capabilities over the prototyping activity.

Subsequently, the project involved local start-ups dealing with vegetable-based food. Within an exploratory meeting, the company aimed to provide startups with new entrepreneurial advice about the production and consumption of vegetable-based food through the visual communication design capability. Indeed, the company explained to startups new possible requirements that vegetable-based food production and consumption could be pursued when the project's local production and consumption of vegetable-based dairy is the outcome. The visual communication capability of design was retained as fundamental for showing startups the lead-users findings. Visual communication enabled the prototyping activity about future shared visions among startups, so entrepreneurial activity in the company's interesting outcome was enabled.

Once the company integrated startups and lead-users findings, they communicated the new product development requirements to stakeholders, and framing, reframing, and negotiation design capabilities supported establishing the partnership through a future workshop that integrated different stakeholders' perspectives and interests toward the hub development. Consequently, productive collaboration activities focused on implementing the hub requirements.

A shared business model resulted from several cycles of collaboration. Then, the company decided to move back to influencers for collecting feedback about specific business model directions.

Since the project resulted in a solid business model for the hub development, the company organized a start-ups and investors exploratory meeting. As the interviewee emphasized:

"We decided to show investors the shared vision about vegetable-dairy local production and consumption as their project development could inform the hub about future directions. This is how we started to implement the project toward long-term success."

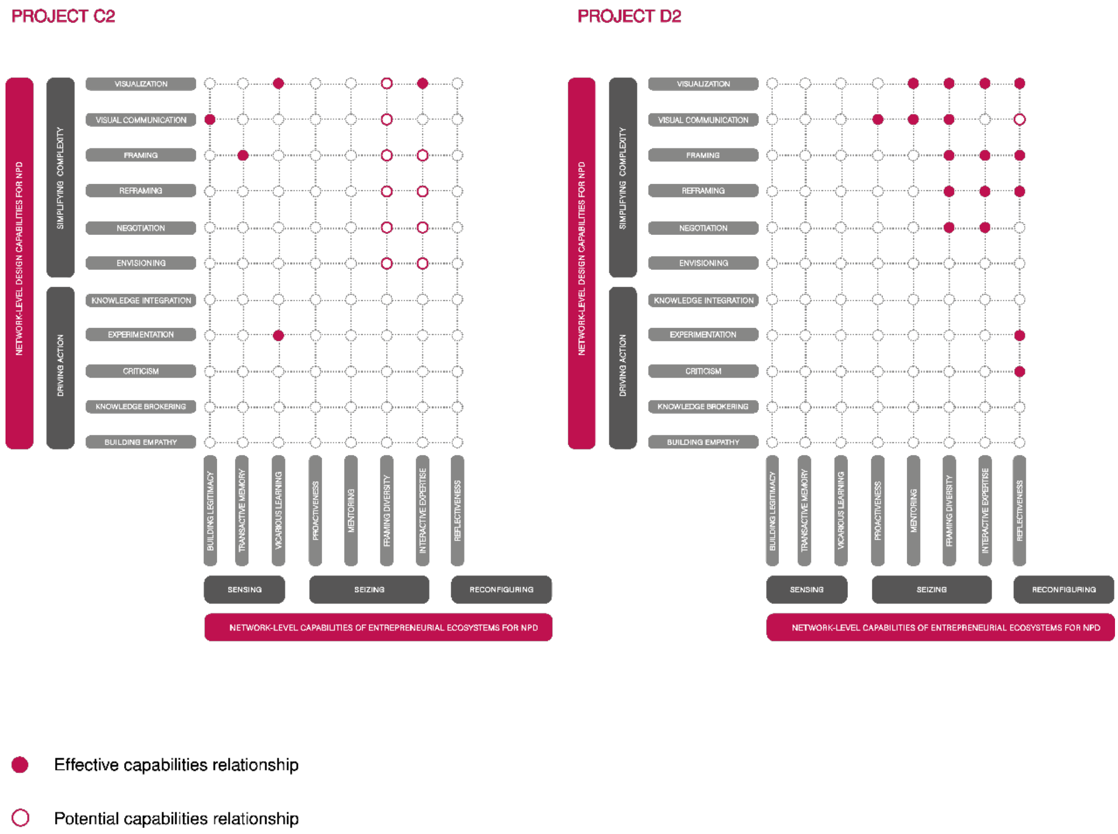


Figure 4. 14 Case study 2: the framework relationships resulted from projects that followed an adaptive logic of competition for NPD

Figure 4. 15 reports the data interpretation of the Projects C2 and D2. By analyzing the proportion of capabilities relationships, both the projects shown the intervention of design capabilities in the sensing and seizing dimensions of entrepreneurial ecosystems. Mainly design capabilities that simplify complexity were employed. However, the design capability of experimentation shown support in both projects. Interestingly, no one on the projects engaged with the consumer when sensing the project opportunity. Moreover, project C2 engaged with stakeholders while Project D2 with lead users. This made the main distinction in the design capabilities interventions over sensing (Project C2) and reconfiguring (Project D2) dimensions of entrepreneurial ecosystems between the projects.

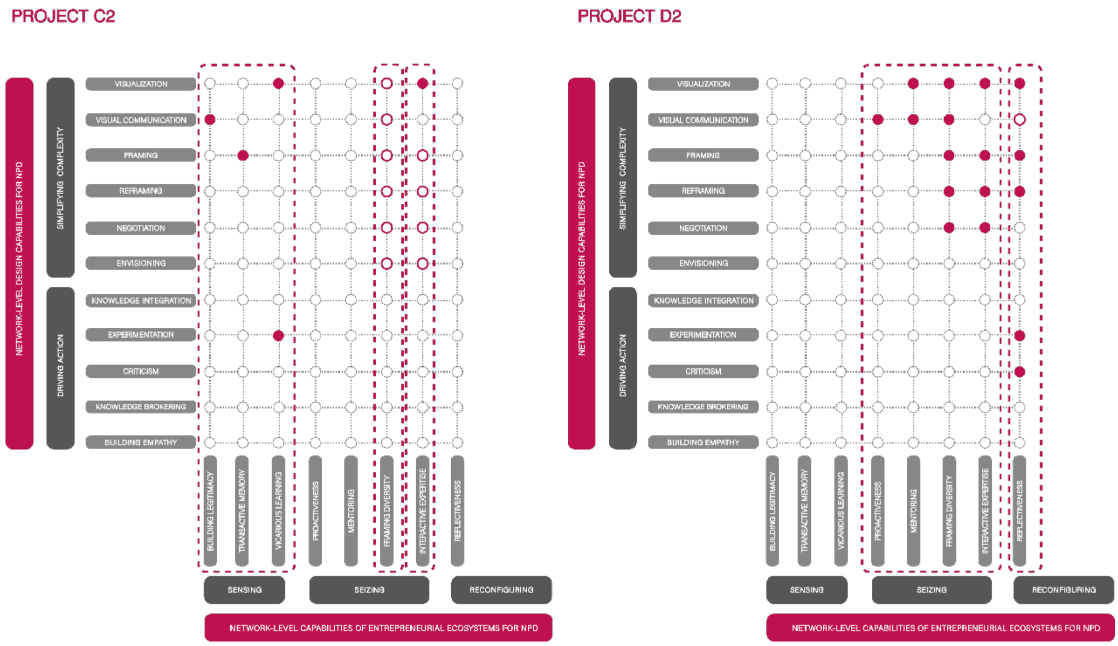


Figure 4. 15 Case study 2: the entrepreneurial capabilities finalities satisfied by design capabilities in the projects that followed an adaptive logic of competition for NPD

As in the previous investigation, the projects that showed a dominant design and an adaptive logic of competition were all concerned with engaging systemic knowledge to develop the project plans' goals and achieve the expected outcomes. However, dominant design projects relied on systemic knowledge to develop products and services functionality toward the outcomes, while adaptive projects focused on creating the knowledge system to achieve the outcomes. Therefore, the two competition logics differ as they showed a *product-oriented approach* and a *system-oriented approach* for new product development. While dominant design projects aimed to reach the planned product goals as the primary effort when engaging with systemic knowledge, the adaptive logic aimed to create ecosystems through systemic knowledge engagement. Hence, although the functionality of products interested both the logics of new product development, the adaptive logic considered products' functionality in terms of building actionable systemic relationships.

Figure 4. 16 shows a general comparison between the framework relationships that resulted from the examined projects.

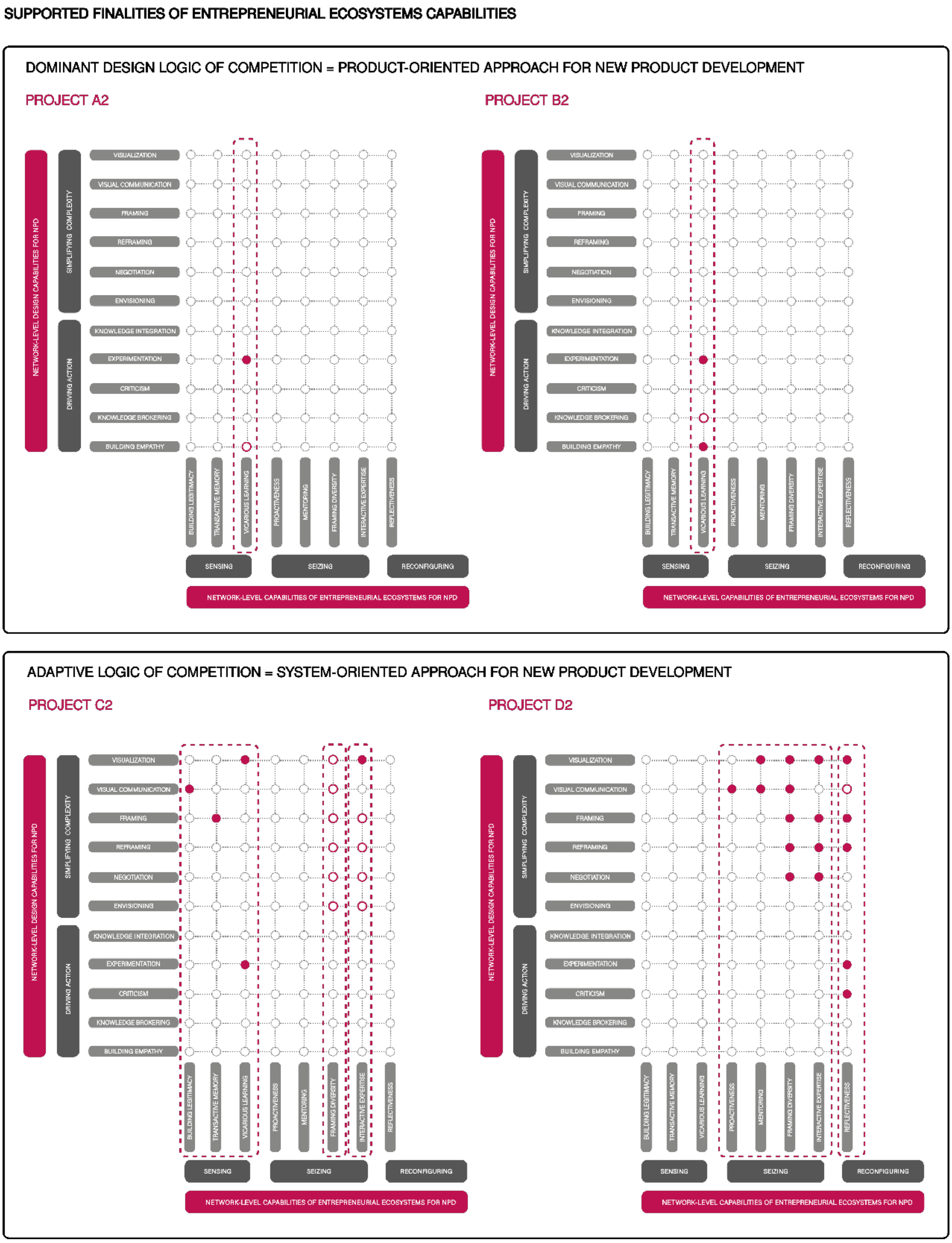


Figure 4. 16 Case study 2: frameworks comparison of capabilities relationships between projects that followed a dominant design and an adaptive logic of competition for NPD

Form the frameworks comparison results that the number of entrepreneurial capabilities finalities satisfied by design capabilities is unbalanced in favor of projects that followed an adaptive logic of competition. Specifically, capabilities that simplify complexity show a wider intervention when engaging system-level entrepreneurial knowledge.

In order to qualify the uniqueness of capabilities relationships, a generalization of design capabilities intervention over the entrepreneurial ecosystems dimensions was provided by the researcher, as it was in the previous investigation (Figure 4. 17). However, in this case, the analysis and interpretation focused on the influence of the second factor of change taken into consideration, namely the complexity of the projects' driving technology.

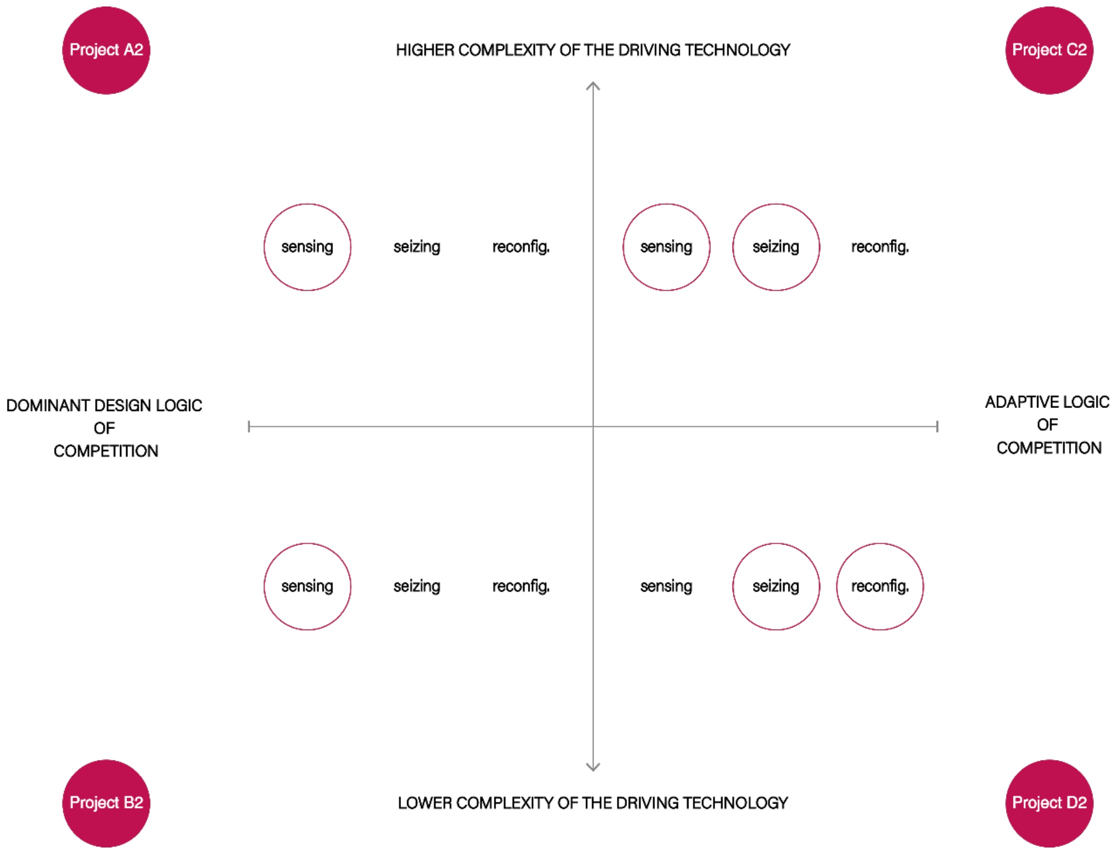


Figure 4. 17 Case study 2: the entrepreneurial ecosystems dimensions of intervention of design capabilities in each investigated project

How technology complexity influenced capabilities relationships

To understand the uniqueness of capabilities relationships over the frameworks, the researcher focused on interpreting the results under four lenses that supported the unpacking of the influence of the complexity of the technology on the projects' capabilities relationships (Figure 4. 11). Specifically, for each project were defined what the the different complexity of the technology enabled when entrepreneurial knowledge was engaged over the projects; what it led design capabilities to support; how the engagement with entrepreneurial knowledge was conducted through design capabilities; the impact of design capabilities on the project when entrepreneurial knowledge was engaged.

By adopting this lens, the projects results are reported below and summarized in Table 4. 6.

Projects that reflected a dominant design logic of competition

As Table 4. 6 shows, higher and lower technology complexity was intended as a means for entrepreneurial knowledge access over the sensing dimension of both Project A2 and B2. Conversely, it did not leads to entrepreneurial knowledge engagement over the seizing and reconfiguring dimensions. Specifically, in Project A2, design capabilities supported the resolution of product design issues in relation to the new performance characteristics of the packaging product. Therefore, design capabilities where employed as a means for entrepreneurial knowledge access over the projects. Through design capabilities of experimentation and building empathy for direct observations of local customers, the realization of functional product tests supported the sensing dimension of new product development.

The limited intervention of design capabilities over the new product development dimensions in Project A2 derives from the consideration of technical knowledge as the wellspring for the product development:

“When we started working on the project, we needed to be sure that technical knowledge sharing for the new product development was protected from our competitors. Then, the first move was to guarantee the intellectual property of the project through non-disclosure agreements between the project’ partners.”

Therefore, the multiple actionable properties provided by the higher complex technology were primarily intended as a means for increasing the product performance. Moreover, the concept of intellectual property was a recurring theme that resulted as the main barrier for system-level entrepreneurial knowledge engagement for new product development. When the interviewee was asked how they engaged with new project’ partners, he answered:

“The packaging sector is a highly competitive one. We rarely trust people that we never met before. When we need new knowledge to develop new products, we pool from our referential people.”

And continued:

“Our approach to new product development is highly linked to the open innovation one. However, until other companies in the packaging sector do not change their approach, it is hard to work together without non-disclosure agreements as otherwise, you are disadvantaged right from the start. […] When most companies in your sector consider new product development a sealed activity, the collaborative events you participate in are a waste of time. None provide an effective contribution for fear of its idea might be stolen.”

From the interview, it was clear that the company perceived new product development as a competitive product development activity rather than relationship-building. As a consequence, the higher complexity of the technology led to design capabilities to engage with entrepreneurial knowledge in the systems to finalize the development process through product design testing:

"The only activities we performed without the limit of intellectual property were direct marketing activities. We engaged with the customer to test if the product might have been attractive on the grocery shelves given its new aesthetic and mode of use. Here is where design capabilities provided support."

In Project B2, the lower driving technology of the project made design capabilities a valid resource to access entrepreneurial knowledge for supporting product differentiation. Through design capabilities of experimentation, knowledge brokering and building empathy, new marketing solutions derived from direct observations of local customers that led to design capabilities impacting on consumers needs discovery.

The limited intervention of design capabilities over the new product development dimensions in Project B2 derives from the consideration of market knowledge as the wellspring for the product development. Indeed, new marketing solutions relied on improved packaging communication and aesthetics through new compatible packaging materials:

"We focus on communicating consumers a new message about the food they can deliver: food delivery can also be concerned with healthy food. So, we focused on searching for new packaging materials suppliers that could supply compatible materials with the vacuum skin packaging technology. It was fundamental that the final packaging communicated to consumers the high quality of the food once it was delivered to their homes or offices."

And continued:

"We tried different packaging solutions that were delivered to selected consumers iteratively. First, we needed to understand if the ergonomy of each solution we prototyped allowed for an easy mode of use. Then we started working on a new brand identity through packaging design."

Hence, within the projects, design capabilities represent a valuable marketing resource that mainly serves packaging design.

Projects that reflected an adaptive logic of competition

As Table 4. 6 shows, higher and lower technology complexity was intended as a means for entrepreneurial knowledge strenght over the seizing dimension of both Project C2 and D2. However, different technology complexities influenced results in the sensing and reconfiguring dimensions.

Specifically, the higher complex technology driving Project C2 was intended as a means for accessing entrepreneurial knowledge in sensing, while it did not provide any actionable information in reconfiguring. By considering the multiple technological characteristics as requiring design capabilities to support the identification of new technology applications, the project focused on exploring the available entrepreneurial knowledge for enabling the seizing phase of new product development:

"When we decided to move the technology application on the e-commerce channel, we needed to interfacing with new knowledge that could show us the main rules that the online sales actors follow."

Therefore, by engaging with diverse "know-what," the project could be informed about new business possibilities. Once the company started engaging with online sales entrepreneurial knowledge, it could define the project directions:

"We needed to expand our working team into developing the platform. So, we engaged with agencies and local restaurants that could provide us the means for implementing the platform."

For this purpose, design capabilities of visual communication and visualization was retained as fundamental as they supported entrepreneurial knowledge sharing:

“Prototyping the website mockup was a fundamental preliminary activity that supported multiple food ecosystem actors to be aware about our future intentions. This was also a way for identify the useful entrepreneurial knowledge we needed to start the platform development. […] Moreover, we participated in local entrepreneurial events that dealt with e-commerce for food, and there was fundamental to have visual supports for sharing our entrepreneurial history.”

From the interview it was clear that the project was enabled by a young technology that is considered disruptive in the corrugated packaging sector. For this reason, finding the the opportunity for apply it represented itself a challenge that moved to the background the reconfiguration phase of new product development.

Conversely, in Project D2, the driving technology was older, thus showing a lower complexity. In this case, scarce actionable properties of the technology mostly required design capabilities to support the adaptation of technological possibilities to evolving social contexts:

“We are a worldwide acknowledged packaging company that develop projects by relying on our most promising technology. However, as times change we must focus on adapting its application to new evolving needs and contexts. That’s why we have a strong innovation team that support the adaptation and implementation of the technology possibilities.”

Specifically, the reconfiguration phase was intended as a fundamental preliminary step that led the company to identify signals of change through the engagement of lead users. Design capabilities impacted on signals of change identification thus supporting technological opportunities adaptation through simplify complexity capabilities that allowed for organize participatory design meetings with lead users.

Lead users provided new directions for the technology application, that moved to the background the sensing phase of new product development due to the expanded entrepreneurial network the company can pool knowledge from.

1 The technology complexity as a means for...

NPD PROJECT LOGIC OF COMPETITION	DRIVING TECHNOLOGY COMPLEXITY	SENSING CAPABILITIES RELATIONSHIPS	SEIZING CAPABILITIES RELATIONSHIPS	RECONFIGURING CAPABILITIES RELATIONSHIPS
DOMINANT DESIGN	HIGHER (Project A2)	system-level entrepreneurial knowledge access	X (technical knowledge engagement)	X (technical knowledge engagement)
	LOWER (Project B2)	system-level entrepreneurial knowledge access	X (market knowledge engagement)	X (market knowledge engagement)
ADAPTIVE	HIGHER (Project C2)	system-level entrepreneurial knowledge access	system-level entrepreneurial knowledge strength	X (iterative cycles of product changes)
	LOWER (Project D2)	X (focus on opportunity reconfiguration)	system-level entrepreneurial knowledge strength	system-level entrepreneurial knowledge reconfiguration

2 The technology complexity led to design capabilities supporting...

NPD PROJECT LOGIC OF COMPETITION	DRIVING TECHNOLOGY COMPLEXITY	SENSING CAPABILITIES RELATIONSHIPS	SEIZING CAPABILITIES RELATIONSHIPS	RECONFIGURING CAPABILITIES RELATIONSHIPS
DOMINANT DESIGN	HIGHER (Project A2)	product design issues resolution	X (technical knowledge engagement)	X (technical knowledge engagement)
	LOWER (Project B2)	testing new marketing solutions	X (market knowledge engagement)	X (market knowledge engagement)
ADAPTIVE	HIGHER (Project C2)	technology's application possibilities identification	technology's application possibilities development	X (iterative cycles of product changes)
	LOWER (Project D2)	X (focus on opportunity reconfiguration)	technology's application possibilities implementation	technology's application possibilities adaptation

3 The technology complexity led to engaging with system-level entrepreneurial knolwedge through...

NPD PROJECT LOGIC OF COMPETITION	DRIVING TECHNOLOGY COMPLEXITY	SENSING CAPABILITIES RELATIONSHIPS	SEIZING CAPABILITIES RELATIONSHIPS	RECONFIGURING CAPABILITIES RELATIONSHIPS
DOMINANT DESIGN	HIGHER (Project A2)	Experimentation and building empathy for direct observations of local customers	X (technical knowledge engagement)	X (technical knowledge engagement)
	LOWER (Project B2)	Experimentation, knowledge brokering and building empathy for direct observations of local customers	X (market knowledge engagement)	X (market knowledge engagement)
ADAPTIVE	HIGHER (Project C2)	Visual communication for sharing historical accounts; Visualization for identifying "who knows what"; Visualization and experimentation for direct observations of local stakeholders	Visualization, visual communication, framing, reframing, negotiation and envisioning for establishing stakeholders partnerships; Visualization, visual communication, framing, reframing, negotiation and envisioning for conducting business experimentation workshops with stakeholders	X (iterative cycles of product changes)
	LOWER (Project D2)	X (focus on opportunity reconfiguration)	Visualization and visual communication for organizing exploratory meetings with startups; Visualization, visual communication, framing, reframing, and negotiation for establishing stakeholders partnerships; Visualization, visual communication, framing, reframing, and negotiation for conducting business experimentation workshops with stakeholders; Visual communication for fostering collaboration between startups and investors	Visualization, visual communication, framing and reframing for gaining feedbacks from lead users

4 The technology complexity led to design capabilities impacting on...

NPD PROJECT LOGIC OF COMPETITION	DRIVING TECHNOLOGY COMPLEXITY	SENSING CAPABILITIES RELATIONSHIPS	SEIZING CAPABILITIES RELATIONSHIPS	RECONFIGURING CAPABILITIES RELATIONSHIPS
DOMINANT DESIGN	HIGHER (Project A2)	consumers engagement in functional product tests	X (technical knowledge engagement)	X (technical knowledge engagement)
	LOWER (Project B2)	consumers engagement in consumers' needs discovery	X (market knowledge engagement)	X (market knowledge engagement)
ADAPTIVE	HIGHER (Project C2)	stakeholders engagement in entrepreneurial knowlege sharing	stakeholders engagement relationship building	X (iterative cycles of product changes)
	LOWER (Project D2)	X (focus on opportunity reconfiguration)	startups and stakeholders engagement in relationship building	lead users engagement in entrepreneurial signals of change identification

Table 4. 6 Case study 2: how the complexity of the driving technologies influenced capabilities relationships over the entrepreneurial ecosystems dimensions of NPD

Considerations

The findings from the interpretation of the second case study's projects led to the consideration that technology complexity influence the intervention of design capabilities in the co-creation of entrepreneurial ecosystems in projects that follow different logic of competition for new product development (Figure 4. 18).

In projects that served a dominant logic of competition, design capabilities engagement with system-level entrepreneurial knolwegde is limited by technology complexity to the sensing dimension of intervention. Therefore, when technology complexity is considered as a factor of change, it reduces the design capabilities possibilities of intervention to the sensing dimension of new product development in entrepreneurial ecosystems. Specifically, in the project driven by an higher technology complexity, design capabilities made an impact on product functionality testing when they supported the engagement of system-level entrepreneurial knowledge. Differently, in the project driven by a lower technology complexity, design capabilities made an impact on consumers needs discovery when they supported the engagement of system-level entrepreneurial knowledge.

Conversely, in projects that served an adaptive logic of competition, design capabilities engagement with system-level entrepreneurial knowledge provided impacts over the three dimensions of new product development. Specifically, the influence of technology complexity in seizing resulted in the same design capabilities impact, that related to the support of stakeholders relationship building. Consumers were not engaged over this phase, as they were not perceived as informative for understanding the possibilities of development or implementation of the driving technology.

Although they served the same logic of competition, the higher or lower technology that drove the projects influenced design capabilities interventions and impacts over the sensing and reconfiguring dimensions. If in the project driven by an higher technology complexity design capabilities were employed for identifying new technological application possibilities through the engagement of system-level entrepreneurial knowledge, in the project driven by a lower technology complexity design capabilities employment focused on adapting current technology possibilities. Therefore, data interpretation led to the result that an higher complex technology requires the identification of opportunities through design capabilities intervening on the sensing dimension of new product development, while a lower complex technology demands for design capabilities intervening on the reconfiguring dimension of new product development toward existing applications adaptation.

Consequently, design capabilities intervening on the sensing dimension as influenced by an higher complex technology resulted in supportive impacts of stakeholder knowledge sharing, while design capabilities intervening on the reconfiguring dimension as influenced by an lower complex technology resulted in supportive impacts of signals of change identification through lead users engagement.

These findings describe the current employment and related impacts of design capabilities when they are supportive in projects that serve different logics of competition and are driven by technologies characterized by different complexity. By considering the limits of possibilities that the technology provide in real contexts of new product development it is possible to compare and integrate this findings with the ones retrieved from the previous investigation. Findings integration supports the definition of a general informative model, as it is described over the last section of this chapter.

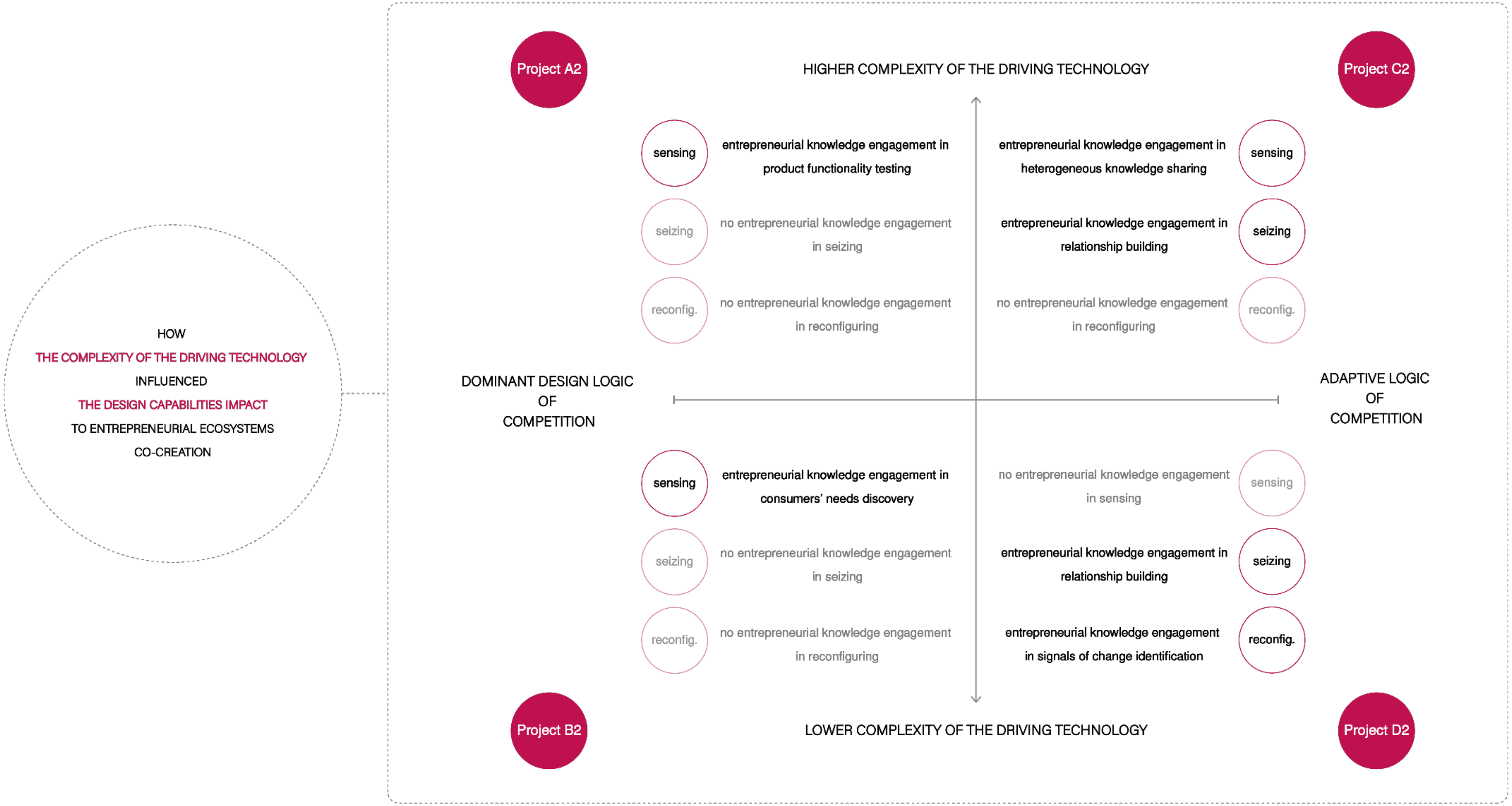


Figure 4. 18 Case study 2: the influence of technology complexity on the design capabilities support to entrepreneurial ecosystems co-creation

4.5. Integrating findings

Findings from the previous case studies were integrated as a unit within this final investigation section (Figure 4. 19).

Integrating previous findings was considered a necessary final step to define how design capabilities can support packaging manufacturing companies to co-create entrepreneurial ecosystems for new product development. When different conditions influence the design capabilities support to new product development, it is necessary to understand how they lead to different design capabilities impacts. This understanding can provide manufacturing companies with informative directions about how to invest on design capabilities when engaging with system-level entrepreneurial knowledge through for the co-creation of entrepreneurial ecosystems.

The two investigation resulted in different design capabilities impacts over the sensing, seizing and reconfiguring dimensions of new product development in entrepreneurial ecosystems, as Figure 4. 10 and Figure 4. 18 shown.

The first investigation focused on *exploring* the influence of different logic of competition without considering the complexity of the projects' driving technology. This led to the identification of capabilities relationships over the dimensions of new product development in entrepreneurial ecosystems (i.e., sensing, seizing and reconfiguring) that consequently informed different design capabilities impacts on the projects. By considering the findings of the first investigation as informative about how different logics of competition shape the purpose, the kind of support and then the impact that design capabilities have when system-level entrepreneurial knowledge is considered the wellspring for new product development, the second investigation adopted a *descriptive* approach for defining the first investigation findings when also the complexity of the projects' driving technology is taken into account.

The definition of findings achieved from the first investigation concerned the examination of effective new product development projects conducted by packaging manufacturing companies. The first part of the investigation proceeded with the same data interpretation strategy for finding a first correspondence of results in terms of capabilities relationships when the logic of competition is the primary differentiator. As the achieved results confirmed a higher proportion of intervention of design capabilities in the support of entrepreneurial ecosystems capabilities finalities when the logic of competition was adaptive, the covered entrepreneurial ecosystems dimensions of new product development and the design capabilities impacts where described.

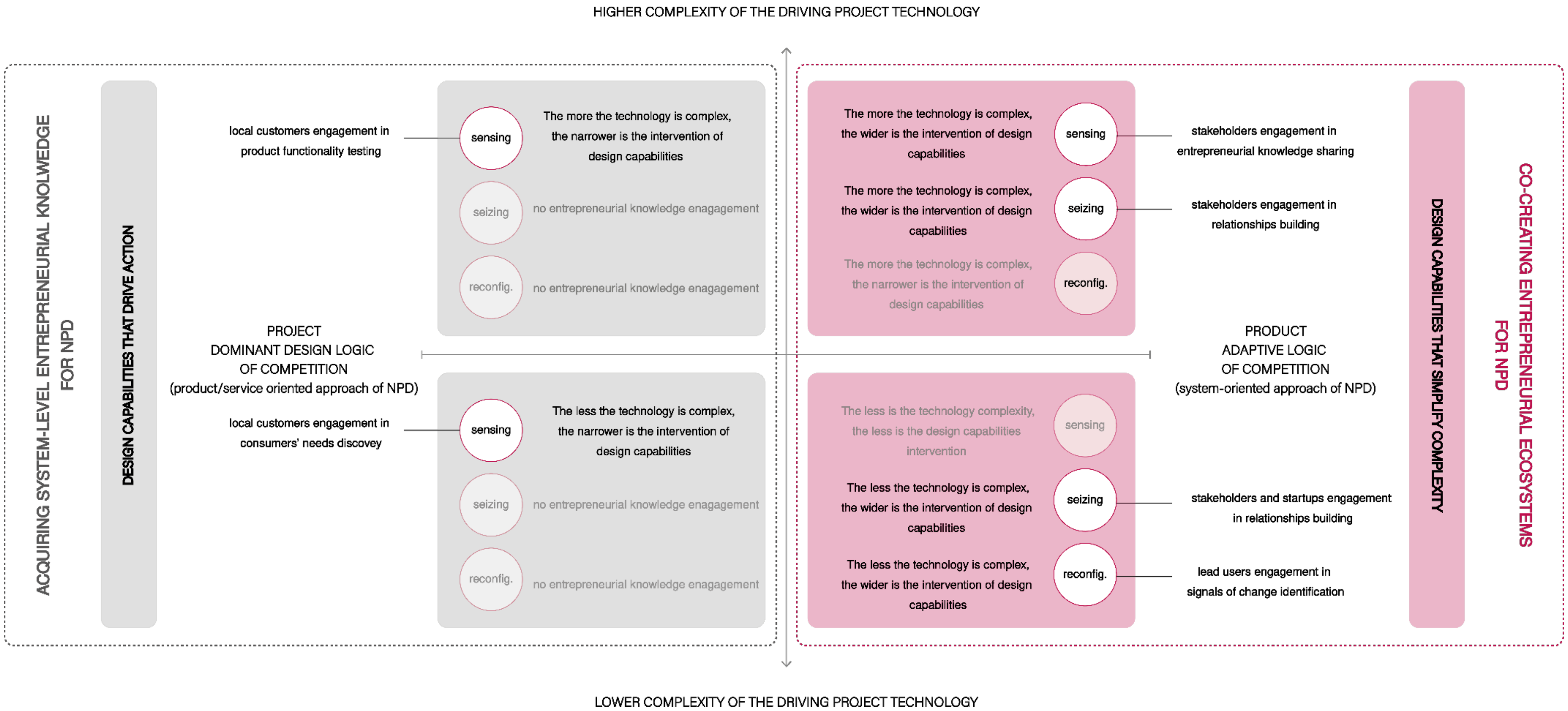
By comparing and integrating the findings from both the investigations, it resulted that technology complexity influences both the dimensions of intervention and the impacts of design capabilities over the two logic of competition. Specifically Figure 5. 20 shows that when lower or higher complex technologies drive projects under different logic of competition, the intervention of design capabilities in the sensing, seizing and reconfiguring dimensions of entrepreneurial ecosystems is limited, encouraged, confirmed or discouraged as compared to the first investigation findings. Therefore, just considering the logic of competition as the factors that influence the definition of how design capabilities can support the co-creation of entrepreneurial ecosystems for new product development in manufacturing risks to hide the limits and potentialities of design capabilities when system-level entrepreneurial knowledge is engaged over sensing, seizing and reconfiguring.

Under these conditions, each project was unique as it showed different goals and expected outcomes. Therefore the definition of specific design capabilities that can support the co-creation of entrepreneurial ecosystems was not considered by the researcher as informative when a general direction of intervention want to be outlined. Rather, the generalization of impacts that can be pursued over sensing, seizing and reconfiguring in entrepreneurial ecosystems through different ontological categories of design capabilities was retained as a supportive indication.

By analysing the dominant design projects, the researcher found that design capabilities that drive action enabled the described impacts when system-level entrepreneurial knowledge was engaged over the projects. The complexity of the driving technology influenced the dimension of intervention of design capabilities by limiting it to the sensing one. When the dominant design logic of competition drive the project purposes definition, design capabilities intervene only in the sensing dimension of entrepreneurial ecosystems' new product development. Hence, engaging with entrepreneurial knowledge is perceived more as a form of entrepreneurial knowledge acquisition that informs internal strategies of resources mobilization and reconfiguration.

By analysing the adaptive projects, the researcher found that design capabilities that simplify complexity enabled the described impacts when system-level entrepreneurial knowledge was engaged over the projects. The complexity of the driving technology influenced the dimension of intervention of design capabilities by encouraging or discouraging interventions over the sensing and reconfiguring dimensions given its complexity. When the adaptive logic of competition drive the project purposes definition, design capabilities intervene only in the sensing, seizing and reconfiguring dimensions of entrepreneurial ecosystems' new product development. Hence, engaging with entrepreneurial knowledge is perceived as a strategy for accessing and strengthening entrepreneurial knowledge that informs new product development through engaging with a multi-actor entrepreneurial interface.

The research findings show how different logics of competition constraint or enable projects activities (and packaging manufacturing companies decisions behind them) to follow an economic adaptation logic to innovate when developing new products. Design capabilities that simplify the complexity of a multi-actor interface through knowledge codification and synthesis show wider possibilities of intervention and impact, and different complex technologies inform their direction of intervention.


HIGHER COMPLEXITY OF THE DRIVING PROJECT TECHNOLOGY
ACQUIRING SYSTEM-LEVEL ENTREPRENEURIAL KNOLWEDGE FOR NPD
DESIGN CAPABILITIES THAT DRIVE ACTION
local customers engagement in product functionality testing
sensing
The more the technology is complex, the narrower is the intervention of design capabilities
seizing
no entrepreneurial knowledge enagagement
reconfig.
no entrepreneurial knowledge enagagement
PROJECT DOMINANT DESIGN LOGIC OF COMPETITION (product/service oriented approach of NPD)
local customers engagement in consumers' needs discovey
sensing
The less the technology is complex, the narrower is the intervention of design capabilities
seizing
no entrepreneurial knowledge enagagement
reconfig.
no entrepreneurial knowledge enagagement
The more the technology is complex, the wider is the intervention of design capabilities
sensing
stakeholders engagement in entrepreneurial knowledge sharing
The more the technology is complex, the wider is the intervention of design capabilities
seizing
stakeholders engagement in relationships building
The more the technology is complex, the narrower is the intervention of design capabilities
reconfig.
PRODUCT ADAPTIVE LOGIC OF COMPETITION (system-oriented approach of NPD)
The less is the technology complexity, the less is the design capabilities intervention
sensing
The less the technology is complex, the wider is the intervention of design capabilities
seizing
stakeholders and startups engagement in relationships building
The less the technology is complex, the wider is the intervention of design capabilities
reconfig.
lead users engagement in signals of change identification
DESIGN CAPABILITIES THAT SIMPLIFY COMPLEXITY
CO-CREATING ENTREPRENEURIAL ECOSYSTEMS FOR NPD
LOWER COMPLEXITY OF THE DRIVING PROJECT TECHNOLOGY

5. CO-CREATING ENTREPRENEURIAL ECOSYSTEMS FOR NPD IN MANUFACTURING

The findings of this thesis are synthesized in Figure 5. 20 and described in the previous chapter. The interest of manufacturing companies to invest in design capabilities for engaging with system-level knowledge for new product development is reported within a solid body of work (Celaschi et al., 2009; Deserti & Zurlo, 2011). However, current advancements in the technological and social context often challenge the development of successful and competitive products, and the consequent economic growth and prosperity (Porter & Heppelmann, 2014; Whitney, 2015). The approach taken in this research explores and describes an alternative approach for investing in design capabilities when building systemic entrepreneurial relationships is described as a promising direction for new product development in fast-changing environments (World Economic Forum, 2013). Specifically, adopting the entrepreneurial ecosystems approach for new product development can open up new understandings of design capabilities employment under a system-level organizational lens of engagement, because design capabilities were employed for accessing and strengthening system-level entrepreneurial knowledge over the organizational phases of new product development in entrepreneurial ecosystems.

This chapter discusses the implications of employing design capabilities for new product development through the entrepreneurial ecosystems approach. While investigating the relationship between acknowledged design capabilities for new product development and entrepreneurial ecosystems, the researcher uncovered different design capabilities impacts under the two conditions of change that influence new product development through entrepreneurial ecosystems. These differences are discussed in this chapter, along with implications that inform new product development managers and designers with professional practices.

5.1. Enabling NPD through adaptive contexts

The research question aimed to outline *how* design capabilities could support packaging manufacturing companies to co-create entrepreneurial ecosystems for new product development. Given the research interest to provide findings that inform the concept of co-creation by connecting two different domains, answering this question required identifying a theoretical "bridge" that informed the engagement dimensions of design capabilities as described in contexts of open innovation, like entrepreneurial ecosystems are.

Enabling the development of new products in adaptive contexts means that design capabilities can satisfy different entrepreneurial ecosystems engagement finalities because new product development in entrepreneurial ecosystems is enabled by a process of relationship building (Spigel, 2017b). When companies in entrepreneurial ecosystems develop new products, they focus on accessing and strengthening system-level knowledge by searching and integrating diverse and distributed knowledge over the process (Roundy & Fayard, 2019).

In this context, a strong emphasis on the engagement dimension enabling new product development makes engagement the fundamental lens for classifying design capabilities. Specifically, open innovation informed design capabilities classification in terms of knowledge searching. When knowledge for new product development is searched by an open innovation approach, cognitive and experiential capabilities for heuristics collection are required (Lopez-Vega et al., 2016). Starting from this basis, design capabilities were ontologically classified under the cognitive dimension (simplifying complexity) and the experiential dimension (driving action) of knowledge search in open innovation.

As design knowledge is inherent to a social process, the participatory dimension of engagement is already embedded in design capabilities (Bucciarelli, 1994). Therefore, the employment of design capabilities is ontologically linked to knowledge integration over the design process. Steen (2013) clarifies this concept by outlining the design capabilities involved in co-design projects when collaboration enables new products to be developed. By drawing on Sanders and Stappers' (2008) and Kleinsmann and Valkenburg's (2008) definitions of co-design, Steen (2013) points out that design capabilities have a role in integrating relationships between groups. Although design capabilities are widely acknowledged as a fundamental enabler of diverse knowledge integration through diverse actors participation, the finalities of employing design capabilities over new product development processes do not coincide with the finalities of entrepreneurial ecosystems for new product development.

While design capabilities in co-design processes enable opportunity identification, resources mobilization, and opportunity reconfiguration through product-oriented finalities (i.e., exploring and defining the problem, perceiving the problem and conceiving possible solutions, trying out and evaluating solutions) (Kleinsmann & Valkenburg, 2008; Sanders & Stappers, 2008; Steen, 2013), entrepreneurial ecosystems capabilities focus on engagement-oriented finalities (Roundy & Fayard, 2019; Spigel, 2017b). For this reason, when new product development draws on entrepreneurial knowledge search and integration, design capabilities can have a role if they satisfied the specific finalities of entrepreneurial ecosystems capabilities over sensing, seizing, and reconfiguring.

This consideration led to the development of an engagement-oriented taxonomy of design capabilities, which enabled the investigation of capabilities relationships when the aim was co-creating entrepreneurial ecosystems for new product development. Therefore, the taxonomy allowed design capabilities potential interventions as their finalities moved from product-oriented to organizational finalities through collaboration. Although the employment of design capabilities for organizational finalities is not new in the open innovation literature of new product development (see Acha, 2008), their role and impacts are valuable when a central authority coordinates the intervention system. Indeed, design capabilities for task partitioning in complex product systems support the organization of a complex set of stakeholders toward new product development when they are an internal asset of the central authority.

Entrepreneurial ecosystems as complex adaptive systems work due to self-organization characteristics (Roundy & Bayer, 2019). As Fredin and Lidén (2020) emphasize, entrepreneurship emerges from hundreds of possible components that interact, and it is not the result of intended effects. When entrepreneurship is an emergent process, local unintended actions for new product development drive its emergence. This does not mean that companies act without an informed choice but highlights that answering to market opportunities is driven by their ability to *enter* a complex network of collaboration. As each relationship informs new informative relationships, companies adapt to new actions toward new product development (Ratten, 2020).

For this reason, design capabilities could not have a role in the co-creation of entrepreneurial ecosystems for new product development if they were classified under coordinative dimensions of collaboration. Conversely, setting design capabilities under knowledge search dimensions supported the investigation of capabilities relationships and made possible the definition of design capabilities impacts when the finalities for new product development are different from product-oriented and coordinative ones.

Furthermore, research findings showed that investigating the support and impacts of design capabilities under the developed taxonomy made relational aspects driving collaborative new product development explicit. As relational aspects of new product development are often implicit dynamics that happen during collaboration (Steen, 2013), they often are not the focus of participatory design research despite representing the infrastructure of collaborative new product development (Dindler & Iversen, 2014). Hence, highlighting the relational activities of design capabilities informed the engagement dimension of new product development in adaptive contexts.

The next section discusses in detail how design capabilities related to entrepreneurial ecosystems capabilities and dimensions for new product development.

5.2. Participating in NPD through adaptive contexts

The participation of design capabilities in the co-creation of entrepreneurial ecosystems for new product development relied on the assumption that *if design capabilities engage with systemic knowledge to serve internal companies' new product development strategies, they can engage with systemic knowledge to co-create entrepreneurial ecosystems for new product development.* Therefore, expanding the level of engagement for enabling design capabilities intervention toward the support of system-level outputs required moving the focus of system-level knowledge engagement analysis from new product development to the process that supports relational actions for new product development.

Widening the lens of new product development by considering system-level entrepreneurial relationships required focusing on entrepreneurial knowledge as the wellspring for new product development rather than technical and market knowledge because entrepreneurial knowledge exchange sets aside the limits of technical and market knowledge exchange for new product development. When entrepreneurial knowledge supports the investigation of knowledge engagement for new product development, new product development is enabled by peer production. Benkler (2008) emphasizes how networks of entrepreneurial knowledge exchange lead to increased benefits as social exchange does not involve the sharing of secreted knowledge. Consequently, entrepreneurial actors do not perceive competitive advantage as deriving from secreted knowledge exchange and exploiting but from their possibility to participate in a complex network of continuous knowledge access and strength (Ratten, 2020; Roundy, 2020).

By relying on this concept, the investigation focused on linking design capabilities for new product development to capabilities that support the organization of entrepreneurial knowledge over the sensing, seizing and reconfiguring dimensions of new product development in entrepreneurial ecosystems. As Benkler (2008, p. 109) states, social exchange represents a "fuzzier medium" that enables profitability. Consequently, the investigation focused on clarifying the relationship between design capabilities and capabilities of entrepreneurial ecosystems that support the design capabilities nourishment of the relational fuzzy front-end of entrepreneurship.

The empirical evidence positively relates the employment of design capabilities that ontologically simplify complexity to the satisfaction of entrepreneurial ecosystems finalities over the sensing, seizing, and reconfiguring dimensions of new product development. Conversely, design capabilities that ontologically drive action shown a limited pattern of intervention. Design capabilities that simplify complexity were defined as those that support system-level knowledge engagement through its codification and synthesis. Therefore, through design capabilities that simplify complexity, action was enabled by continuous relational interactions.

These findings are coherent with the definition that Björgvinsson et al. (2010, p. 44) relate to design in contexts where multiple actors participate in the design process. The authors define design as "continuous co-creation in the collective interweaving of people, objects and processes." When design deals with the interrelation of technical, social, and organizational arrangements, it participates in activities of infrastructuring (Karasti, 2014). By extending this concept to design activities in participatory infrastructuring, Bødker et al. (2017) define design for infrastructuring as performing specific activities that support the engagement of heterogeneous actors in the process of design.

It is interesting to note that those activities always rely on simplifying complexity capabilities of design. Although in the participatory design literature (Simonsen & Robertson, 2012) the design role in complex socio-technical arrangements traditionally refers to facilitation activities, the authors (Bødker et al., 2017) emphasize that for multiple actors to participate in new product development, the focus must be also on the front-end of facilitation, namely on tying different knots.

In this context, staging activities rely on cognitive design capabilities that support the relational interactions to function before, during, and after new product development projects. Specifically, Andreasen et al. (2015, p. 1) define staging as the activity of "arranging a team's cooperation and project work." This arrangement resulted in the research findings over the sensing, seizing, and reconfiguring dimensions of new product development within the investigated projects. Although participatory infrastructuring does not directly refer to entrepreneurship, it reports similarities in how it focuses on relational finalities for new product development. Hence, the researcher finds that design capabilities that simplify complexity can support the infrastructuring of entrepreneurial knowledge when it is engaged in the co-creation of entrepreneurial ecosystems for new product development.

The following section discusses the support and impact that resulted from the employment of design capabilities that simplify complexity over the projects' sensing, seizing and reconfiguring dimensions.

5.3. Developing new products through adaptive contexts

Design capabilities that ontologically simplify complexity led to the evidence of an expanded satisfaction of entrepreneurial ecosystems capabilities finalities over the projects that followed an adaptive logic of competition. Moreover, within those projects design capabilities resulted in different impacts due to the influence of the higher or lower complexity of the projects' driving technology. While the technology complexity did not influence design capabilities intervention in seizing, it led to different impacts over the sensing and reconfiguring dimensions.

Specifically, in the project driven by a higher technology complexity, design capabilities employment was encouraged over the sensing dimension while it was discouraged over the reconfiguring dimension. As emerged from the interview, a younger technology informed several actions of opportunity identification through system-level entrepreneurial knowledge. In contrast, it did not inform actions for the identification of signals of change. In this context, design capabilities had a significant impact in enabling knowledge sharing through the engagement of stakeholders.

Conversely, in the project driven by a lower technology complexity, design capabilities employment was encouraged over the reconfiguring dimension while discouraged over the sensing dimension. As emerged from the interview, the older technology required the project to plan activities that identify signals of change to expand the technology field of application. In this context, design capabilities had a significant impact in capturing signals of change through lead users engagement.

Therefore, findings showed the link between design capabilities and entrepreneurship through entrepreneurial ecoystems for new product development in manufacturing is influenced by factors that leads design capabilities engaging with different entrepreneurial actors at the system level.

Although several authors started recently to think about design capabilities at the organizational level (Buchanan, 2008; Dong et al., 2016; Liedtka, 2020), the explicit connection between design capabilities and organizational capabilities for new product development in entrepreneurial ecosystems in terms of design capabilities impacts that emerged from this research represent a unique contribution. Moreover, while few authors recently contributed to make the conncection more explicit, they focus on the definition of "dynamic design capabilities" (Cautela et al., 2021; Magistretti et al., 2021) without taking into account the multi-actor interface of entrepreneurial ecosystems.

Below, the definition of design capabilities impacts that emerged from the research investigations are compared with the rencent literature linking design capabilities and dynamic capabilities for new product development.

Sensing through entrepreneurial knowledge: enhancing knowledge sharing

Sensing, or the opportunity identification phase of new product development (Teece, 2007), is described by the entrepreneurial ecosystems literature as a the phase where entrepreneurial actors access system-level entrepreneurial knowledge through capabilities of legitimacy building, transactive memory and vicarious learning (Roundy & Fayard, 2019; Spigel, 2017b). Therefore sensing in entrepreneurial ecosystems represents the ability of companies to search for and learn from system-level entrepreneurial knowledge while entering the entrepreneurial community.

As emerged from the research findings, design capabilities for sensing provide different impacts to new product development projects when they are set under a specific logic of competition, and when the complexity of the project driving technology is higher or lower. By comparing the founded design capabilities impacts in the sensing dimension of entrepreneurial ecosystems with the current literature linking design capabilities to sensing dynamic capabilities, the researcher found a correspondence with the impacts described by Magistretti et al. (2021) when the projects'logic is dominant design and when the complexity of the driving technology is lower.

Under this specific setting, the dominant logic of competition is a means for accessing entrepreneurial knolwegde for firm-level product proposals generation. Through design capabilities of experiential learning, opportunity identification relies on sensing what users experience in everyday life so that users needs are discovered. However, when the complexity of the driving project technology is taken in consideration, the same impact is supportive only when the technology shows a lower complexity. Indeed, when the technology shows a higher complexity, design capabilities are considered a strategic investment for new product development when they engage with system-level entrepreneurial knowledge for supporting the product design functionality improvement. Hence, technology complexity define the design capabilities impacts of users needs discovery relevant when product differentiation is required.

Although product differentiation is described a relevant determinant for competitive advantage in dominant design logic of competition, it is not perceived as the prioritary kind of support that new product development requires when identifying new opportunities in adaptive logic of competition. In this context, it is important to engaging with the entrepreneurial community so that companies can enter a complex network of relationships that can inform about the existence of new opportunities. Consequently, product differentiation is perceived as a consequence deriving from the ability of companies to identify new technological application possibilities. Under this perspective, design capabilities impacted on enhancing knowledge sharing through stakeholders engagement. Specifically, the higher complexity of the technology encourages technological application identification through design capabilities that codify and synthesize the diverse entrepreneurial knowledge.

Therefore, sensing through entrepreneurial knowledge expands the design capabilities impacts when a stakeholder-centered orientation is adopted rather than a consumer-centered one.

Seizing through entrepreneurial knowledge: building relationships

Seizing, or the resource mobilization phase of new product development (Teece, 2007), is described by the entrepreneurial ecosystems literature as a the phase where entrepreneurial actors strengthen the interdependence among system-level entrepreneurial knowledge through capabilities of proactiveness, mentoring, framing diversity and interactive expertise (Roundy & Fayard, 2019; Spigel, 2017b). Therefore seizing in entrepreneurial ecosystems represents the ability of companies to increasing the degree to which different actors goals and tasks depend on other system-level actors.

As emerged from the research findings, design capabilities for seizing provide different impacts to new product development projects when they are set under a specific logic of competition, and when the complexity of the project driving technology is higher or lower. By comparing the founded design capabilities impacts in the seizing dimension of entrepreneurial ecosystems with the current literature linking design capabilities to seizing dynamic capabilities, the researcher found a correspondence with the impacts described by Magistretti et al. (2021) only when the projects'logic of dominant design is considered as a factor of influence.

Under this perspective, the dominant logic of competition is a means for accessing entrepreneurial knolwegde for firm-level insights deduction and development. Through design capabilities of experiential learning, resource mobilization relies on engaging with system-level entrepreneurial knowledge for converging different know-hows in the creation and testing of a deduced product hypothesis. However, when the complexity of the driving project technology is taken in consideration, the design capabilities impact of hypothesis synthesis and testing through consumers and stakeholders engagement is not considered as relevant. Indeed, when the technology shows a higher or a lower complexity, design capabilities are not considered a strategic investment for new product development when they engage with system-level entrepreneurial knowledge as insights deduction and development relies on technical and market knowledge engagement. Hence, technology complexity limits the design capabilities impacts to the sensing dimension of new product development through entrepreneurial ecosystems in terms of users needs discovery for product differentiation.

Although technical and market knowledge sharing is described a relevant determinant for competitive advantage, it is perceived as limiting the enhancement of entrepreneurial knowledge interdependence. Due to intellectual property rules, technical and market knowledge are not easily to be shared. In this context, technical and market knowledge sharing happens when a product-oriented approach is adopted by the new product development project and developing a specific product requires diverse know-how. Consequently, technical and market know-how rather than entrepreneurial know-what enables the effective new product development. However, in entrepreneurial ecosystems, technical and market knowledge sharing is perceived as a natural consequence deriving from the ability of companies to build trust relationships of complementarity between different entrepreneurial actors. Under this perspective, design capabilities impacted on increasing the degree to which heterogeneous entrepreneurial actors collaborate toward a shared system-oriented goal. Specifically, the higher and lower complexity of the technology respectively encourages technological application development and implementation through design capabilities that codify and synthesize the diverse entrepreneurial knowledge over collaboration activities.

Therefore, also in this case, seizing through entrepreneurial knowledge expands the design capabilities impacts when a stakeholder-centered orientation is adopted rather than a consumer-centered one.

Reconfiguring through entrepreneurial knowledge: identifying signals of change

Reconfiguring, or the knowledge adaptation phase of new product development (Teece, 2007), is described by the entrepreneurial ecosystems literature as a the phase where entrepreneurial actors sense and implement external changes through system-level entrepreneurial knowledge engagement and reconfiguration through the capability of reflectiveness (Roundy & Fayard, 2019; Spigel, 2017b). Therefore reconfiguring in entrepreneurial ecosystems represents the ability of companies to search for and learn from system-level entrepreneurial knowledge for adapting to changes.

Magistretti et al. (2021) define reconfiguring as a phase where design capabilities of reframing and envisioning enable value creation. In this phase diverse ideas are converged into a final solution through abductive thinking and iterative cycles of change. As emerged from the research findings, this definition of reconfiguring is embedded in design capabilities interventions over the seizing dimension of entrepreneurial ecosystems. As such, iteration through design capabilities that simplify complexity supported the relationships formation between heterogeneous stakeholders for value co-creation.

The main difference between the literature description of dynamic design capabilities and dynamic capabilities in entrepreneurial ecosystems draws on a different perception about how reconfiguring contribute to value creation. If in the design literature, reconfiguring is the final step following inductive and deductive thinking toward a new solution development, in entrepreneurial ecosystems reconfiguring represents the ability to continuously adapt to external changing circumstances. This enable continuous cycles of engagement with different entrepreneurial knowledge for continuous opportunity identification and seizing. Therefore, the main difference resides in the consideration of a wider level of engagement for reconfiguring knowledge that leads to continuous value co-creation at the level of the system in entrepreneurial ecosystems.

For this reason, the entrepreneurial ecosystems literature emphasizes that reconfiguring requires the engagement of specific entrepreneurial actors, such as lead users and entrepreneurs, that can support the identification and implementation of signals of change in consumption and technological areas. This was evident from findings retrieved from the project that followed an adaptive logic of competition under a lower complex technology. When an older technology requires to adapt to novel application possibilities, design capabilities impacted on the identification of changes by involving lead users over participatory activities of framing, reframing and envisioning. This allower for engaging with multiple actors over the seizing phase, which is here perceived as a consequent phase of new product development for the new application opportunity implementation.

Differently, in the project that was driven by an adaptive logic of competition under a higher technology complexity, the need for reconfiguring knolwegde for system level interventions was not perceived. Conversely, it was more relevant to focusing on the sensing phase for entering a network of entrepreneurial knowledge that could inform new opportunities identification.

Therefore, technology complexity under an adaptive logic of competition strongly influences the possibilities of intervention of design capabilities in reconfiguring for knowledge adaptation.

To conclude, entrepreneurial knolwedge engagement for new product development requires thinking about value creation not as the final step in which design capabilities converge insights into a final solution, but as a continuous process of co-creation that is enabled by system-level entrepreneurial knowledge engagement under the influence of different conditions, namely the logic of competition and the complexity a technology. This provides indications about how to employ design capabilities under different conditions when a stakeholder-centered orientation determines the success of new product development.

5.4. Implications

The investigation of the relationship between design capabilities and entrepreneurial ecosystems can support managers dealing with new product development in packaging manufacturing to expand their possibilities of decision making when investing in design as a competitive resource. By being aware of an alternative adaptive logic of competition on the basis of which new product development projects can pursue system-oriented goals through the employment of design capabilities can expand possibilities of intervention and competitive advantage. Specifically, managers can be aware of the impacts of design capabilities when technologies with higher or lower complexity drive the projects set under an adaptive logic of competition in entrepreneurial ecosystems.

This chapter has pointed at several aspects to consider when design capabilities are employed as a support for the engagement of system-level entrepreneurial knowledge in new product development. First, enabling new product development in adaptive contexts requires design capabilities to be employed according to entrepreneurial ecosystems' finalities of entrepreneurial capabilities. This aspect is supported when design capabilities engage with system-level entrepreneurial knowledge through the codification and synthesis of heterogeneous knowledge over participation activities. Second, developing new product development through adaptive contexts requires design capabilities to intervene over the entire organizational phases of new product development in entrepreneurial ecosystems, namely sensing, seizing, and reconfiguring. This means expanding the design capabilities intervention from the opportunity identification phase of entrepreneurship to the resource mobilization and reconfiguration phases.

Research findings also inform the professional practice of designers when they participate in new product development projects that follow a system-oriented approach. As engaging with system-level entrepreneurial knowledge represents the wellspring of new product development, designers are provided with indications about the class of design capabilities to employ and the type of entrepreneurial actors that can lead to specific impacts over sensing, seizing, and reconfiguring.

Finally, the research opens up a new space of investigation for managers and researchers interested in expanding the discussion on new product development when an adaptive logic of competition drives new product development. Specifically, while this research focuses on the manufacturing context, they might contribute by investigating the relationships of design capabilities and entrepreneurial ecosystems for new product development in different contexts.

6. CONCLUSION

This thesis started from the premise that the employment of design capabilities for developing new products through system-level entrepreneurial knowledge engagement is limited in manufacturing companies. Despite the recent emphasis on adopting the entrepreneurial ecosystems approach for new product development, manufacturing companies primarily invest in design capabilities as a strategic resource to inform vertical product-oriented strategies at the firm level. Described as able to access and synthesize dispersed knowledge and to reframe it into final competitive solutions, design capabilities currently lack a proper definition of their impacts when the company requires to enter a complex network of entrepreneurial relationships by engaging with system-level entrepreneurial knowledge under an organizational perspective.

In the pursuit of bridging this gap, the researcher developed a comprehensive model that reports and compares different design capabilities impacts when design capabilities are employed over the entrepreneurial ecosystems' necessary phases of new product development, namely opportunity identification (i.e., sensing), resources mobilization (i.e., seizing), and knowledge reconfiguration (i.e., reconfiguring) by engaging with a multi-actor entrepreneurial interface. The model was intended to support manufacturing companies to (1) making decisions about the kind of design capabilities to invest in when new product development projects aim to follow a system-oriented approach, (2) being aware of the organizational phases of new product development in which design capabilities can provide an impact when system-level entrepreneurial knowledge is engaged, (3) being aware of design capabilities impacts for accessing and strengthening system-level entrepreneurial knowledge for new product development.

The model also informs design practitioners that deal with complex new product development projects adopting a system-oriented approach. Designers can be aware of the engagement dimensions of design capabilities that can best support their practices when nurturing specific entrepreneurial finalities represent the necessary condition for developing new products.

Within the situated context of packaging manufacturing for the food industry ecosystem, the research advanced knowledge in the way it positions design capabilities under the entrepreneurial ecosystems approach to new product development. Specifically, the research identifies and differentiates the impacts of design capabilities over the organizational dimensions of entrepreneurial knowledge engagement (i.e., sensing, seizing, and reconfiguring) under the influence of the two primary factors of change that define different entrepreneurial actions for new products development in entrepreneurial ecosystems (i.e., the logic of competition adopted by the project and the complexity of the project's driving technology). Consequently, they should be two important factors to consider when investing in design capabilities if one is interested in developing new products through the entrepreneurial ecosystems approach. Reporting how new product development projects can be conducted under the entrepreneurial ecosystems perspective, and highlighting how design capabilities can have an impact, contributes to widening the design capabilities spaces of intervention beyond packaging design, thus opening new possibilities for investing in design as a strategic resource in this context.

Under a broader theoretical lens, this research intends to contribute to:

- The definition of design capabilities impacts when a different meaning of co-creation drives new product development:

When co-creation is intended as "the enactment of creation through interaction" (Ramaswamy & Ozcan, 2018) rather than "any act of collective creativity" (Sanders & Stappers, 2008), design capabilities intervene under open innovation forms of co-creation. In the context of entrepreneurial ecosystems, this means that knowledge access and strength goals rather than the acknowledged goals defining co-design processes drive design activities for new product development. This shift in the meaning of co-creation led to the identification of design capabilities that ontologically *simplify complexity* (capabilities that rely on engaging entrepreneurial knowledge through codification and synthesis) as the ones that showed a wider and general pattern intervention in satisfying entrepreneurial capabilities finalities for new product development. Specifically, the empirical evidence reported enhancing stakeholder knowledge sharing, relationship building and signals of change identification as the design capabilities impacts in the situated context under examination. Although a theoretical generalization could not be achieved due to the low number of projects considered, the results show an preliminary informative direction for further studies.

- The expansion of the discussion on design capabilities for new product development in manufacturing when the organizational level of entrepreneurial knowledge engagement is considered:

As described over the literature review, manufacturing companies traditionally adopt a vertical approach of technical and market knowledge engagement that informs firm-level strategies and practices for superior product development. Consequently, design capabilities are highly specialized in satisfying companies' consumer-centered approaches by engaging with knowledge in the systems for informing companies' new product directions. However, as several challenges in developing superior products that satisfy consumers' needs in the Twentyfirst century are highlighted in the literature, manufacturing companies often lack organizational knowledge about the entrepreneurial process of new product development. Nevertheless, the literature review did not report classifications of design capabilities for new product development in manufacturing that emphasize the strategic role of design capabilities under an organizational perspective of entrepreneurial knowledge engagement. Specifically, when the design literature links design to open innovation (e.g., see Acha, 2008), design capabilities cover a role in task partitioning once a central authority defines a priori the technical and market knowledge needed for new product development. This research adopts the definition of entrepreneurial ecosystems as complex adaptive systems.

Consequently, the property of self-organization requires design capabilities to intervene in a complex and not predetermined network of relationships for new product development. The conducted investigations showed how design capabilities might be classified and employed in adaptive contexts for new product development.

- Providing an empirical work that defines design capabilities impacts under the sensing, seizing, and reconfiguring dimensions for new product development in manufacturing

Although several authors in the design literature recently reported design capabilities impacts in sensing, seizing, and reconfiguring, they do not refer to empirical findings in situated contexts but focus on their theoretical conceptualization (e.g., see Dong et al., 2016; Liedtka, 2020; Magistretti et al., 2021). Cautela et al. (2021) provide a recent contribution based on the empirical investigation that describes design capabilities as dynamics, but the focus of the work is about micro-foundations. This research provides a contribution to the topic by showing how design capabilities due to their ontologies nurture the teleologies of entrepreneurial capabilities for new product development. Moreover, this research is unique in the way it expands the topic under the entrepreneurial ecosystems perspective, thus opening a new investigation space for studying design capabilities as dynamic when a multi-actor interface of entrepreneurial knowledge drives new product development.

Two practical contributions mainly supported the theoretical contributions:

- An engagement-driven taxonomy of design capabilities informed by open innovation theory

The researcher developed a design capabilities taxonomy that could enable the investigation of the relationship between design capabilities and entrepreneurial ecosystems. Although design capabilities traditionally deal with heterogeneous knowledge participation when employed for new product development, the finalities by which they are classified reflect a product-centered rather than a system-centered orientation of engagement. Consequently, a new taxonomy that classified design capabilities under ontological engagement dimensions was developed by integrating design and open innovation knowledge about the classes of action that enable system-level engagement, namely *simplifying complexity* and *driving action*. Specifically, simplifying complexity capabilities relied on engaging knowledge through codification and synthesis, while driving action capabilities relied on engaging knowledge through experiential learning. This allowed for investigating which design capabilities could serve the entrepreneurial capabilities teleologies (i.e., aims and goals) for new product development in entrepreneurial ecosystems. Although the engagement-driven taxonomy reports design capabilities for new product development in manufacturing, the logic behind the classification might be replicated by design researchers for investigating the relationships between different design capabilities and entrepreneurial ecosystems.

- A framework that creates an analytical and interpretative space by visually displaying capabilities belonging to two different domains: design and entrepreneurial ecosystems

Due to the need to visualize data deriving from the coding activity, the researcher developed a framework that supported analytical and interpretative research activities. Specifically, the logic behind the framework structure is to display an open and visual space of analysis that derives from the clustering of design and entrepreneurial capabilities and related dimensions over a vertical and a horizontal axes. Each design capability ontology can potentially intersect with all the entrepreneurial capabilities teleologies, and intersections nodes indicate this possibility within the investigation space. The logic adopted for developing the framework might practically support other researchers interested in investigating the relationship between design capabilities and entrepreneurial ecosystems for new product development.

Although the investigation of the relationship between design capabilities and entrepreneurial ecosystems reported informative findings that can potentially support further research, the researcher finds that the study's main limitation was the unintentionality of developing the examined projects under an entrepreneurial ecosystems perspective. Although the projects reported characteristics that enabled the investigation, their selection was made based on opportunities presented to the researcher over the doctoral path. Collaborating in research with researchers that currently investigate new product development projects intended to serve an adaptive logic of competition might have led to the interpretation of a more informed set of data. Nevertheless, this research represents a novel touchpoint between the design and the entrepreneurial ecosystems communities when investigating the relationship between design capabilities and entrepreneurial ecosystems for new product development in manufacturing.

Moreover, by leveraging this work, new product development managers and researchers might extend the discussion by answering the broader research question about how design capabilities might support the co-creation of entrepreneurial ecosystems for new product development within different contexts and sectors. This would allow the possibility of expanding the understanding of system-level entrepreneurial knowledge engagement for new product development from a design perspective.

GLOSSARY

Adaptive logic of competition

The stakeholder-oriented approach of developing new products

Quote: “In the field of entrepreneurial ecosystems, networks are crucial to its success as they enable information and knowledge to be exchanged. Networks have a relational nature as they depend on the interactions of members. This means that the duration of the network needs to be considered when understanding its impact on entrepreneurship. Networks are especially pertinent to entrepreneurship as they enable resources to be obtained. As entrepreneurs expand their network it can help them to find different kind of contacts. This enables a more multi-layered exchange to develop predicated on the assumption of reciprocity. Due to the complex interdependencies amongst network members it can take time for relationships to obtain a result. This means that there is an accumulation advantage for network members that are well connected. It is better for entrepreneurs to be part of the complex adaptive system that represents an entrepreneurial ecosystem. This means it is important for members to stay connected otherwise they are at risk of not being recipients of new knowledge.” (p.8)

Ratten, V. (2020). Entrepreneurial ecosystems. *Thunderbird International Business Review*, *62*(5), 447–455.

Co-creation

The enactment of creation through interactions.

Quote: “We seek to ground our inquiry in the enactment of creation through interactions. This goes beyond two or more human actors coming together in activities. Rather, as we discuss, it entails a multiplicity of interactive system-environments among persons and material entities (e.g., devices). […] Our envisioning approach to conceptualizing co-creation brings a novel, unifying perspective to what co-creation is, by anchoring its theorization in interactive system-environments whose heterogeneous relations can be configured anywhere in the “value creational system”, i.e., regardless of whether it concerns activities of “producing”, “exchanging”, or “using” goods and services. In doing so, we explicitly distinguish the concept of co-creation from the site of its application in the activity system, i.e., production, exchange, or use of goods and services.” (pp. 196-197)

Ramaswamy, V., & Ozcan, K. (2018). What is co-creation? An interactional creation framework and its implications for value creation. *Journal of Business Research*, *84*(November 2017), 196–205.

Design capabilities

Design abilities that support the development of competitive new products.

Quote: "Design scholars would further claim that the processes associated with the deployment of a design draw together superior skills that contribute to competitive advantage, even if the firm does not produce a design *per se*. Design-oriented capabilities (as superior skills) allow firms to tolerate ambiguity, see possibilities, and generate alternative solutions to problems." (pp. 60-61)

Dong, A., Kleinsmann, M., & Snelders, D. (2021). The Design of Firms: Part 2-Competitive Advantage. *Design Issues*, *37*(3), 59-77.

Dominant design logic of competition

The customer-centered approach of developing new products.

Quote: "Products or services based on the technology might be crude, unreliable, or expensive, but might suit the needs of some market niches. In this phase, firms experiment with different form factors or product features to assess the market response. Eventually, however, producers and customers begin to arrive at some consensus about the desired product attributes, and a dominant design emerges." (p. 59)

Schilling, M. A. (2010). *Strategic Management of Technological Innovation.* Tata McGraw-Hill Education.

Entrepreneurial capabilities

The abilities of entrepreneurial actors to engage with their ecosystem.

Quote: "An ecosystem in a way is a form of dynamic capability as it purposefully tries to extend its resource base. The dynamic capability perspective refers to the way an organization can deliberately create and modify its resources. Resources such as human capital, knowledge, and distribution channels can all contribute to an ecosystem working in a dynamic manner. This means that changes occur within an ecosystem based on opportunities emerging in the market. By sensing new opportunities organizations can leapfrog their competitors in terms of offering more valuable services. This means that seizing opportunities is required by organizations in order to transform their market capabilities. In this respect, it can be helpful for an organization to learn from mistakes and move forward in a more positive manner. To manage an ecosystem from a dynamic capabilities perspective can take some time so skill is important to refine these skills in the market by continually engaging in a pattern of organizational learning." (p. 4)

Ratten, V. (2020). Entrepreneurial ecosystems. *Thunderbird International Business Review*, *62*(5), 447–455. https://doi.org/10.1002/tie.22164

Entrepreneurial ecosystem

A set of interdependent actors and factors coordinated in such a way that they enable productive entrepreneurship within a particular territory.

Quote: "The entrepreneurial ecosystem approach has so far been constructed ad hoc by different authors, without any shared definition. A definition that nevertheless seems widely applicable is that of "the entrepreneurial ecosystem as a set of interdependent actors and factors coordinated in such a way that they enable productive entrepreneurship". In this case, entrepreneurial activity is considered the process by which individuals create opportunities for innovation. This innovation will eventually lead to new value in society, and this is, therefore, the "ultimate outcome" of an entrepreneurial ecosystem, while entrepreneurial activity would be more an "intermediary output" of the system." (p. 1765)

Stam, E. (2015). Entrepreneurial Ecosystems and Regional Policy: A Sympathetic Critique. *European Planning Studies*, *23*(9), 1759–1769.

Entrepreneurial knowledge

The knowledge about the entrepreneurial process.

Quote: "[…] Ecosystems also signal a similar shift in how we understand the role of knowledge in the entrepreneurship process. Market and technical knowledge is seen as a wellspring of entrepreneurial innovation within both the cluster and the RIS literatures. Within the context of EE we must also include a third type of knowledge: knowledge about the entrepreneurial process." (p. 156)

Spigel, B., & Harrison, R. (2018). Toward a process theory of entrepreneurial ecosystems. *Strategic Entrepreneurship Journal*, *12*(1), 151–168.

Knowledge economy

An economy that is directly based on the production, distribution, and use of knowledge and information.

Quote: "OECD science, technology and industry policies should be formulated to maximise performance and well-being in "knowledge-based economies" – economies which are directly based on the production, distribution and use of knowledge and information. This is reflected in the trend in OECD economies towards growth in high-technology investments, high-technology industries, more highly-skilled labour and associated productivity gains. Although knowledge has long been an important factor in economic growth, economists are now exploring ways to incorporate more directly knowledge and technology in their theories and models. "New growth theory" reflects the attempt to understand the role of knowledge and technology in driving productivity and economic growth. In this view, investments in research and development, education and training and new managerial work structures are key." (p.7)

OECD. (1996). *The Knowledge Based Economy*.

New product development

The combination of complementary and heterogeneous knowledge that productively collaborate toward economic growth and prosperity.

Quote: "[…] Products are vehicles for knowledge, but embedding knowledge in products requires people who possess a working understanding of that knowledge. […] It depends on the diversity of knowledge across individuals and on their ability to combine this knowledge, and make use of it, through complex webs of interaction." (p.15)

Hausmann, R., Hidalgo, C. A., Bustos, S., Coscia, M., & Simoes, A. (2014). *The atlas of economic complexity: Mapping paths to prosperity*. Mit Press.

Open innovation

A particular form of co-creation (Loureiro)

Quote: "Open innovation and co-creation are two concepts that deal with collaboration and interaction. However, these concepts still differ to some extent. First, open innovation concerns active collaboration among different organisations or groups of stakeholders. In contrast, co-creation focuses more on specific relationships between the organization and a defined stakeholder, according to the more classic definitions. Second, open innovation focuses on a single process, while co-creation can involve several (not only co-innovation but also co-design or co-production, among others). These differences are becoming less evident in the last decade, due to an expansion of the research focus in co-creation from an organisational level to a network level, which implies exploring the systemic processes and social relationships involved in this process. Consistent with this evolution, one may suggest that co-creation can involve interactions between several stakeholders and, therefore, open innovation is a particular form of co-creation." (pp. 391-392)

Loureiro, S. M. C., Romero, J., & Bilro, R. G. (2020). Stakeholder engagement in co-creation processes for innovation: A systematic literature review and case study. *Journal of Business Research*, *119*(February 2018), 388–409.

Product

The manifestation of knowledge dynamics it embeds.

Quote: "What are things made out of? One way of describing the economic world is to say that things are made with machines, raw materials and labor. Another way is to emphasize that products are made with knowledge. Consider toothpaste. Is toothpaste just some paste in a tube? Or do the paste and the tube allow us to access knowledge about the properties of sodium fluoride on teeth and about how to achieve its synthesis? The true value of a tube of toothpaste, in other words, is that it manifests knowledge about the chemicals that facilitate brushing, and that kill the germs that cause bad breath, cavities and gum disease." (p. 15)

Hausmann, R., Hidalgo, C. A., Bustos, S., Coscia, M., & Simoes, A. (2014). *The atlas of economic complexity: Mapping paths to prosperity*. Mit Press.

Stakeholders

Those who are or can be affected by the actions of others.

Quote: "Stakeholders can be broadly defined as those who are or can be affected by the actions of others. This broad definition acknowledges that there is both direct and indirect effects in the business environment. Organizations have direct relationships with customers and suppliers that shape most of their decisions. However, there are also indirect relationships through the involvement in different kind of dealings. This include third party arrangements that take place via another entity. Increasingly these kinds of arrangements are becoming more common in the sharing economy that is characterized by different kinds of market transactions. Thus, stakeholders now extend beyond the traditional forms of relationships to include the community and society. This means that firms can benefit from different types of arrangements depending on the circumstances. Increasingly having a broad network is viewed in a positive way in terms of stakeholder engagement. There has been a noticeable increase in the number of studies on entrepreneurial ecosystems that take both a stakeholder and network approach." (p. 8)

Ratten, V. (2020). Entrepreneurial ecosystems. *Thunderbird International Business Review*, *62*(5), 447–455. https://doi.org/10.1002/tie.22164

Technology affordances

The actionable characteristics of a technology.

Quote: "Affordance theory asserts a number of things, but I'd focus on its claims that technologies produce fields of action (including unexpected actions)." (p. 303)

Neff, G., Jordan, T., McVeigh-Schultz, J., & Gillespie, T. (2012). Affordances, Technical Agency, and the Politics of Technologies of Cultural Production. *Journal of Broadcasting and Electronic Media*, *56*(2), 299–313.

Quote: "Assuming that technologies are just tools that happen, more or less, to be there, and are employed in any given society in a pattern that depends only on what that society and culture makes of them is too constrained. A society that has no wheel and no writing has certain limits on what it can do. Barry Wellman has imported into sociology a term borrowed from engineering—affordances. […] The idea is simple to explain, and distinct from a naı¨ve determinism. Different technologies make different kinds of human action and interaction easier or harder to perform. […] Technology sets some parameters of individual and social action. […] Different patterns of adoption and use can result in very different social relations that emerge around a technology." (pp. 17-18)

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APPENDIX

PROTOCOL OF THE SEMI-STRUCTURED INTERVIEW

Company name:

Year of foundation:

Job position of the interviewee:

Educational background of the interviewee:

NPD project details:

Project's goal and expected outcome:

Driving technology:

TOPICS OF THE INTERVIEW

TOPIC 1

Preliminary assessment of design capabilities used within the project

TOPIC 2

Activities of opportunity identification conducted through the involvement of external knowledge

TOPIC 3

Activities of opportunity development conducted through the involvement of external knowledge

TOPIC 4

Activities of opportunity adaptation through the involvement of external knowledge

TOPIC 1

Preliminary assessment of design capabilities used within the project

Please indicate which of the following design capabilities were employed over the project.

Design capabilities definitions:

1. Building empathy

The ability to take the perspective of another.

Example: conducting ethnographic observations or qualitative interviews

2. Knowledge brokering

The ability to access the implicit understanding of products' function and meaning that are shared inside the users' cultural community.

Example: conducting participatory product observations

3. Knowledge integration

The ability to codify and communicate different perspectives.

Example: creating models and synthetic images of abstract concepts

4. Visualization

The ability to make ideas and insights visual and tangible, and to represent abstract concepts.

Example: creating sketches, drawings, mock-ups, prototypes, and in general physical artifacts

5. Visual communication

The ability to reveal and explain patterns and simplify complex phenomena to their fundamental essence.

Example: using texts, drawings, slides, posters, reports, photo, video, CAD drawings, diagrams, demonstrations etc.

6. Framing

The ability to order systems and synthesize patterns.

Example: creating affinity diagrams, mind maps and customer journey maps

7. Reframing

The ability to reposition a concept, solution or option in different contexts.

Example: creating counter-briefs, conducting future workshops

8. Envisioning

The ability to imagine and represent alternative future possibilities.

Example: representing scenarios, storyboards

9. Criticism

The ability to interpret the network partners' perspectives.

Example: providing partners with "things to use" or broader perspectives on a topic

10. Negotiation

The ability to create a shared understanding of the problem and foster a joint commitment to possible resolution actions.

Example: conducting brainstorming sessions, focus groups, future workshops and holding retreats

11. Experimentation

The ability to learn through iterative forms, prototypes and trials that test a range of possible solutions with end-users.

Example: testing prototypes (e.g., A/B tests)

TOPIC 2

Activities of opportunity identification conducted through the involvement of external knowledge

The initially identified opportunity can often be better defined due to the company's interaction with external entrepreneurial knowledge.

1) Did you shared your entrepreneurial history and future entrepreneurial intentions with other entrepreneurial actors so that you could exchange perspectives and ideas about the project development?

Which activities supported this phase?

2) Did you participated in entrepreneurship-oriented events (such as conferences, webinars, workshops) so that you could identify "who knows what" about opportunity implementation possibilities over the project?

Which activities supported this phase?

3) Did you find it relevant to directly and/or indirectly observe how other entrepreneurial actors succeeded or failed when developing new products?

Which activities supported this phase?

4) Did you find it relevant to gaining consumers' feedback to inform product improvements?

Which activities supported this phase?

TOPIC 3

Activities of opportunity implementation conducted through the involvement of external knowledge

Once the opportunity has been defined, it is often necessary to mobilize diverse external resources that inform the project development.

1) Did you support establishing partnerships and deals among different involved entrepreneurial actors so that a collaboration might start?

Which activities supported this phase?

2) Did you interact with entrepreneurial actors speaking a different professional language than yours over the project?

Which activities supported this phase?

3) Did you elaborated on different entrepreneurial actors' perspectives so that you could define the criteria for the project development?

Which activities supported this phase?

4) Did you act as mentors for specific entrepreneurial actors so that you supported their entrepreneurial growth?

Which activities supported this phase?

TOPIC 4

Activities of opportunity adaptation conducted through the involvement of external knowledge

As the external market shifts rapidly, it is often required to adapt the established configuration of resources to updated configurations.

1) Did you engage with lead users so that you could identify new technological and market needs?

Which activities supported this phase?

2) Did you engage with other entrepreneurial actors so that you could implement new organizational configurations of resources?

Which activities supported this phase?