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ECOSYSTEM MANAGEMENT CAPABILITIES: DEVELOPMENT AND MENSURATION OF A SCALE

CAPACIDADES DE GESTÃO DE ECOSSISTEMAS: DESENVOLVIMENTO E MENSURAÇÃO DE UMA ESCALA

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ECOSYSTEM MANAGEMENT CAPABILITIES: DEVELOPMENT AND MENSURATION OF A SCALE

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ABSTRACT

The complementarity and technological interdependence are central features of ecosystems. However, despite its relevance being widely recognized, it is still unclear how focal firms develop and manage complementarity and technological interdependence in ecosystems. While the current literature implicitly places these features as if it emerges automatically inside ecosystems, I propose that they need to be nurtured and managed by the focal firm through new ecosystem management capabilities. My main objective lies in the proposal of unveiling how focal firms develop complement arity and interdependence for ecosystem management through a capability lens. The methodology employed consisted of a qualitative and a quantitative phase. I started with an exploratory multiple case study in ten ecosystem focal firms, from which I proposed two new capabilities: the complementarity management capability and the technological management capability management capability. I described each capability with its own set of activities, definition, and measurement scale. The quantitative phase consisted of a survey with 275 executives. First, I used principal component factorial analysis, which resulted in the creation of two constructs for complementarity: i) ecosystem connections and ii) integration, and oth er two for technological interdependence: i) technological modularity and ii) co-development. Then, I applied structural equation modeling to validate the scales, which provided evidence to empirically support that the development of innovation can be associated with the development of the complementarity management capability and the technological interdependence management capability. These findings contribute to the capabilities-based view by showing a new type of capability that goes beyond the individual firm and considers its interaction with the ecosystem. For the ecosystem literature, this thesis contributes by presenting an understanding of how focal firms articulate the most central features of ecosystems into two new capabilities. Finally, I also contributed by developing and measuring two new constructs: a scale to measure complementarity and technological interdependence for focal firms.

Keywords: Ecosystems; innovation; strategy; capabilities; complementarity; interdependence.

RESUMO

A complementaridade e a interdependência tecnológica são características centrais dos ecossistemas. No entanto, apesar de sua relevância ser amplamente reconhecida, ainda não está claro como as firmas focais desenvolvem e gerenciam a complementaridade e a interdependência tecnológica nos ecossistemas. Embora a literatura atual implicitamente trate essas características como se surgissem automaticamente dentro dos ecossistemas, eu argumento que elas precisam ser desenvolvidas e gerenciados pela empresa focal por meio de novas capacidades para gestão de ecossistemas. Meu principal objetivo é desvendar como empresas focais desenvolvem complementaridade e interdependência para a gestão de ecossistemas utilizando a visão baseada em capacidades. A metodologia empregada consistiu de uma fase qualitativa e outra quantitativa. Comecei com um estudo de caso múltiplo exploratório em dez firmas focais de ecossistemas, a partir do qual propus duas novas capacidades: a capacidade de gestão da complementaridade e a capacidade de gestão da interdependencia tecnológica. Descrevi cada capacidade com seu próprio conjunto de atividades, definição e escala de mensuração. A fase quantitativa consistiu em uma pesquisa com 275 executivos. Primeiramente, utilizei a análise fatorial por componentes principais, que resultou na criação de dois construtos para complementaridade: i) conexões ecossistêmicas e ii) integração, e outros dois para interdependência tecnológica: i) modularidade tecnológica e ii) co-desenvolvimento. Em seguida, apliquei uma modelagem de equações estruturais, que forneceu evidências para sustentar empiricamente que o desenvolvimento da inovação está associado ao desenvolvimento da capacidade de gestão da complementaridade e da capacidade de gestão da interdependência tecnológica. Essas descobertas contribuem para a visão baseada em capacidades, mostrando um novo tipo de capacidade que vai além da empresa individual e considera sua interação com o ecossistema. Para a literatura de ecossistemas, esta tese contribui ao apresentar uma compreensão de como as empresas focais articulam as características mais centrais dos ecossistemas em duas novas capacidades. Por fim, também contribuí desenvolvendo e mensurando dois novos constructos: uma escala para medir a complementaridade e outra para a interdependência tecnológica em empresas focais.

Palavras-chave: Ecossistemas; inovação; estratégia; capacidades; complementaridade; interdependência.

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SUMMARY

1 INTRODUCTION

In the management literature, we observe that it is common when a new organizational function within the companies starts to emerge, that scholars try to translate the set of activities necessary to develop this new role as a capability. As an example, I can mention the innovation function, which was derived into an innovation capability (Lai et al., 2015), or the internationalization function, which was treated as an internationalization capability (Peng & Lin, 2021). Recently, firms have come to realize that they can no longer depend only on themselves and their supply chain, and are moving towards the development of ecosystems to deal with the uncertainty and complexity of the environment (Riquelme-Medina et al., 2022). Due to the distinct nature of ecosystems, Gomes et al. (2022) introduced the ecosystem management function, arguing that focal firms need a specific function to perform activities related to ecosystem management. However, to develop this function, I argue that a new set of capabilities specific for ecosystem management is needed, which, prior to the context of competition via ecosystems (Moore, 1993), was not necessary. This happens because the rise of ecosystems increased the complexity of working with multiple actors, thus requiring companies to develop new capabilities (Parida et al., 2019; Story et al., 2017). For my conceptualization of this new set of ecosystem management capabilities, I understand a capability simply as the ability of an organization to perform a coordinated set of activities, utilizing organizational resources, for the purpose of achieving a particular end result (Helfat & Peteraf, 2003). As for ecosystems, I define then as a set of hierarchically independent, yet interdependent heterogeneous participants who collectively generate a coherent value proposition (Thomas & Autio, 2020). I also define the ecosystem management as the design, planning, and management of all activities related to distributed value creation (Vasconcelos Gomes et al., 2021), which is generally orchestrated by the ecosystem focal firm (Dattée et al., 2018).

I argue that while the literature provides a broad understanding of different types of capabilities for different functions (innovation, internationalization, production, etc.), both theoretically and empirically, little is known about capabilities that are specific for ecosystem management (Hannah and Eisenhardt, 2018; Hou et al., 2020). There is a growing line of researches that evidence the relevance of dynamic capabilities for EM (Bogers et al., 2019; Faridian & Neubaum, 2021; Ganesh & Marathe, 2019; Helfat and Raubitschek, 2018; Heaton et al.; 2019; Linde et al., 2021; Lütjen et al., 2019; Nenonen et al., 2019; Riquelme-Medina et al., 2022; Siaw & Sarpong, 2021; Sunder & Ganesh, 2021; Warner & Wäger, 2019). However, another group of schoolars affirms that theres must exist new and specific capabilities for the context of ecosystems (Hannah & Eisenhardt, 2018; Hou et al., 2020; Kay, Leih & Teece, 2018; Kolagar et al., 2022; Teece, 2020b; Vasconcelos Gomes et al., 2021). This line of inquiry states that the creation of value in ecosystems can be linked to specific capabilities that allow companies to transcend their organizational boundaries and collaborate, coordinate and orchestrate with a set of external actors (Lütjen et al., 2019; Pitelis & Teece, 2018). There is a research gap as there is still a lack of knowledge on capabilities for ecosystems management (Dedehayir et al., 2018; Linde et al., 2021; Sklyar et al., 2021; Sklyar et al., 2018; Tian et al., 2021). Some initial studies tried to approach this problem and give an initial answer. For example, Hannah & Eisenhardt (2018) investigate how firms navigate nascent ecosystems over time, identifying three strategies and the capabilities required for each of them: the bottleneck strategy and dynamic capabilities; the component strategy and the innovation and collaborative capability; and the system strategy and the innovation capability. Another paper, of Gueler & Schneider (2021), sought to assess the determinants of a provided input's (any resource and/or capability) value within ecosystems as a function of its contribution to the value proposition, scarcity (bottleneck), complementarity, and the input provider's reputation. Helfat & Raubitschek (2018) propose three types of dynamic capabilities for firms at the center of platform-based ecosystems, including innovation capabilities, environmental scanning and sensing capabilities, and integrative capabilities for ecosystem orchestration. Kolagar et al. (2022) proposed the relational and digitalization capabilities as one of the triggers for ecosystem transformation. Siaw & Sarpong (2021) proposed the dynamic exchange capabilities for value co-creation in ecosystems, emphasizing the transience and potential trajectory of exchanges in ecosystems.

These articles show that it is emerging a new research avenue to understand the capabilities for ecosystem management. However, although interesting, these articles do not explain the emergence of the two central features of ecosystem management, which is complementarity (Gueler & Schneider, 2021; Jacobides et al., 2018; Pitelis & Teece, 2018; Shipilov & Gawer, 2020) and interdependence (Adner & Kapoor, 2010; Jacobides et al., 2018; Kapoor, 2018; Nambisan, Zahra & Luo, 2019). Complementarity is the definitive feature of ecosystems (Jacobides et al., 2018; Shipilov & Gawer, 2020) and the centripetal force that push ecosystem firms together toward integration (Holgersson et al., 2022). Also, complementarity is a central feature of ecosystem management (Gomes et al., 2021). It relates to when collaboration between ecosystem actors results in a more significant benefit for both than could be obtained individually (Pitelis & Teece, 2018; Shipilov & Gawer, 2020). Complementarities allow different organizations to use ecosystem resources to leverage their own performance and that of the ecosystem as a whole (Godley, 2021). As for the interdependence, it describes the collaborative structure of interactions between ecosystem actors that allow both to benefit (Adner & Kapoor, 2010; Kapoor, 2018; Nambisan, Zahra & Luo, 2019). Interdependence can be defined as a set of interactions that arise in multilateral configurations dependent on each other (Adner, 2017; Jacobides et al., 2018), and can shape ecosystem value co-creation and co-evolution (Baldwin & Clark, 2003; Jacobides et al., 2006). Specifically, in this thesis I will work with technological independence (Adner and Kapoor, 2010).

Both features are at the heart of ecosystem development and management. However, despite its relevance being widely recognized in the literature, it is still unclear how focal firms can develop and manage complementarity and interdependence for ecosystem value creation. Complementarity is still poorly understood in the literature, and although there's good research on it (for example Autio, 2022; Gueler & Schneider, 2021; Hannah & Eisenhardt, 2018; Holgersson et al., 2022; Jacobides, 2018), it is often treated as a feature that arises spontaneously inside ecosystems, and its not clear how complementarity can be developed and managed in ecosystems. On the other hand, the interdependence in ecosystems is nontrivial in that it goes against stablished literature in supply chain management, where firms look for mechanisms to reduce interdependence (Crook & Combs, 2007; Lambert & Cooper, 2000), while in ecosystems, the focus is on increasing interdependence among actors (Jacobides, 2018), making firms shift to manage the contradictory logic of coopetition, as in the ecosystem context, partners must effectively collaborate to quickly respond to market changes (Riquelme-Medina et al., 2022). In this way, it is not clear in the literature how ecosystems are managed through their main features, which is the management of complementarity and interdependence in the ecosystem. Both features does not arise automatically in the ecosystem, but instead, they need to be developed and managed (Bogers et al., 2019) by the focal firm (Dattée et al., 2018; Warner & Wäger, 2019).

This thesis aims to expand the capabilities-based view for ecosystem management, and is guided by the following research question: how focal firms develop complementarity and technological interdependence for ecosystem management through a capability lens? My main objective in this thesis is to unveil how focal firms develop complementarity and technological interdependence for ecosystem management through a capability lens. I argue that focal firms need a new set of capabilities to be able to manage its ecosystem for value creation. These ecosystem features are central for ecosystem management, but not sufficient. However, in order to begin the debate, I centered in this. To achieve this objective, the methodology employed consisted of a qualitative and a quantitative phase. I started with an exploratory multiple case study in ten ecosystem focal firms. The data was collected through 47 in-depth open interviews, in order to have greater freedom to explore how these firms manage their ecosystems. I've followed a similar approach to Corley and Gioia (2004): the interviews considered questions about the company's history and context, decisions, sector context, capabilities, and relationship with the ecosystem, with non-directive questions. The methodology used for data analysis combined multiple cases comparison (Eisenhardt, 1989) with coding analysis. The results evidence how focal firms where able to develop and manage complementarity and technological interdependence in its ecosystem. To characterize this, I've identified through the qualitative research the main activities performed by the focal firms participating in the study, which triggered the management of complementarity and technological interdependence in the ecosystem. This set of activities aimed at a certain result gave rise to two new ecosystem management capabilities: the complementarity management capability and the technological interdependence management capability. I described each capability with its own set of activities, definition, and developed a measurement scale. The quantitative phase consisted of a survey with 275 executives. First, I used principal component factorial analysis, which resulted in the creation of two constructs for complementarity: i) ecosystem connections and ii) integration, and other two for technological interdependence: i) technological modularity and ii) co-development. Then, I applied structural equation modeling (SEM) to validate the scales, which provided evidence to empirically support that the development of innovation can be associated with the development of the complementarity management capability and the technological interdependence management capability.

1.1 RESEARCH PROBLEM

This thesis aims to expand the capabilities-based view for ecosystem management, and is guided by the following research question: how focal firms develop complementarity and technological interdependence for ecosystem management through a capability lens?

To answer this question, I formulated a general objective and four specific ones:

1.2 RESEARCH OBJECTIVES

General objective of the thesis: unveil how focal firms develop complementarity and technological interdependence for ecosystem management through a capability lens.

The general objective was divided into the following specific objectives:

Specific objectives:

1. Explore and define the concept of complementarity and technological interdependence for ecosystem management.
2. Identify the variables of complementarity and technological interdependence for ecosystems management.
3. Develop a measurement scale for the ecosystem management capabilities.
4. Apply the survey to measure the ecosystem management capabilities and verify the association with innovation.

1.3 THEORETICAL AND PRACTICAL JUSTIFICATION

There are three main reasons why I argue that the discussion of capabilities for ecosystems management is relevant. The first of them concerns the theoretical implications that the rise of ecosystems brings for approaches to strategy and innovation, especially in the capabilities-based view. If, on the one hand, capabilities are relevant to understanding how companies compete within their ecosystem, on the other hand, understanding capabilities for ecosystems management requires new understandings. Competition for ecosystems takes place through structures of complementarity and interdependence that the current theory of strategy does not address (Adner, 2017; Nambisan, Zahra & Luo, 2019). Thus, it is necessary understand the new and specific capabilities for ecosystems, ecosystems management and its specificities, to develop an expanded capability-based view, that is, applied to the new context of competition, in which to obtain competitive advantage, companies need to articulate resources and capabilities not only internal, but also of its entire ecosystem (Teece, 2020a).

The second reason concerns the capabilities-based view, which despite its popularity in the field of organizational strategy (Teece, 2019), has not yet been discussed in depth in the context of ecosystems. In this sense, the literature still lacks consistent attempts to formalize a vision based on the capabilities for business ecosystems management. The literature points out that, through capabilities, companies can leverage their own resources and of the ecosystem to obtain competitive advantage (Kay, Leih & Teece, 2018), implying that evolutionary aptitude requires firms to maintain alignment with their ecosystem (Pitelis & Teece, 2018). It is noted, therefore, that capabilities are the mechanism by which it is possible to coordinate the strategic management of the ecosystem (Teece, 2020b). However, the literature that bridges ecosystems and capabilities is still scarce and fragmented. My contribution is primarily done by presenting a broader capabilities debate that considers not just the value creation for the individual firm, but for the ecosystem. I did this by characterizing a new type of capability specific for ecosystem management, which I named ecosystem management capabilities. I proposed two: one focused on managing complementarity in the ecosystem and another on managing the technological interdependence, and I've discussed the main activities of each of them. While there is previous researches that has tried to address capabilities for ecosystems value creation (Hannah and Eisenhardt, 2018; Heaton et al.; 2019; Helfat and Raubitschek, 2018; Hou & Shi, 2020; Hou et al., 2020; Kay, Leih & Teece, 2018; Kindstrom et al., 2013; Kohtamäki & Rajala, 2016; Nenonen et al., 2019; Linde et al., 2021), none of these works explored in depth the capabilities focused on the two central characteristics of ecosystems, which is complementarity (Pitelis & Teece, 2018; Shipilov & Gawer, 2020) and the interdependence (Adner & Kapoor, 2010; Kapoor, 2018; Nambisan, Zahra & Luo, 2019).

The third reason stems from the practical relevance that ecosystems have for today's competitiveness. The literature on ecosystems is still relatively recent (Adner, 2017) and lacks consolidated and effective models for its management. The capabilities-based view has a theoretical structure that can assist managers in formulating strategies (Pisano, 2017), including to develop companies and ecosystems that create and capture value (Kay, Leih & Teece, 2018). For this, however, it is necessary to expand the capabilities-based view to understand the capabilities that focal firms need to develop for ecosystem management. This development allows us to extract practical implications in two ways. On the one hand, it allows us to understand how companies can benefit from the capabilities of the actors in their ecosystem. On the other hand, it gives us insights on how to develop the capabilities of companies to strengthen their ecosystem. I contribute to this debate by presenting an understanding of how focal firms articulate the two most central features of ecosystems in two new capabilities. This contribution is relevant, as the literature implicitly treats these two features as if they were a phenomenon that emerges spontaneously or automatically within ecosystems. While there are articles dealing with these elements (Adner & Kapoor, 2010; Kapoor, 2018; Nambisan, Zahra & Luo, 2019; Pitelis & Teece, 2018; Shipilov & Gawer, 2020), these authors fail to empirically articulate their development and understand these features in the light of a capability. I've contributed by empirically highlighting the activities effectively employed by focal firms to develop these features in their ecosystem, characterizing this through two new ecosystem management capabilities.

In this sense, I also contribute by developing and measuring two new constructs, a scale to measure complementarity for focal firms and one for technological interdependence. These contributions change the ecosystem discussion since now its central features, which are complementarity and technological interdependence, can no longer be seen as spontaneous, as the literature implicitly describes them. On the contrary, there are new capabilities and from now on, complementarity and interdependence need to be seen as ecosystem features that can be developed and managed. Finally, I also contribute to the practice of ecosystem management by highlighting the capabilities with their respective activities and final results obtained by focal firms to manage their ecosystem.

1.4 STRUCTURE OF THE THESIS

This thesis project is formed, in addition to this introduction, by six more sections. Section 2 presents the theoretical background. In sequence, Section 3 describes the methodological procedures. In Section 4 the results obtained for the management of complementarity are showed. Following, Section 5 presents the results and findings for the technological interdependence management. Section 6 shows a brief discussion and implications of the results. Lastly, in Section 7 is the final considerations of the thesis.

2. THEORETICAL BACKGROUND

2.1 ECOSYSTEM MANAGEMENT

The perspective of ecosystems was initially proposed in the literature by Moore (1993), based on the observation that the nature of competition is no longer of company versus company, but ecosystem versus ecosystem. Originally borrowed from biology, the ecosystem concept refers to a several interacting organizations that are interdependent with each other (Shilipov & Gawer, 2020). This concept has many similarities to that of open innovation (Chesbrough, 2003), which is defined as a “distributed innovation process based on purposively managed knowledge flows across organizational boundaries” (Chesbrough & Bogers, 2014, p. 12), since both explain how knowledge and resources sources are orchestrated by many partnerships to deliver solutions used as complements to internal innovation processes (McGahan et al., 2021), and both can be managed through capabilities (Bogers et al., 2019; Linde et al., 2021). However, there are some key differences. The ecosystem concept goes two steps further than open innovation. First, while in open innovation the value proposition is complemented by third parties but articulated at the firm level (Von Delft et al., 2019), the ecosystem is centered on the focal value proposition that is materialized by a set of interdependent actors (Bouwman et al., 2020). In ecosystems, there is a need to go beyond a focal firm’s boundaries to fully understand how value is created (Von Delft & Zhao, 2020). Second, ecosystems contemplate the temporal element as the actors centered on the focal value proposition co-evolve (Hou & Shi, 2020) over time.

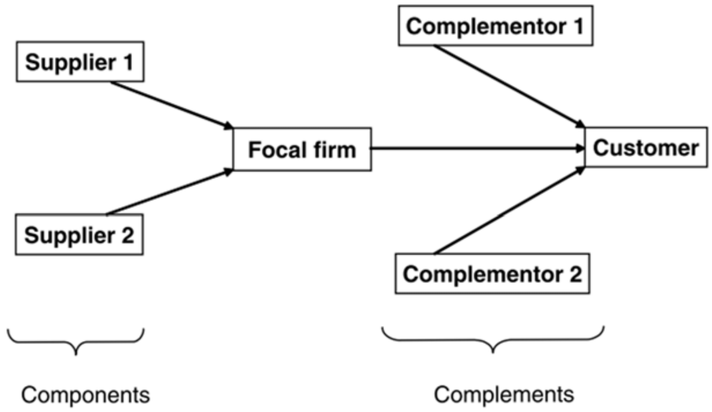
An ecosystem can be defined as a set of hierarchically independent, yet interdependent heterogeneous participants who collectively generate a coherent value proposition (Thomas & Autio, 2020). There are four main types of actors in ecosystems: focal firm, suppliers, complementors, and customers (Adner & Kapoor, 2010), that are connected to each other around the ecosystem’s focal value proposition (Kapoor & Lee, 2013). Generally, the focal company is the most relevant actor (Dattée et al., 2018; Laczko et al., 2019), since co-evolution within the system generally depends on its leadership, providing a platform around which other members of the ecosystem, providing complementary inputs and goods, align their investments and strategies (Teece & Linden, 2017). For this reason, more structured ecosystems are usually associated mainly with a well-established focal company (Gomes et al., 2018), that does the alignment of multiple participants for the ecosystem to function successfully (Kretschmer et al., 2020). For this reason, my conceptualization of ecosystem management capabilities is centered on the focal firm. However, most innovations and value capture do not occur in isolation in the ecosystem, as suppliers, complementors and clients play a key role in this process (Adner, 2006), making up the ecosystem dynamics (Basole, 2020). Therefore, ecosystem actors greatly depend on each another, and successful ecosystems require their actors to strike a balance between cooperative value generation and competitive value appropriation (Hannah & Eisenhardt, 2018).

Currently, the ecosystem concept has become one of the key concepts to the strategic management theory and practice since its introduction to the literature by the seminal work of Moore (1993). However, little is known about how they fit into the strategic management field up to date (Kay, Leih & Teece, 2018). This shift towards the ecosystem perspective has been driven mainly by the emergence of new technologies such as digital infrastructures (e.g., Internet of Things, Cloud Computing, Blockchain, Artificial Intelligence, Big Data Analytics) and the infusion of digital technologies in products, services, and processes (Nambisan, Lyytinen, Majchrzak & Song, 2017). Its rise has mirrored an increasing interest and concern with interdependence across organizations and activities, with implications for strategy, business models, platforms, capability development, technology systems and organizational boundaries (Adner, 2017). An ecosystem comprises the evolving set of actors, activities, institutions, and relations, including complementary and substitute relations, that are important for the innovative performance of an actor or a population of actors (Granstrand & Holgersson, 2019). They represent complex sets of relationships that are formed between actors or entities whose functional goal is to enable technology development, value capture and innovation (Jackson, 2011). Inside of an ecosystem, companies co-evolve capabilities around innovations: they work cooperatively and competitively to develop and support new products or services, and incorporate complex innovations (Moore, 1993), and can function as a way for companies to outsource its production activities (Gomes, Facin, Salerno & Ikenami, 2018).

This happens due to the nature of ecosystems, which are constituted by a shared set of technologies, components, services, architectures, and relationships that serve as a common foundation for diverse sets of actors to converge, capture and create value (Gawer, 2014). Additionally, they also frequently transcend borders, locations, and industries (Tsujimoto, Kajikawa, Tomita & Matsumoto, 2018). Ecosystems characterize collaborative interactions among its members and reflect and reinforce these members' co-specialization in different economic activities that are often orchestrated by a central firm (Nambisan, Zahra & Luo, 2019). They enable opportunities for joint value creation and appropriation among buyers, suppliers, and complementors (Kapoor & Lee, 2013). Due to this nature of the ecosystem, they enable cross-border as well as cross-sector collaboration opportunities with partners, significantly fostering the availability and usage of open resources for all types of businesses (Nambisan *et al.*, 2017).

Ecosystems represent a structure where people, companies, and technologies interact to capture value (Carayannis & Campbell, 2009). The literature has been divided into two approaches to understanding ecosystems (Adner, 2017). This author calls the first one "ecosystem as affiliation", centered on communities of associated actors, defined by their networks and platform affiliations. The second approach is called "ecosystem as a structure", focused on the interdependence of the actors, with activity configurations defined by a value proposition. In this thesis, ecosystems are understood from the perspective of the structural view, as they consider the interdependent relationships between organizations with more holistic implications for the field of strategy (Sant *et al*., 2020). This approach is also better suited to explain the competitive advantage of companies through their ecosystem (Rong *et al*., 2018). Figure 1 summarizes the ecosystem as a structure view.

Figure 1: Ecosystem as structure.



Source: Adner e Kapoor (2010).

The ecosystem as structure perspective proposed by Adner (2017) helped to understand the activity configurations defined by a focal value proposition in ecosystems. This structural view presented the researchers with a holistic view for ecosystem strategy (Sant et al., 2020), ecosystem management (Rong et al., 2018) and ecosystem coevolution over time (Hou & Shi, 2020). But still, ecosystem management is in its infancy (Gomes et al., 2021). The argument that ecosystems can be managed is gaining traction in the literature as the concept evolved from a metaphor to a structure (Kuckertz, 2019). As organizations of organizations, ecosystems require management among multiple participants to function successfully (Kretschmer et al., 2020). In this sense, ecosystem management strategy involves a complex pattern of cooperation and competition that requires adroit management to maintain and balance of the ecosystem (Hannah & Eisenhardt, 2018). I define the ecosystem management as the design, planning, and management of all activities related to distributed value creation (Vasconcelos Gomes et al., 2021), which is orchestrated by the ecosystem focal firm (Dattée et al., 2018). Currently, there is a growing stream of literature stating that ecosystems can be managed through capabilities (Bogers et al., 2019; Faridian & Neubaum, 2021; Ganesh & Marathe, 2019; Hannah & Eisenhardt, 2018; Helfat and Raubitschek, 2018; Heaton et al.; 2019; Hou et al., 2020; Kay, Leih & Teece, 2018; Kolagar et al., 2022; Linde et al., 2021; Lütjen et al., 2019; Nenonen et al., 2019; Riquelme-Medina et al., 2022; Siaw & Sarpong, 2021; Sunder & Ganesh, 2021; Teece, 2020b; Vasconcelos Gomes et al., 2021). This discussion is central as ecosystems represents a heterogeneous set of organizations that co-evolve capabilities for value co-creation (Adner & Kapoor, 2010; Dedehayir et al., 2018; Moore, 1993). Its literature expands the traditional lens with an emphasis on the individual company to a context of interconnectivity between different parties organized by a focal value proposition (Adner, 2017; Öberg & Alexander, 2019; Gomes et al., 2021), repositioning the companies' strategy in a model where capabilities are shared and co-developed through the ecosystem (Tiberius et al., 2020).

2.2 CAPABILITIES BASED-VIEW

The capabilities-based view (CBV) is currently one of the main paradigms in the field of strategic management (Teece, 2019). This approach had its intellectual roots in the seminal work of Penrose (1959) and the resource-based view (RBV) (Barney, 1991). Originally proposed by Teece and Pisano (1994) and Teece et al. (1997) in their article on dynamic capabilities, this approach was driven by an attempt to explain how companies gain a competitive advantage in turbulent environments of rapid and unpredictable changes. At its most basic unit, a capability consists of the ability of an organization to perform a coordinated set of activities, utilizing organizational resources, for the purpose of achieving a particular end result (Helfat & Peteraf, 2003). Traditionally, the literature divides capabilities into two categories: higher-order and lower-order capabilities (Teece, 2018). This notion derives from the study by Zollo and Winter (2002) that related dynamic capabilities to operational routines, and later, Winter (2003) coined the term operational capabilities as those zero-level capabilities by which dynamic capabilities, which are those of higher level, operate inside firms. Operational capabilities are related to the performance of organizations' specific functions, which are necessary to carry out tasks (Zahra et al., 2006). On the other hand, the dynamic capabilities are those that transform and renew operational capabilities (Teece & Pisano, 1994; Teece et al., 1997; Winter, 2003). One of the most notable advances in the concept of dynamic capabilities was made by Teece (2007), who broke them down into three dimensions: (i) sensing, which involves identifying, diagnosing, developing and evaluating the market; (ii) seizing, which includes decision making and resource mobilization; (iii) reconfiguration, which involves continuous renewal necessary to maintain a competitive advantage. Teece (2020a) also notes that both operational and dynamic capabilities can be applied in the unit of analysis of businesses, companies, and at the level of ecosystems.

The emergence of ecosystems has considerable implications for strategic management theories and their relevance in view of the new competitive landscape. The resource-based view (RBV) of the firm is often recognized as one of the most prominent and powerful theories to describe, explain and predict organizational relationships and competitive advantage (Barney, Ketchen & Wright, 2011). Resource-based theory’s model builds on prior work in economics and argues that economic profits can be generated when firms leverage rare, inimitable, and non-substitutable resources (Barney, 1991). Like other theories in the field of strategic management, RBV must be able to explain both how economic profits are generated and how they are appropriated by firms (Barney, 2018). However, RBV implicitly assumes that competitive advantage and growth trajectories is closely tied to the demarcation of the resources possessed by a firm (Santos & Eisenhardt, 2005). This assumption brings boundary issues in the context of competition via business ecosystems, where competitive advantage no longer can be sustained by companies working by itself.

Given this, an issue researchers face with the traditional approaches to strategy is that they cannot explain competitive advantage in the context of the modern economy, where companies compete within structures of ecosystems (Adner, 2017). Ecosystems offer a new dynamic business context that requires to broaden the theories about strategy and management (Nambisan, Zahra & Luo, 2019). These changes make it necessary to reassess long-held assumptions about competitive advantage and improve strategic management theories to better fit the new emerging reality. One contemporary perspective that can explain how business ecosystems fits into the strategic management of companies is that of capabilities-based view. The organizational capabilities are not bound to the level of the enterprise. Instead, they may be an emergent phenomenon at ecosystem level (Teece, 2020b), and the enterprise’s ability to leverage these capabilities may depend on its participation in the ecosystem and the coevolution of the enterprise with the ecosystem's capabilities (Kay, Leih & Teece, 2018).

The capabilities-based view framework is a systemic theory of strategic management (Teece, 2017) that encompasses processes for identification, development, and calibration of technological opportunities and managerial decision-making, reconfiguration of assets and the sources of competitive advantage (Teece, 2019). Capabilities are quite general and require contextual specifications, have managerial implications, and can be applied at the business unit, enterprise, or ecosystem level (Teece, 2020a), and has the potential to explain the process by which companies create, define, discover, and explore entrepreneurial opportunities in external and volatile environments (Jiao *et al.*, 2013). The capabilities-based view implies that a firm must maintain strategic alignment vis-a-vis its ecosystem (Pitelis & Teece, 2018). Capabilities are enriched by the deeper technological and market understanding that comes with openness to external knowledge sources and by the managerial skills to orchestrate assets and activities across organizational boundaries (Teece, 2020a). In this sense, "enterprises with strong dynamic capabilities (...) not only adapt to business ecosystems, but also shape them through innovation and through collaboration with other enterprises, entities, and institutions" (Teece, 2007; p. 1319). Strong dynamic capabilities may even enable the firm to shape the surrounding business ecosystem to reap full advantage of new business models (Schoemaker, Heaton & Teece, 2018) and transcend firm boundaries to be embedded in the ecosystem (Kay, Leih & Teece, 2018).

In this sense, the emergence of the ecosystem concept presents a new dynamic context that demands expanding current theories and concepts of strategy and innovation (Nambisan, Zahra & Luo, 2019). However, little is understood about what are the specific capabilities to manage ecosystems (Teece, 2020b; Kay, Leih & Teece, 2018). Maintaining competitiveness in the new context of ecosystems requires companies to transcend their organizational boundaries (Pitelis & Teece, 2018) to co-evolve capabilities with other actors in their ecosystem through collaboration and competition (Moore, 1993). Competition in ecosystems occurs through structures of interdependence that the traditional capability-based view does not address (Nambisan, Zahra & Luo, 2019). Through this composition, conventional approaches to a strategy focused on the firm do not explain the competitive advantage obtained through ecosystem competition (Adner, 2017). That said, I argue that it is necessary to develop an expanded approach for capability-based view to manage ecosystems. In this new context, companies need to build capabilities to manage ecosystems in collaboration with other actors in the ecosystem (Teece, 2020a; Pisano, 2017). Understanding the capabilities for managing ecosystems is relevant for both theoretical and managerial discussions. If, on the one hand, capabilities are important to understand how companies create competitive advantage, on the other hand, understanding capabilities for managing ecosystems requires extensions to the capabilities-based view (Teece, 2019). Given this, an expanded capabilities-based view is required, that is, applied to the new context of competition, in which to obtain a competitive advantage, companies need to develop capabilities not only to compete in isolation but also through the ecosystem (Teece, 2020a). In managerial terms, this implies for executives the need to expand the development of organizational capabilities for an application beyond the firm, that is, for the business ecosystem (Pisano, 2017).

2.3 ECOSYSTEM MANAGEMENT CAPABILITIES

The ecosystem management capabilities I'm proposing in this thesis derives both from the ecosystem and the CBV literature. Few studies so far have considered the specific capabilities needed to manage a diverse set of ecosystem actors, who are often not directly connected with the focal firm (Gomes et al., 2021; Hannah & Eisenhardt, 2018; Hou et al., 2020; Kay, Leih & Teece, 2018; Kolagar et al., 2022; Lütjen et al., 2019; Teece, 2020b). Most of the existing literature on this topic focuses on the role of dynamic capabilities for ecosystem management (Bogers et al., 2019; Faridian & Neubaum, 2021; Ganesh & Marathe, 2019; Helfat and Raubitschek, 2018; Heaton et al.; 2019; Linde et al., 2021; Lütjen et al., 2019; Nenonen et al., 2019; Riquelme-Medina et al., 2022; Siaw & Sarpong, 2021; Sunder & Ganesh, 2021; Warner & Wäger, 2019). For example, Heaton et al. (2019) evidenced that the cultivation of dynamic capabilities can help to sustain and enhance ecosystems, thus, being a useful framework for thinking about ecosystem management. Linde et al. (2021) showed that ecosystem management can offer a path to sustained competitive advantage for ecosystem leaders, but the authors stated that it also requires the development of capabilities to sense, seize, and reconfigure opportunities in a dynamic ecosystem environment. Helfat and Raubitschek (2018) also evidenced the dynamic capabilities are necessary for ecosystem management by platform leaders, proposing that three capabilities are critical: innovation capabilities, environmental scanning and sensing capabilities, and integrative capabilities. Nenonen et al. (2019) analyzed the role of marketshaping and dynamic capabilities in inducing changes in the markets or business ecosystems surrounding the firm. Warner & Wäger (2019) points to the relevance of digital transforming capabilities for navigating in innovation ecosystems. Siaw and Sarpong (2021) proposed the dynamic exchange capabilities for value co-creation in ecosystems, emphasizing the transience and potential trajectory of exchanges in ecosystems. Sunder and Ganesh (2020) have used systems thinking perspective to propose a dynamic capabilities ecosystem which captures organisations as complex systems with bundles of capabilities and inter-relationships. Lütjen et al. (2019) evidenced that a high level of service innovation is linked to ecosystem-related dynamic capabilities. Faridian and Neubaum (2021) argue for inter-organisational relationships based on asset sharing for dynamic capabilities development in open-source ecosystems. Riquelme-Medina et al. (2022) evidenced the mechanisms that enable firms to manage the contradictory logics of coopetition in business ecosystems, including the absorptive capability. Even Hannah and Eisenhardt (2018) acknowledge the importance of developing dynamic capabilities to manage bottlenecks and complementors, especially in nascent ecosystems.

Given all these articles, the discussion of capabilities is at the core of ecosystem management. However, another group of schoolars affirms that theres must exist new and specific capabilities for the context of ecosystems (Hannah & Eisenhardt, 2018; Hou et al., 2020; Kay, Leih & Teece, 2018; Kolagar et al., 2022; Teece, 2020b; Vasconcelos Gomes et al., 2021). This literature is far less explored (Parida et al., 2019; Story et al., 2017; Teece, 2020a), some authors like Hannah and Eisenhardt (2018), Hou et al. (2020), Kay, Leih and Teece (2018), Teece (2020b) and Vasconcelos Gomes et al. (2021) acknowledge the importance of finding new capabilities that are specific to ecosystem management. The ecosystem management capabilities I'm proposing derives from this stream. I argue that an expanded CBV is required, that is, applied to the new context of where companies need to develop capabilities not only for thenselves but also through the ecosystem (Teece, 2019; Teece, 2020a). This implies for executives the need to expand the development of capabilities for an application beyond the firm level, that is, at the ecosystem level (Giudici et al., 2018; Kindstrom et al., 2013; Pisano, 2017). A CBV aproach could explain how firms tap into novel markets or create novel products with the ecosystem, as well as how firms access to resources that a single company would not have (Lingens et al., 2020). My line of inquiry states that the creation of value in ecosystems can be linked to specific capabilities that allow companies to transcend their organizational boundaries and collaborate, coordinate and orchestrate with a set of external actors (Lütjen et al., 2019; Pitelis & Teece, 2018). There is a research gap as there is still a lack of knowledge on capabilities for ecosystems management (Dedehayir et al., 2018; Linde et al., 2021; Sklyar et al., 2021; Sklyar et al., 2018; Tian et al., 2021). However, there is little consensus on which are the capabilities needed to better organize the multiplicity of partnerships involved in an ecosystem (Linde et al., 2021). Some initial studies tried to approach this problem and give an initial answer. For example, Hou et al. (2020) states that ecosystem actors who have capabilities to self-organise could dynamically search and interact with collaborators within and across the firm's boundary for collective adaptation. Kolagar et al. (2022) proposed the relational and digitalization capabilities as one of the triggers for ecosystem transformation. Gueler & Schneider (2021) sought to assess the determinants of a provided input's (any resource and/or capability) value within ecosystems as a function of its contribution to the value proposition, scarcity (bottleneck), complementarity, and the input provider's reputation. Burström et al. (2021) established the need for artificial intelligence capabilities for business-model innovation in ecosystems.

However, ecosystems have some unique features that differentiate them from other concepts (Gomes et al., 2021; Jacobides, 2018). I argue that although interesting, these articles do not explain the emergence of the two the most central features of ecosystem management: which is complementarity (Gueler & Schneider, 2021; Jacobides et al., 2018; Pitelis & Teece, 2018; Shipilov & Gawer, 2020) and interdependence (Adner & Kapoor, 2010; Jacobides et al., 2018; Kapoor, 2018; Nambisan, Zahra & Luo, 2019). Next, I present a brief description of each feature.

2.3.1 Complementarity

The concept of complementarity is present in the seminal work by Teece (1986), who proposed the Profit from Innovation (PFI) framework, which highlighted the importance of complementarity from the point of view of combining resources and capabilities for the commercialization of innovations. Therefore, the PFI framework linked successful value appropriation to ownership of complementary assets and technologies (Gambardella et al., 2021). A key feature of ecosystems is that none of the actors have all of the required complementary resources to deliver the value proposition on their own (Talmar et al., 2020). Due to this, this concept is central in the literature on ecosystem management, because ecosystems are limited by its complementarities (Gomes et al., 2021). Given this, the value of the outputs generated by any individual ecosystem participant is partly defined by the presence of complementary outputs independently and voluntarily generated by other (Autio, 2022). The development of ecosystems depends on the ability of the leading firm to coordinate and create complementarity strategies, as complementary assets are no longer just mechanisms for creating and capturing value, but may be necessary for technologies to work in ecosystems

(Teece, 2018). Thus, complementarity can be seen as an antecedent to the creation and capture of value in ecosystems (Xu et al., 2020).

Complementarity occurs when collaboration between ecosystem actors results in a more significant benefit for both than could be obtained individually (Pitelis & Teece, 2018; Shipilov & Gawer, 2020). Jacobides et al. (2018) and Shilipov and Gawer (2020) distinguish between generic and non-generic complementarity. While the first characterizes buyer-supplier transactions, the second characterizes relationships where the benefits generated by collaboration are greater than the sum of the individual inputs of each firm. According to the authors, only the non-generic complementarity characterizes an ecosystem. Similarly, Holgersson et al. (2022) defines as weak complements when goods are valuable on their own, but more valuable together than the sum of their separate values. Both are useful on their own, but provide much more powerful navigation when used jointly. To this authors, strong complements are objects that are (almost) useless on their own but valuable together. Also, according to the authors, the stronger the complementarity, the larger the need for management (Holgersson et al., 2022).

Complementarity is important because it involves firms in the ecosystem, and therefore, they bring new ideas, knowledge and innovations that the focal firm alone would never have thought of or imagined (Jacobides, 2022). Complementarities allow different organizations to use ecosystem resources to leverage their own performance and that of the ecosystem as a whole, and are coordinated or facilitated through a central actor (Godley, 2021). Thus, in ecosystems it is necessary that there is a coordination of the complementarities that emerge in a non-hierarchical way and in the absence of formal contracts (Shipilov & Gawer, 2020). The management of complementarity is even more important as ecosystems greatly depend on distinct, autonomous actors' complementary resources, who are sometimes only loosely interconnected, yet independent (Dattée, et al., 2018).

In this way, ecosystems can be understood as a set of evolving organizations that explore a shared set of complementary technologies and skills (Autio & Thomas, 2014). To create value, ecosystems depend on complementary resources made by interconnected but independent organizations (Dattée et al, 2018; Holgersson et al., 2018). Ecosystem complementarities involve collaboration with different actors so that the strengths of each can offset the weaknesses of the other (Godley, 2021). Complementarity allows a given party to gain competitive advantages through the resources of other organizations in the ecosystem, creating and capturing value beyond its organizational boundaries (Lee et al., 2010). Focal firms often rely on complementary technologies of ecosystem to create value (Nenonen et al., 2019).

In this sense, complementarity is an essential feature for ecosystems and ecosystem management, and often, it is the focal firm who is responsible for orchestrating the resource flow (Linde et al., 2021). However, despite its relevance being widely recognized in the literature, complementarity is still poorly understood in the literature, and although there's good research on it (for example Autio, 2022; Gueler & Schneider, 2021; Hannah & Eisenhardt, 2018; Holgersson et al., 2022; Jacobides, 2018), it is often treated as a feature that arises spontaneously inside ecosystems, and its not clear how complementarity can be developed and managed in ecosystems.

One of the main features of ecoystems is that they are are organized around a final product such that their components are complementary, and firm cannot create value in its ecosystem unless all complementors are connected (Hannah & Eisenhardt, 2018). Ecosystem value creation can only occur via a web of connected firms coordenated through a stable web of interactions enabled by an ecosystem leader (Jacobides, 2022). Given this, in order for a focal value proposition to materialize, there's a need to connect all the necessary actors to deliver the solution (Linde et al., 2021). After the connection, there's the need to manage the interdependent activities with complementors, which include arm-length relationships, firm-complementor collaborative alliances, and hierarchical relationships that requires integration with ecosystem organizations (Shipilov & Gawer, 2020). In ecosystems, complementarity is the centripetal force that push ecosystem firms together toward integration (Holgersson et al., 2022). Given this, the mechanisms related to the alignment and integration across organisations are central for ecosystem management (Gomes et al. 2022). Focal firms need to look at each part of their value proposition and consider whether they should provide the offering themselves, or act as a system integrator (Jacobides, 2022).

2.3.2 Technological Interdependence

Interdependence is probably the most widely referenced feature of ecosystems in the literature (Thomas & Autio, 2020). The relevance of this concept is due to the empirical observations that within ecosystems, the structure of interdependence is the mechanism by which companies are connected to each other (Ganco et al., 2020). In general, interdependence describes the collaborative structure of interactions between ecosystem actors that allow both to benefit (Adner & Kapoor, 2010; Kapoor, 2018; Nambisan, Zahra & Luo, 2019), and can be defined as a set of interactions that arise in multilateral configurations dependent on each other (Adner, 2017; Jacobides et al., 2018). Although a central link in ecosystem management, interdependence is not an exclusive term of this literature. Other fields such as supply chain management (SCM), project management, value chain, systems technology and open innovation already address interdependence, as they are all constructs that address the interaction between multiple parties (Adner, 2016; Luo, 2018). However, in these concepts, relationships are often treated as decomposable into bilateral relationships (e.g. decisions to make internally versus subcontracting), and even when multilateral interdependence is present, it is in the context of fragility of the chain (Adner, 2016).

It is in the ecosystems literature that the architecture of independence between firms is analyzed in a broader context, where it can shape value co-creation and co-evolution (Baldwin & Clark, 2003; Jacobides et al., 2006). This is because ecosystems have coordination without requiring hierarchical governance, as they allow complementors to make their own decisions (in terms of design, pricing, etc.), while also allowing a complex interdependent product or service to be produced (Jacobides et al., 2018). In this sense, the interdependence in ecosystems is nontrivial in that it goes against stablished literature in supply chain management, where firms look for mechanisms to reduce interdependence (Crook & Combs, 2007; Lambert & Cooper, 2000), while in ecosystems, the focus is on increasing interdependence among actors (Jacobides, 2018), making firms shift to manage the contradictory logic of coopetition, as in the ecosystem context, partners must effectively collaborate to quickly respond to market changes (Riquelme-Medina et al., 2022). In ecosystems, value creation is highly interdependent among actors (Gueler & Schneider, 2021). Thus, although interdependent value creation has always been a concern for the field of strategy, it was in the context of ecosystems that specific visions emerged to structurally explain their arrangement around a focal value proposition (Adner, 2016).

The ecosystem as structure view (Adner, 2016) admits that interdependencies can be created or improved as a result of collective action by organizations or technological development (Shipilov & Gawer, 2020). A structural view of the interdependence among ecosystem participants raises the question of how ecosystems are coordinated and managed (Autio & Thomas, 2014). From this perspective, interdependencies are treated as deliberately established interorganizational structures, consisting of coalitions of autonomous companies that depend on each other (Autio & Thomas, 2014). And it is for this reason that Adner (2016) stated that looking at ecosystems as an arrangement of interdependencies will grow in prevalence and importance in the literature in the coming years.

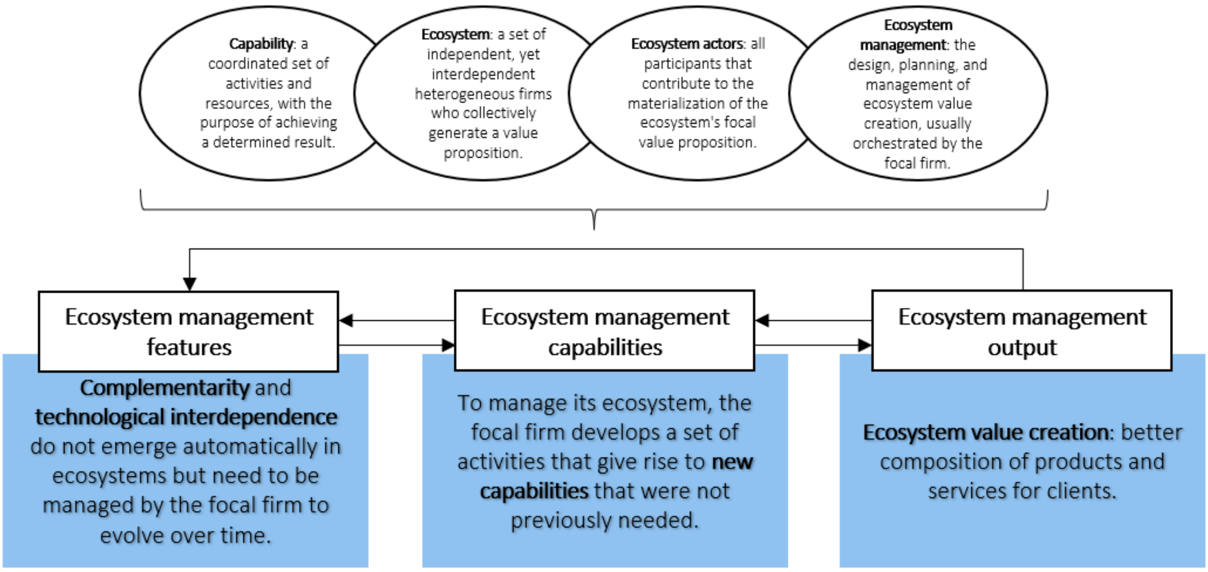
There are three types of interdependence (Gomes et al., 2021; Thomas & Autio, 2020): technological (products and processes) (Jacobides et al., 2018), economic (resources and interests) (Thomas & Autio, 2020) and cognitive (knowledge, skills and collective identity) (Cornelissen et al., 2007). In this thesis, my focus of attention will be on technological interdependence. This form of interdependence is relevant to explain the creation of value in ecosystems, as it represents the combination of interdependent technologies designed by all ecosystem organizations that shape the technological configuration of an ecosystem (Luo, 2018). As a result of technological interdependence, the technology choices of individual companies can positively or negatively influence the technology choices and performance of other companies (Ganco et al., 2020; Luo, 2018).

As the concept of interdependence implies, firms cannot generate value alone. For this, one of the most relevant elements for focal firms to develop technological interdependence in its ecosystem is modularity. Technological modularity allows interdependent components to be produced by different parts, granting autonomy to the way organizations design, assess and operate their respective modules, although this process requires coordination of a central link (Jacobides et al., 2018), as the focal firm of the ecosystem. Technological modularization reduces the need for tight control and coordination, and it simplifies the coordination of innovation across firm boundaries (Holgersson et al., 2022). Ecosystems facilitate the collective generation of ecosystem outputs. One such output comprises products and services that are compatible with one another, often adhering to a modular product architecture that allows the user to assemble a customized composition of modules to suit individual references (Thomas & Autio, 2020). After developing technological modularity, firms need to work together in ecosystems. The creation of value in an ecosystem is made possible by the presence of interdependencies and complementarities between actors, however, there are many possibilities regarding how offers can be organized in an ecosystem (Kapoor, 2018). For this, I argue that co-development is key in developing technological interdependence among ecosystem partners. Co-development supports interactions and relationships with external parties, allowing companies to align activities and products, resources and capabilities, investments and objectives with their ecosystem partners (Chen et al., 2017; Tiberius et al., 2020). Co-development also facilitates the inclusion of organizations, robust levels of innovation, the orchestration of assets and the identification of complementarities among other members of the ecosystem (Heaton et al., 2019). With co-development, the focal company connects and exploits the strengths of each complementary value provider, coordinating production and delivery between companies to deliver value to a specific customer segment, giving greater market power to the ecosystem (Autio & Thomas, 2014).

2.4 CONCEPTUAL FRAMEWORK

To summarize the logical structure of my thesis, I created a conceptual framework that summarizes the main building blocks of my work, which comprises my understanding of capabilities, ecosystem, ecosystem actors and ecosystem management. I've articulated these elements starting with the features of ecosystem management. I've argue that it is not clear in the literature how ecosystems main features, which is the complementarity and technological interdependence, can be developed by focal firms. Both features do not arise automatically in the ecosystem, but instead, they need to be developed and managed (Bogers et al., 2019) by the focal firm (Dattée et al., 2018; Warner & Wäger, 2019) over time. To deal with the challenges of developing these features within the ecosystem, the focal firm needs to create new capabilities, which I call ecosystem management capabilities. In this way, I affirm that to manage its ecosystem, the focal company needs to develops a new set of activities that give rise to a new set of capabilities that it did not have before engaging in ecosystem management. These new capabilities affect the creation of value within the ecosystem, which manifests itself in a better composition of products and services for customers, transfer of resources and knowledge between actors and locking mechanisms. Figure 2 presents my conceptual framework.

Figure 2: Building-blocks of the theoretical framework.



Source: the author.

2.5 HYPOTHESES DEVELOPMENT

Ecosystem management relates to innovation within and outside the firm as well as to dealing with technological and market disruptions and change over time (Gawer & Cesumano, 2014). Even Moore (1993) in his seminal work, proposed that in business ecosystems, members "work cooperatively and competitively to support new products, satisfy customer needs, and incorporate the next round of innovation" (Moore, 1993, p.76). Since then, the literature has presented cumulative evidence that the development of ecosystems is central to increase the innovative performance of the focal firms (Sant´ Ana et al., 2020). This argument is so well documented in the academic literature that the innovation ecosystem construct has emerged as a promising approach in the literature on strategy, innovation, and entrepreneurship (Gomes et al., 2018). To achieve a complex value proposition, firms often need to rely on other actors in their ecosystem to innovate, which raises many new challenges for the managers of these firms (Talmar et al., 2020). As firms are faced with increased dynamism due to rapid technological development, digitalization, and sustainability requirements, ecosystems provide firms with novel opportunities for innovation (Linde et al., 2021). Grandstrand and Holgersson (2020) identified in a literature review on innovation ecosystems that complementarity and interdependence are elements present in academic conceptualizations of innovation ecosystems.

As there is a well-documented relationship in the literature between ecosystems and innovation, and this thesis aims to measure the management of complementarity and technological interdependence for ecosystem focal firms, the formulated hypotheses aim to verify whether the ecosystem management capabilities for focal firms are positively associated with innovation in the firms participating in our survey. The two hypotheses that I aim to verify are described below:

Hypothesis 1*: The complementarity management capability is positively associated with innovation in focal firms.*

Hypothesis 2*: The technological interdependence management capability is positively associated with innovation in focal firms.*

3. METHODOLOGICAL PROCEDURES

The methodology used consisted of a qualitative and exploratory phase, to understand how focal firms manage complementarity and technological interdependence, which resulted in the development of a scale to measure the complementarity management capability for focal firms and the technological interdependence management capability. Afterward, I performed a quantitative phase to validate the developed scales. First, I performed a principal component analysis, which resulted in the creation of two factors for the complementarity management capability: i) ecosystem connections and ii) integration, and other two factors for the technological interdependence management capability: i) technological modularity and ii) co-development. Afterward, I applied a structural equation modeling which provided evidence to empirically support that the development of innovation in the focal firms of my study can be explained by the development of the complementarity management capability.

Given the objective of this research was to understand a theme that is still little explored in the literature, I considered suited to start with a exploratory and qualitative research (Creswell & Clark, 2015). The research strategy was a multiple case study (Eisenhardt, 1989), in favor of immersion and a deep understanding of the phenomenon. This combination was selected to allow us to openly explore empirically how focal firms manage their ecosystems. I also employed Gioia et al. (2013) to develop the code tree.

3.1 QUALITATIVE RESEARCH

As the objective in this stage was to understand in depth the functioning of the capabilities that focal firms developed for ecosystem management, I adopted a theoretical sampling (Eisenhardt et al., 2016), where cases (focal firms) that work collaborating and competing through ecosystems were selected for the analysis. Using these criteria, it was searched for potential cases in Venture Capital (VC) databases and websites, open innovation websites, and the connections with entrepreneurial ecosystems. The sample involved companies that operate in different segments and represent different ecosystems in which they participate. This level of diversity was relevant for collecting evidence and understanding the development of complementarity in different industries and contexts. A total of 10 cases (Table 1) were selected to compose the multiple case study, ranging from startups and platforms that have the concern to increase the level of innovation in their ecosystem to grow and operate in fast-changing markets, to multinational technology firms, to a business group in the financial industry, to consultancy and hospital segments, and even a multinational operating in the electricity production and distribution, which have a large part of the innovation coming from partnerships within their ecosystem.

I used several data sources: (i) interviews with entrepreneurs and top managers; (ii) interviews with middle-level managers, specialists, and other stakeholders; and (iii) secondary materials (including company websites, news, reports, videos, and documents). The primary data collection technique was in-depth open interviews. In total, It was carried out 47 interviews that lasted from 40 to 60 minutes and were all recorded. This enabled us to identify patterns (for instance, different activities employed for ecosystem development and management) that may be inherent to each focal firm's ecosystem strategy. For the interviews, I followed a similar approach to Corley and Gioia (2004): the interviews considered questions about the company's history and context, decisions, capabilities, and relationship with the ecosystem, with non-directive questions. The interviews were conducted between 2020 and 2021.

Table 1: Description of the cases.

Case name	Company description	Number of interviews	Informants
Bohemiken	Is a Brazilian company dedicated to the production of beverages, including beers, soft drinks, energy drinks, juices, teas, and water. It is one of the largest companies in the country in terms of net revenue and controls a large portion of the Brazilian beer market.	6	3 interviews with the Global Innovation Director; 1 interview with the Innovation Ecosystem Manager; 1 interview with the Community manager; 1 interview with the Chief Technology Officer of a partner startup.
Builders Gateway	A startup that created a digital marketplace to strengthen retail in the Brazilian construction sector, approaching store owners, store sellers, and construction professionals.	6	3 interviews with the CEO; 2 interviews with the Head of Digital Retail Business; 1 interview with a Tech Lead.
Dockit	It's a manufacturer and supplier of high-tech medical equipment to hospitals with a focus on innovation. Through international partnerships in its ecosystem, this company has developed and manufactured the first Brazilian mammograph.	3	2 interviews with the Chief Financial Officer; 1 interview with a Marketing Coordinator.
Energy Plus	A multinational company and one of the main publicly traded private electric power transmission concessionaires in Brazil, currently working on developing an innovation ecosystem.	5	3 interviews with the Vice-president of innovation; 1 interview with two senior innovation managers; 1 interview with an innovation analyst.
FinFuture	Is one of the main Brazilian private banks with at least one branch in all municipalities in the country. It has been	5	1 interview with the Chief Operating Officer; 1 interview with the Artificial Intelligence

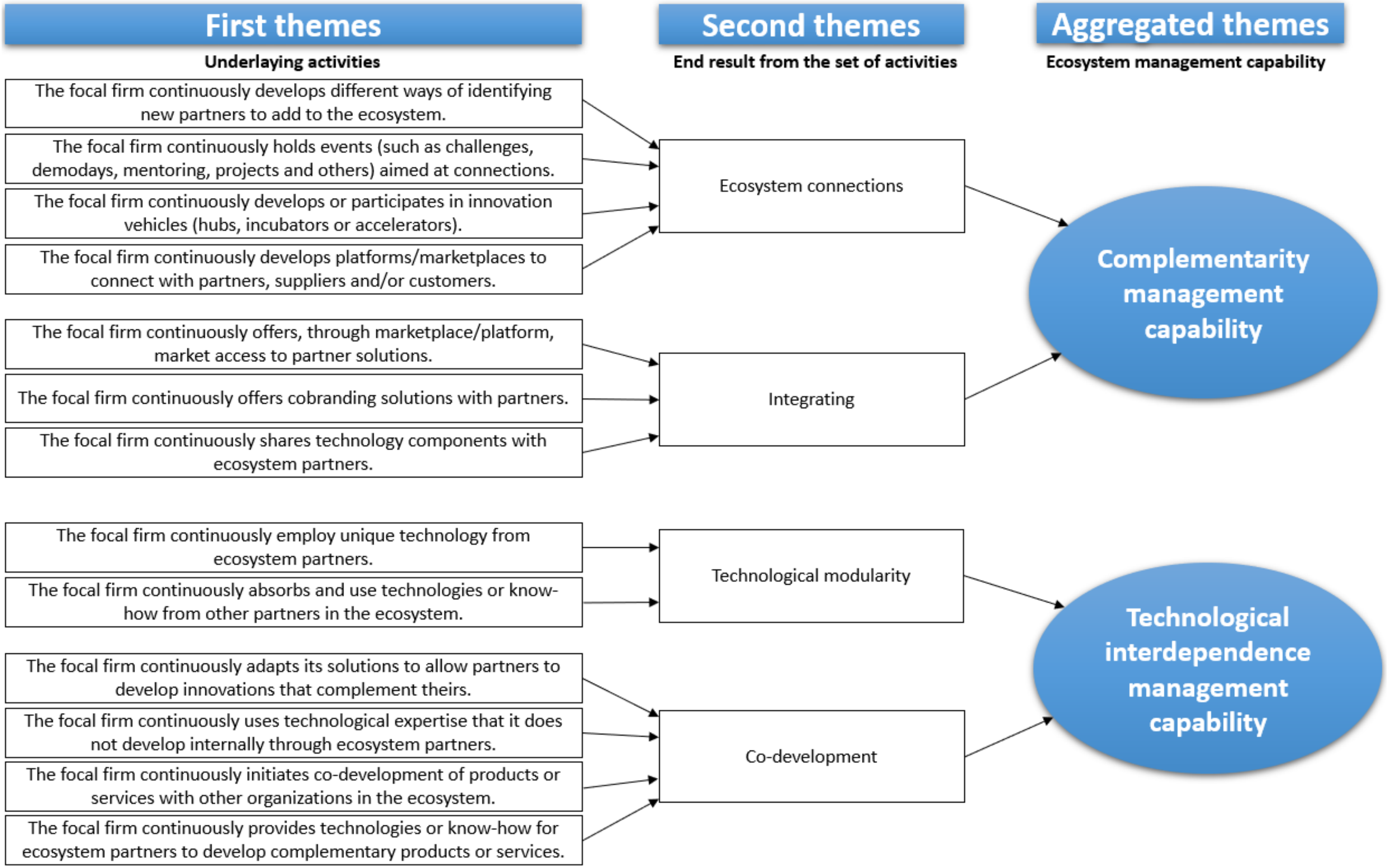
	voted the most innovative company in financial services several times by various sources and publications.		Innovation Manager; 1 interview with the blockchain specialist; 1 interview with an innovation specialist; 1 interview with a Startup Hunter.
Innovare Hospital	One of the main large private hospitals in Brazil with a focus on innovation and outstanding quality service. The hospital has developed an innovation ecosystem to complement its offer of services, treatments, and operational solutions.	3	1 interview with the Director of innovation and digital transformation; 1 interview with an incubator coordinator, and 1 interview with an HR analyst.
PayTech	It's a multinational company provider of payment systems and solutions for the financial system, connecting businesses, banking, and capital markets. The company makes use of its innovation ecosystem to build and implement new products and services.	3	1 interview with the Innovation Coordinator; 1 interview with the Marketing Coordinator; 1 interview with the New Product Development Coordinator.
Software House	A multinational company operating in the business management software segment, with emphasis on ERP, CRM, BI, E-commerce, and artificial intelligence with experience in more than 12 industries. Uses the ecosystem to acquire and develop innovations.	5	1 interview with the Executive Director; 1 interview with the Innovation Director; 1 interview with a Digital Offer Specialist; 1 interview with the head of Strategic Partnerships; 1 interview with the CEO of a business unit.
Tech Master	A multinational company creator of business management software including ERP and finance, CRM, networks,	6	1 interview with the Head of Innovation in Latin America; 2 interviews with the Channels Sales

	supply chain, HR, and technology. Has developed an ecosystem as a strategy for long-term growth and innovation.		Director; 2 interviews with a VP of Ecosystem and Channels; 1 interview with a Software Solution Partner.
uHappy	A startup that created one of the main digital marketplaces for food delivery in Brazil, connecting customers, restaurants, and couriers. More recently, a payment system, logistics services, and database integration have also been implemented.	5	1 interview with the founder; 1 interview with two Product Managers; 1 interview with an Innovation Manager; 1 interview with an RH specialist.

Source: interviews and secondary data.

The methodology used for data analysis combined multiple case comparisons (Eisenhardt, 1989) with coding analysis. The interviews were transcribed and then, I began by analyzing each case, mapping events, decisions, and actions regarding the capability development and its relationship with the ecosystem. Then, I proceed to identify initial open codes (Corbin & Strauss, 2015): it was analyzed segments of the transcribed interviews and other documents to identify and classify events and actions undertaken by the firms regarding ecosystem management. Then, it was analyzed the initial codes to categorize them and establish the second-order codes. In the next phase, I systematically categorized the first-order categories into second-order themes (Gioia et al., 2013). Finally, we performed a within and cross-case analysis to identify overarching patterns among the studied cases to define the activities employed by focal firms to develop the complementarity management capability and the technological interdependence management capability. The code tree can be seen in Figure 3.

Figure 3: Code tree.



Source: the author.

3.2 QUANTITATIVE RESEARCH

The quantitative phase of the research consisted of a survey of primary data having as units of analysis managers of Brazilian focal firms. A survey was adopted as a data collection technique, and the questionnaire was made available electronically to respondents, composed of presidents, vice presidents, area directors, ecosystem managers, community managers, project managers, and other positions related to the ecosystem, through the platform Survey Monkey. The questionnaire consisted of closed questions, with a five-point scale. At one extreme, the value "1" indicated "completely disagree" and at the other extreme the value "5" indicated "completely agree". All the questions used for the complementarity management capability and for the technological interdependence management capability were raised from the results of the qualitative research that raised the main activities carried out by the focal firms to develop these characteristics in the ecosystem. The questionnaire for the complementarity management capability can be seen bellow:

Table 2: Complementarity management capability questionnaire.

For the creation of new products/services in our business ecosystem, my company constantly:		Strongly disagree 1	2	3	4	Strongly agree 5
C1	Perform events (such as hackathons, challenges, demodays, mentorships, design sprints, projects and others) to identify/attract new partners in the business ecosystem.	☐	☐	☐	☐	☐
C2	Creates or participates in innovation vehicles (hubs, incubators, or accelerators) to identify/attract new partners in the business ecosystem.	☐	☐	☐	☐	☐
C3	Develops different ways (hubs, hackathons, mentorships) to identify/attract new partners in the business ecosystem.	☐	☐	☐	☐	☐
C4	Develop platforms/marketplaces to connect with partners, suppliers and/or customers.	☐	☐	☐	☐	☐
C5	Shares technology components with business ecosystem partners.	☐	☐	☐	☐	☐
C6	Offers through marketplace/platform, market access to partner solutions.	☐	☐	☐	☐	☐
C7	Offers solutions in cobranding with business ecosystem partners.	☐	☐	☐	☐	☐

Source: the author.

The complementarity management capability construct consisted of seven questions, based on the practices raised in the qualitative phase and are described in the first themes of the coding tree (Figure 3). As for the technological interdependence management capability, 8 questions were developed for its mensuration. The questionnaire for the technological interdependence management capability can be seen bellow:

Table 3: Technological interdependence capability questionnaire.

To develop our new products/services and of partners, my company continuously:		Strongly disagree 1	2	3	4	Strongly agree 5
IT1	Seeks to develop technologies jointly with business ecosystem partners that have complementary technologies to those of my company.	☐	☐	☐	☐	☐
IT2	Provides technologies and/or knowledge for partners to develop complementary products/services.	☐	☐	☐	☐	☐
IT3	Absorb technologies and/or knowledge from other business ecosystem partners.	☐	☐	☐	☐	☐
IT4	Depends on technological specialties that my company does not develop internally.	☐	☐	☐	☐	☐
IT5	Relies on unique technology from business ecosystem partners.	☐	☐	☐	☐	☐
IT6	Adapts its solutions to enable partners to develop innovations complementary to my company's mix of products and services.	☐	☐	☐	☐	☐
IT7	Develops close relationships with other companies that have knowledge or technologies that mine does not have.	☐	☐	☐	☐	☐
IT8	Conduct pilots, MVPs or POCs with business ecosystem partners.	☐	☐	☐	☐	☐

Source: the author.

In addition to these, it was also included a question for the respondent to measure the level of innovation also with a five-point scale: "In the last 3 years, my company implemented innovations related to:" with four forms of innovation: i) processes; ii) products; iii) services and; iv) platforms. The questionnaire with the innovation questions can be seen bellow:

Table 4: Innovation questionnaire.

In the last 3 years my company implemented innovations related to:		Strongly disagree 1	2	3	4	Strongly agree 5
INOV1	Processes.	☐	☐	☐	☐	☐
INOV2	Products.	☐	☐	☐	☐	☐
INOV3	Services.	☐	☐	☐	☐	☐
INOV4	Platforms.	☐	☐	☐	☐	☐

Source: the author.

The companies selected to participate in the study were raised based on financial performance indexes, lists of innovative companies and associations of companies. In these companies, professionals from areas related to innovation and ecosystems were selected to answer the questionnaire. In total, the questionnaire was sent to 3338 contacts between August and December 2022, of which 628 accessed the questionnaire, and 275 professionals answered the questionnaire completely, that is, the response rate was 8.24%. The calculation of the minimum sample size was performed using the G*Power 3.1.9.4 software (Ringle et al. 2014), which outlined a minimum sample of 77 questionnaires, that is, it was obtained more than 3 times what was necessary. Of the 275 respondents participating in the study, 215 (79.3%) work on Brazilian firms, and 56 (20.7%) in foreign firms. 272 respondents indicated the sector in which the company operates:

Table 5: Sector of the firms.

Sector	Quantity	Quantity (%)
Agribusiness	15	5,5%
Automotive industry	10	3,7%
Chemical industry	6	2,2%
Construction	6	2,2%
Consumer Goods and Food	12	4,4%
Education Services	12	4,4%
Electricity	3	1,1%
Electronics Industry	3	1,1%
Financial services	42	15,4%
Health and wellness	12	4,4%
Health services	8	2,9%
Insurance	6	2,2%
Minerals and Metals	5	1,8%
Oil and Gas	4	1,5%
Other Sector	53	19,5%
Paper And Cellulose	3	1,1%
Professional Services	24	8,8%
Real estate	4	1,5%
Renewable energy	3	1,1%
Retail and Distribution	7	2,6%
Sanitation	2	0,7%
Software	18	6,6%
Telecommunications	7	2,6%
Textile industry	3	1,1%
Transportation and logistics	4	1,5%

Source: the author.

Among the most expressive sectors that appeared in the survey, the other sector (19.5%), financial services (15.4%) and professional services (8.8%) stand out. The size of the companies participating in the study can be seen below:

Table 6: Size of the firms.

Number of employees	Quantity	Quantity (%)
From 1 to 10 employees	31	11,5%
From 11 to 50 employees	22	8,1%
From 51 to 100 employees	28	10,4%
From 101 to 500 employees	40	14,8%
Over 500 employees	149	55,2%

Source: the author.

Additionally, people at different hierarchical levels and functional areas participated in the survey, with the most expressive being Other positions (13.1%), general manager (11.7%) and Innovation analyst (10.6%). The main positions are showed bellow:

Table 7: Positions of the respondents.

Positions	Quantity	Quantity (%)
Business Development	5	1,8%
Chief Executive Officer	17	6,2%
Chief Financial Officer	9	3,3%
Chief Operational Officer	3	1,1%
Chief Product Officer	2	0,7%
Commercial Analyst	2	0,7%
Commercial Director	9	3,3%
Community Manager	3	1,1%
Consultant	4	1,5%
Coordinator	11	4,0%
Director	19	6,9%
Director of New Business	3	1,1%
Ecosystem Manager	2	0,7%
Founder	3	1,1%
Head of Innovation	5	1,8%
Head of Open Innovation	2	0,7%
Innovation Analyst	29	10,6%
Innovation Consultant	7	2,6%
Innovation Coordinator	6	2,2%
Innovation Manager	6	2,2%
Innovation Specialist	12	4,4%
Management analyst	17	6,2%
Manager	32	11,7%
Open Innovation Analyst	6	2,2%
Open Innovation Coordinator	2	0,7%
Open Innovation Manager	4	1,5%
Others	36	13,1%
Product Manager	5	1,8%
Project Analyst	2	0,7%
Project Coordinator	2	0,7%
Project Manager	7	2,6%
R&D Coordinator	2	0,7%

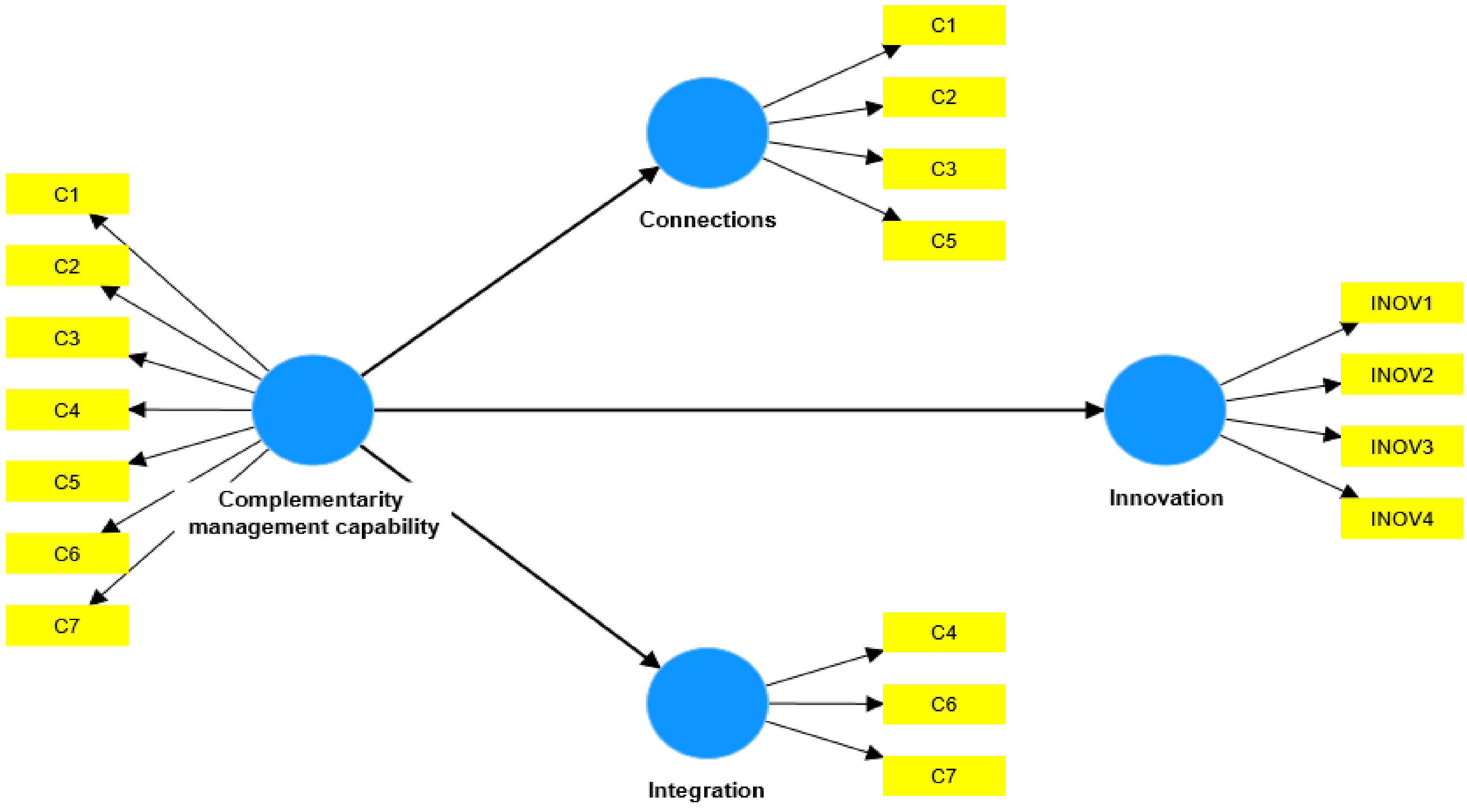
Source: the author.

After this stage, it was performed an exploratory factor analysis by principal components (Fávero & Belfiore, 2019) in the Stata 13 software, to group the seven variables into factors. The results of this factorial analysis resulted in two factors for the complementarity management capability: the first I called ecosystem connections and contains four questions with activities of the focal firm to connect actors to its ecosystem; the second factor, which I called integrating, contains the activities of the focal firms aimed at integrating different actors into their ecosystem. For the technological interdependence management capability, the results of the factorial analysis also resulted in two factors: the first one is technological modularity, consisting of two questions to evaluate the focal firm dependence on its ecosystem actors; the second factor is co-development, which consists of six questions that evaluate the level in which the focal firm continuously develop new products and services with its ecosystem partners.

Based on the results of the exploratory factor analysis, I applied the confirmatory technique of structural equation modeling (PLS) (Ringle et al. 2014) through the SmartPLS 4 software to verify the effects of complementarity management capability and the technological interdependence management capability in the innovation produced by the firms participating in the study. Afterward, to validate the measurement scale, I ran the data again by splitting the database into two samples, the first containing the first 138 responses obtained, and the second, containing the remaining 137 responses, obtaining similar results in the two samples, without significant distinction in any key indicator. The structural equation model that I've run on the base for the complementarity management capability can be seen in Figure 4:

Figure 4: Structural equation modeling for the complementarity management capability.

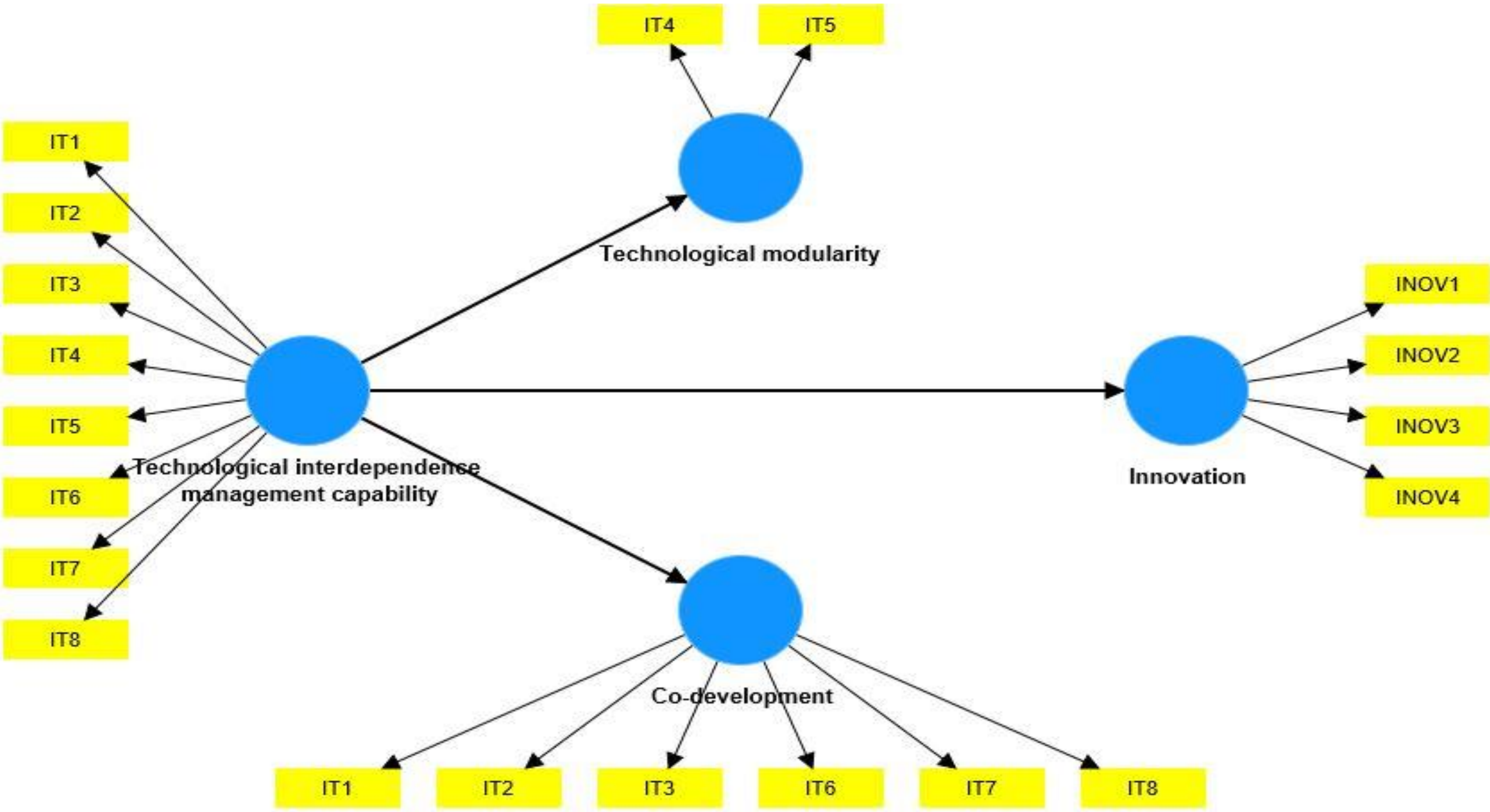
Source: obtained from SmartPLS 4 software.



Source: obtained from SmartPLS 4 software.

The codes used for the variables in the model are described up in the questionnaire's tables. The structural equation model that I've run for the technological interdependence management capability can be seen below in Figure 5:

Figure 5: Structural equation modeling for the technological interdependence management capability.



Source: obtained from SmartPLS 4 software.

3.3 METHODOLOGY QUALITY ASSESSMENT

It was considered several mechanisms to ensure reliability and validity as described by Yin (2011). For the validation of the results, I did triangulation of data collection and data analysis. The triangulation of the data collection technique was performed when considering data from company interviews and a survey considering several respondents at different organizational levels, documentary analysis of the literature, and secondary data. The triangulation of data analysis took place by using companies (multiple case study and survey), which included companies in several industries.

In the quantitative research, it was followed all the procedures for factor analysis such as global adequacy analysis of factor analysis, the definition of factors, eigenvalues (Kaiser's criterion), commonalities and rotation (Fávero & Belfiore, 2019), and for the modeling of structural equations, I followed all the steps of measuring and evaluating the model's structure, evaluating the quality criteria, multicollinearity, evaluation of validity and reliability, suggested by Ringle et al. (2014).

I also followed the steps of scale development and validation (Suter et al., 2018). In the conceptualization, I started defining the construct with a literature review looking for works on complementarity, interdependence, ecosystems, and capabilities. For the second step of development of measures, I did a qualitative and exploratory multiple case study to survey the practices employed by focal firms to develop and manage complementarity and technological interdependence in their ecosystem. I did content and face validation through weekly meetings for 6 months with 8 researchers, being 2 specialists in scale development, 2 specialists in ecosystems, and 4 doctoral students. The other steps in the development and mensuration of the scale involve the results obtained through structural equation modeling and are described in the results section.

4. RESULTS FOR THE COMPLEMENTARITY MANAGEMENT

4.1 MULTIPLE CASE STUDY

The transition of a focal firm from the moment it decides to develop its ecosystem is multifaceted and complex. As depicted in Figure 2, it was found some key activities that were performed by the focal firms in this study that resulted in the development of complementarity in the ecosystem. I grouped this set of activities according to the result of the exploratory factor analysis, which grouped the activities into two constructs: the first was **ecosystem connections**, in which the focal firms implemented new activities seeking to bring in new actors that could complement the ecosystem focal value proposition. The second was **integrating**, where the focal firm seeks to combine resources/technologies between key ecosystem partners.

The ecosystem connections describe the first set of activities initiated by the focal firms in which they implemented new activities seeking to bring in new actors that could complement the ecosystem focal value proposition. All the cases in this study went through a similar understanding, that they could benefit from more actors in their ecosystem. There are several distinct activities that the focal firms in the sample used to develop their ecosystem connections. The most common form is *scouting* for actors or startups that can complement the value proposition of the ecosystem managed by the focal firm. An example of this can be seen in an excerpt from Builders Gateway:

> “What we do as a strategy is to identify large operating companies in this environment and then we invite these companies to join the skills of [name of Builders Gateway] in IoT, artificial intelligence, automation, and channels, to add to the skills of this other company that usually operates in this market." (Head of Digital Retail Business at Builders Gateway, 2020).

This excerpt shows that Builders Gateway seeks connections with key actors that can add to its value proposition. According to the excerpt, the firm made a scouting of the companies that have incremental resources to its own, thus identifying which firms have technological resources that Builders Gateway does not, and which it wants to develop a closer relationship with. Through this action, Builders Gateway can bring into its ecosystem partners that contain complementary technological resources that it does not have. In this way, Builders Gateway can acquire a new set of resources that it previously did not have, and put them to generate new products, services, or innovations in its ecosystem. Other firms like Dockit, Innovare Hospital, and Sofware House also reported using scouting to bring actors into their ecosystems. FinFuture for example has a function for scouting: "*We have a process that we call* *proactive scouting, which is where we link the bank's strategy and the business areas*” (Startup Hunter at FinFuture, 2021).

Another activity for forming ecosystem connections observed in this study was the structuring of *ecosystem events* such as challenges, demodays, mentoring, projects, and others. An innovation expert at EnergyPlus described: "*doing a hackathon and launching a challenge to startups, etc*.”. Other companies like Bohemiken, Software House, and Tech Master also launched challenges and Hackathons. This type of event is important, as pointed out by the interviewees, as it communicates the needs of the focal firm to the market and helps to attract potential partners who can later play a role in the ecosystem.

Another key activity that some focal firms resorted to increase the ecosystem connections was through *innovation vehicles*, mainly the participation or creation of startup incubators and accelerators, as was the case with FinFuture: “*the [name of the FinFuture incubator] has two types of player, he has startups on one side that bring innovative solutions, new alternatives for doing these things and on the other side we have corporations*” (Chief Operational Officer at FinFuture). Bohemiken, Energy Plus, Innovare Hospital, and Software House are also examples of focal firms that have engaged in this type of process.

Another type of process observed was *platformization*, that is, the creation of platforms to connect with partners and clients. In this study, Tech Master and Software House used this strategy and Bohemiken acquired a startup that has a beverage platform to increase its influence over its ecosystem. The platforms offer some unique benefits and offer incentives for participants to get in. These activities also bring the benefit of generating network effects, more visible in the focal firms that orchestrate platforms, where the number of actors doing business on the network itself becomes an attraction for more organizations to want to participate in the ecosystem. The speech of one of the co-founders of the leading platform for food delivery in Brazil demonstrates this type of process:

> "Over time, we realized the great value of all this. The network effect is a barrier to entry, and it brings a very strong competitive advantage in the long run. So, the more orders on our platform, the more restaurants, the more restaurants, the more orders, and then the business snowballs. It's a virtuous circle. However, increasing user recurrence on the platform started to be our main indicator of internal metrics". (Co-founder at uHappy, 2020).

From this, it was also identified that the focal firm develops an activity of continuously redesigning and managing its platforms for ecosystem value creation. An example of this can be seen below in Bohemiken:

> "Today my managements are platforms. So, for example, there's the design platform that takes the problem and turns it into something minimally viable. It has the ecosystem platform to do business through startups, I have the R&D platform, and I have the product platform" (Innovation Specialist at Bohemiken, 2021).

This excerpt shows that the focal firm always needs to monitor and actively manage its platforms, which are essential for developing complementarity. Platform redesign and management are necessary to improve and deepen ecosystem connections. Fostering ecosystem connections is an important activity for ecosystem development. However, just connecting actors and partners in the ecosystem is not enough to develop complementarity. I want to highlight this aspect with a speech by one of the Energy Plus innovation experts that makes this very clear:

> “There was our innovation strategy, some companies in the group try to make some moves like this, which I understand are still poorly structured, but... it's some move, in the sense of doing a hackathon and it's... launching a challenge to startups, etc. But what is lacking is... in my view, the structure to be able is... to process it like this and transform it into a real result in a partnership and generate new things from these interactions”. (Innovation specialist at Energy Plus, 2020).

In this excerpt, the innovation specialist reports that the company can make ecosystem connections, but this does not translate into business, products, services, or innovations for the ecosystem. For this, I argue that another set of activities is key, which consists of **integrating**. Integrating is where the focal firms seek to combine resources/technologies between ecosystem actors. This set of actions was quite relevant for the complementarity in the ecosystem of the focal firms of this study, as it is the main activity that able the focal firm to organize the combination of resources between the actors of the ecosystem. By doing this, the focal firm is effectively engaging with the management of its ecosystem and organizing the connections and combinations of resources between the actors that participate in it. As with other activities, there are different things that focal firms can take to integrate their ecosystem. Builders Gateway gives an example of this:

> “The marketplace was born from this, it comes to meet some of the retailer's pains, so the retailer brought to us very strongly the importance for him to have a digital operation but he didn't even know where to start, the importance he saw in bringing channels complementary to the sale of his product (…). So at the end of the day, we are helping them to structure themselves". (Head of Digital Retail Business at Builders Gateway, 2020).

This example shows that the focal firm can continuously offer, through its marketplace/platform, *market access* to partner products/solutions. The creation of platforms to connect ecosystem actors in the cases was not only relevant to increase ecosystem connections, but also to generate more business and increase value generation within the ecosystem. By connecting and combining resources from both actors, on the one hand, the platform, and on the other, retailers, both benefit and can extract more value by acting together than they would be able to individually or in another ecosystem. Another example is given by Software House, which not only connects with startups but tries to integrate its solutions with the ecosystem:

> “I connect startups with startups, I connect startups with partners, with channels. The idea is to expand the performance a little, to publicize it as well, we end up promoting these startups to the Software House ecosystem in a way that complements”. (General Director at Software House, 2021).

Another activity that it was observed after the focal firms established their platforms, was the development and commercialization of new solutions in co-branding with ecosystem partners, as can be seen below in the case of Paytech:

> “Maybe I can bring my innovative idea, you plug it into your system and we sell it to them. So... that's it, right, it's... it's... it's the starting point, and it's very focused on complementing the products. So, [name of Paytech] has huge products like this, and then some pieces are missing, these pieces are... they are brought by companies from outside" (Marketing Coordinator at Paytech, 2020).

Thus, one of the integration mechanisms to develop complementarity in the ecosystem that it was observed was the development of this activity focused on the *co-branding* of solutions, where the focal firm continuously offers co-branding solutions of ecosystem partners solutions. Another integration-oriented activity that it was observed in some of the focal firms, which is related to the first two, is the sharing of technology with other actors in the ecosystem. The following excerpt from Tech Master demonstrates this:

> “We make this platform available to these startups so that they can make their app available or anything on top of that, it's a very broad platform that runs several programming languages there, that's one thing, another thing is when we decide that this startup will be part of our ecosystem because it has a specific solution in a certain model... in a certain industry that we operate and that is not covered by our software, right, so we treat this startup in one of the pillars of our partners is... so that we can sell their solution together with ours together at the time we will present it to the client” (Head of Innovation in Latin America of Tech Master, 2021).

Tech Master, Paytech, and Software House are examples of focal firms that share development tools with other actors in their ecosystem and put their technology embedded in the solutions generated by these actors. In this way, the focal firm manages to place its technology embedded in third-party solutions, which in turn benefit from having access to a set of technological resources important for their development, and at the same time, this creates benefits for more partners to enter and stay in the ecosystem managed by the focal firm.

From this qualitative stage, it was identified in the multiple case study that the focal firms developed the ability to continuously perform the following activities to develop the complementarity management capability:

Table 8: Activities for the complementarity management capability.

Activity	Actions
Scouting	Perform events (such as hackathons, challenges, demodays, mentorships, design sprints, projects and others) to identify/attract new partners in the business ecosystem.
Ecosystem events	Creates or participates in innovation vehicles (hubs, incubators, or accelerators) to identify/attract new partners in the business ecosystem.
Innovation vehicles	Develops different ways (hubs, hackathons, mentorships) to identify/attract new partners in the business ecosystem.
Platformization	Develop platforms/marketplaces to connect with partners, suppliers and/or customers.
Technology sharing	Shares technology components with business ecosystem partners.
Market access	Offers through marketplace/platform, market access to partner solutions.
Cobranding	Offers solutions in cobranding with business ecosystem partners.

Source: the author.

These findings evidenced that the complementarity in ecosystems did not emerge autonomously but was the result of a series of activities coordinated by the focal firms. The focus was to assess the set of actions that the focal firms executed that allowed the emergence of complementarity in its ecosystem. The analysis indicated that all ecosystems have some degree of complementarity, however, the actions to develop it were different among the focal firms. That said, I argue that to develop complementarity in the ecosystem, focal firms needed to develop a new capability that they did not have before in the context of competition via ecosystems.

4.2 EXPLORATORY PRINCIPAL COMPONENT FACTOR ANALYSIS

The exploratory principal component factor analysis was used to identify correlations between the original variables, aiming at the creation of factors to represent the linear combination of these variables (structural reduction) and to verify the internal validity of the elaborated construct (Fávero & Belfiore, 2019). The main results obtained are described below. Table 9 shows the overall suitability of factor analysis, including Kaiser-Meyer-Olkin (KMO) statistics and Bartlett's test of sphericity.

Table 9: Overall suitability of factor analysis for the complementarity management capability.

```
Determinant of the correlation matrix
Det                =     0.040

Bartlett test of sphericity

Chi-square         =           870.275
Degrees of freedom =                21
p-value            =             0.000
H0: variables are not intercorrelated

Kaiser-Meyer-Olkin Measure of Sampling Adequacy
KMO                =     0.829
```

Source: obtained from Stata 13 software.

The KMO statistic (0.829) indicates the existence of high correlations between the variables, which is conducive to factor extraction, and Bartlett's test of sphericity (p-value 0.000) indicates that the correlation matrix is statistically different from the identity matrix. Cronbach's alpha resulted in a scale reliability coefficient of 0.8550. These results indicate that I can proceed with the factorial analysis. The next table shows the results of the eigenvalues extracted from the factorial analysis by principal components:

Table 10: Factor analysis by principal components for the complementarity management capability**.**

```
Factor analysis/correlation                        Number of obs    =      275
    Method: principal-component factors            Retained factors =        2
    Rotation: (unrotated)                          Number of params =       13
```

Factor	Eigenvalue	Difference	Proportion	Cumulative
Factor1	3.76540	2.65901	0.5379	0.5379
Factor2	1.10639	0.40500	0.1581	0.6960
Factor3	0.70139	0.19182	0.1002	0.7962
Factor4	0.50957	0.12477	0.0728	0.8690
Factor5	0.38480	0.09262	0.0550	0.9239
Factor6	0.29217	0.05190	0.0417	0.9657
Factor7	0.24028	.	0.0343	1.0000

LR test: independent vs. saturated: chi2(21) = 873.49 Prob>chi2 = 0.0000

Factor loadings (pattern matrix) and unique variances

Variable	Factor1	Factor2	Uniqueness
c1	0.7824	-0.3528	0.2634
c2	0.6887	-0.5414	0.2325
c3	0.8398	-0.3274	0.1875
c4	0.6869	0.4774	0.3002
c5	0.7116	0.0134	0.4934
c6	0.7451	0.4987	0.1961
c7	0.6634	0.3238	0.4551

Source: obtained from Stata 13 software.

Starting from the Kaiser criterion (eigenvalues greater than or equal to 1), 2 factors can be extracted from the data set. For a better visualization of the variables that will compose each of the two factors, I performed a rotation using the Varimax method (Fávero & Belfiore, 2019). The new rotated factors can be seen below in table 11:

Table 11: Orthogonal varimax rotation for the complementarity management capability.

```
Factor analysis/correlation                        Number of obs    =      275
    Method: principal-component factors            Retained factors =        2
    Rotation: orthogonal varimax (Kaiser on)       Number of params =       13

    --------------------------------------------------------------------------
         Factor  |     Variance   Difference        Proportion   Cumulative
    -------------+------------------------------------------------------------
        Factor1  |      2.49953      0.12726            0.3571       0.3571
        Factor2  |      2.37226            .            0.3389       0.6960
    --------------------------------------------------------------------------
    LR test: independent vs. saturated:  chi2(21) =  873.49 Prob>chi2 =
0.0000

Rotated factor loadings (pattern matrix) and unique variances

    -------------------------------------------------
        Variable |  Factor1   Factor2 |   Uniqueness
    -------------+--------------------+--------------
              c1 |   0.8098    0.2844 |      0.2634
              c2 |   0.8721    0.0834 |      0.2325
              c3 |   0.8338    0.3425 |      0.1875
              c4 |   0.1678    0.8196 |      0.3002
              c5 |   0.5058    0.5007 |      0.4934
              c6 |   0.1953    0.8751 |      0.1961
              c7 |   0.2568    0.6921 |      0.4551
    -------------------------------------------------

Factor rotation matrix

    --------------------------------
                 | Factor1  Factor2
    -------------+------------------
         Factor1 |  0.7238   0.6900
         Factor2 | -0.6900   0.7238
    --------------------------------
```

Source: obtained from Stata 13 software.

From the rotation, it can be seen that variables C1, C2, C3, and C5 will be within factor 1, while variables C4, C6, and C7 will be in the second factor.

Connections is central for complementarity as one of the main features of ecoystems is that they are are organized around a final product such that their components are complementary, and firm cannot create value in its ecosystem unless all complementors are connected (Hannah & Eisenhardt, 2018). Ecosystem value creation can only occur via a web of connected firms coordinated through a stable web of interactions enabled by an ecosystem leader (Jacobides, 2022). Given this, in order for a focal value proposition to materialize, there's a need to connect all the necessary actors to deliver the solution (Linde et al., 2021). Given these results, the ecosystem connections construct is composed of the following variables:

Figure 6: Ecosystem connection variables.

C1	Perform events (such as hackathons, challenges, demodays, mentorships, design sprints, projects and others) to identify/attract new partners in the business ecosystem.
C2	Creates or participates in innovation vehicles (hubs, incubators, or accelerators) to identify/attract new partners in the business ecosystem.
C3	Develops different ways (hubs, hackathons, mentorships) to identify/attract new partners in the business ecosystem.
C5	Shares technology components with business ecosystem partners.

Source: the author.

After the connection, there’s the need to manage the interdependent activities with complementors, which include arm-length relationships, firm-complementor collaborative alliances, and hierarchical relationships that requires integration with ecosystem organizations (Shipilov & Gawer, 2020). In ecosystems, complementarity is the centripetal force that push ecosystem firms together toward integration (Holgersson et al., 2022). Given this, the mechanisms related to the alignment and integration across organisations are central for ecosystem management (Gomes et al. 2022). Focal firms need to look at each part of their value proposition and consider whether they should provide the offering themselves, or act as a system integrator (Jacobides, 2022). Given these results, the integration construct is composed of the following variables:

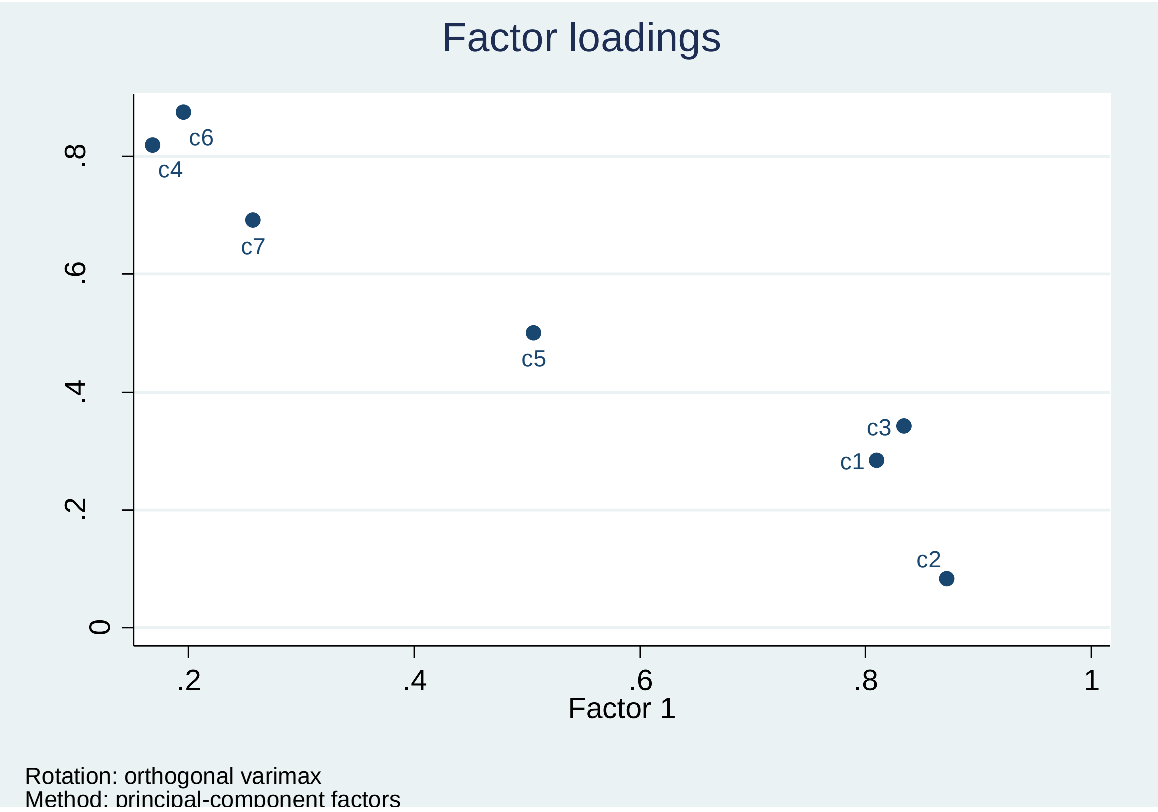
Figure 7: Integration variables.

C4	Develop platforms/marketplaces to connect with partners, suppliers and/or customers.
C6	Offers through marketplace/platform, market access to partner solutions.
C7	Offers solutions in cobranding with business ecosystem partners.

Source: the author.

Additionally, figure 8 shows the loading plot graph, which plots the factor loadings of each variable on the orthogonal axes that represent the two generated factors.

Figure 8: Loading plot for the complementarity management capability.



Source: obtained from Stata 13 software.

4.3 STRUCTURAL EQUATION MODELING

The structural equation modeling was based on Ringle et al. (2014) using the two factors generated in the exploratory factor analysis (ecosystem connections and integrating) as first-order variables that make up the second-order construct "Complementarity management capability", which was related to innovation (Figure 4). The evaluation of the results of the structural equations modeling was developed from the steps of measurement and evaluation of the structural model. In the measurement, quality criteria are evaluated, including the evaluation of validity and reliability. Table 12 presents the coefficients of the validity and reliability parameters of the proposed general model.

Table 12: Construct reliability and validity for the complementarity management capability.

	Cronbach's alpha	Composite reliability (rho_a)	Composite reliability (rho_c)	Average variance extracted (AVE)
Complementarity	0,855	0,859	0,890	0,538
Connections	0,836	0,845	0,892	0,675
Innovation	0,751	0,758	0,842	0,572
Integration	0,778	0,784	0,872	0,695

Source: obtained from SmartPLS 4 software.

All estimated values are adequate to what is recommended in the literature. Extracted Mean-Variance (AVE) values greater than 0.50, Cronbach's Alpha (AC) greater than 0.70, and Composite Reliability (CC) greater than 0.70 (Hair Jr. et al., 2009; Ringle et al., 2014). Discriminant validity is also presented below in Table 13 and, following the criteria of Fornell and Larcker (1981), the values of the diagonal (square root of the AVE) are higher than the others, meeting the prerogatives of this method that validates the difference between the constructs, with the connections and integration constructs was above.

Table 13: Fornell-Larcker criterion for the complementarity management capability.

	Complementarity _management capability	Connections	Innovation	Integration
Complementarity _management capability	**0,733**			
Connections	0,920	**0,821**		
Innovation	0,602	0,579	**0,756**	
Integration	0,845	0,568	0,473	**0,834**

Source: obtained from SmartPLS 4 software.

Continuing the analysis, the adjustment indices of the structural model are checked (multicollinearity, effect size, and explanatory power). All VIF values were below the threshold of 5 (Hair Jr. et al., 2017) and therefore collinearity between prediction constructs is not a critical issue in the structural model. The analysis of effect size and explanatory power is presented in Table 14. In (f^2), it is noted that the construct considered large effect values (above 35%) (Hair Jr. et al., 2017). As for the R^2 values of the construct of interest (innovation), it corresponds to 36.2%, that is, 36.2% of the variations that occurred in the dependent construct can be explained by variations in the explanatory constructs (complementarity management capability) so that this value reflects the existence of the effect.

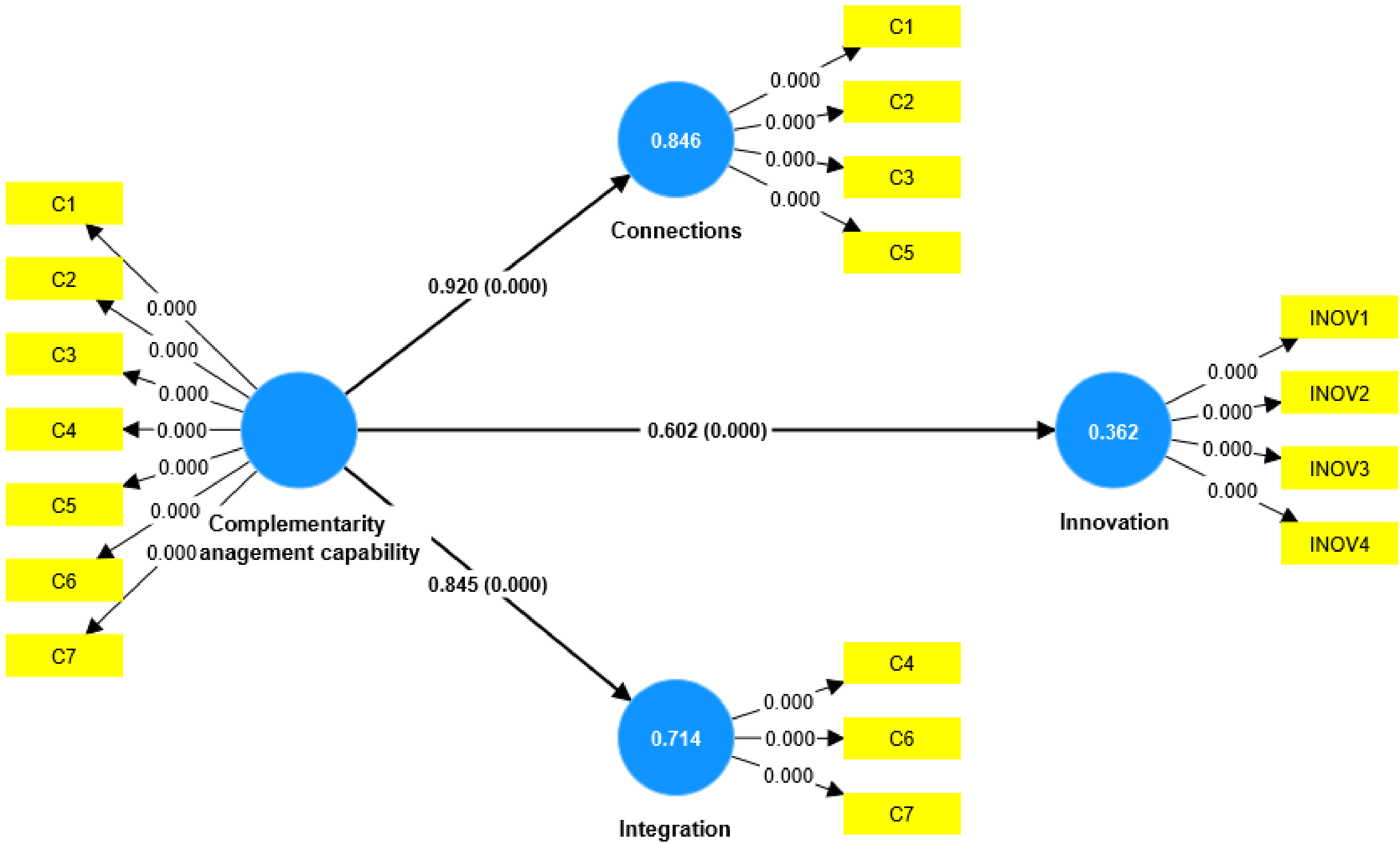
Table 14: Effect Size (f^2) and Explanatory Power (R^2).

	F^2	**R^2**
Complementarity _management capability	*	*
Connections	5,513	0,846
Integration	2,493	0,713
Innovation	0,568	**0,362**

Source: obtained from SmartPLS 4 software.

After verifying the fit of the model, the path coefficients and the statistical significance of the direct relationships are shown in Figure 9. All model constructs showed statistical significance (p-value less than 5%) and positive β coefficients. Therefore, the results of structural equation modeling supported the existence of a relationship between the variables.

Figure 9: Path coefficients and statistical significance of the model for the complementarity management capability.



Source: obtained from Stata 13 software.

These results confirm the Hypothesis 1 of this study as it show a positive association of the complementarity management capability for focal firms with innovation.

Hypothesis 1*: The complementarity management capability is positively associated with innovation in focal firms.*

This result is in accordance to the ecosystem management literature that relates with innovation within and outside the firm as well as to dealing with technological and market disruptions and change over time (Gawer & Cesumano, 2014). Even Moore (1993) in his seminal work, proposed that in business ecosystems, members "work cooperatively and competitively to support new products, satisfy customer needs, and incorporate the next round of innovation" (Moore, 1993, p.76). Since then, the literature has presented cumulative evidence that the development of ecosystems is central to increase the innovative performance of the focal firms (Sant´ Ana et al., 2020), and this study adds with more empirical evidence to support the importance that ecosystem management and complementarity management have for innovation in focal firms.

5. RESULTS FOR THE TECHNOLOGICAL INTERDEPENDENCE MANAGEMENT

5.1 MULTIPLE CASE STUDY

The transition of a focal firm from the moment it decides to develop its ecosystem is multifaceted and complex. I found some key activities that were performed by the focal firms in this study that resulted in the development of technological interdependence in the ecosystem. I grouped this set of activities according to the result produced within the ecosystem. Sequentially, it was described the set of activities focal firms needed to achieve to develop this feature within their ecosystem. Next, it was presented the main findings for each of the characteristics described in the code tree.

The first step began when focal firms recognized that an ecosystem was important. At some point or another, focal firms recognized that the firm does not act in isolation, but that its value proposition can be complemented by third parties. The first set of activities I labeled as **technological modularity**, and it describes the actions where the focal firm adapts its value proposition to allow partners to develop innovations that complement it.

To develop technological modularity in the ecosystem, one of the first activities I observed I labeled as *technological decentralization*, where the focal firm understands that it needs to continuously employ unique technology from ecosystem partners, ceasing to depend only on it and delegating technological development to the ecosystem. Software House presents an example of this:

> "In the modern thinking of creating ecosystems, it no longer involves creating capabilities, it involves integrating capabilities, and a company that wants to operate in an A scenario no longer needs to build an A scenario, I can borrow capabilities from scenario A". (VP Innovation Director at Software House, 2020).

This excerpt shows that the director of innovation at Software House understands that the company no longer needs to develop capabilities internally, but that it is more beneficial to "borrow" from the ecosystem. In this way, the focal firm manages to develop the technological modularity that is one of the most basic aspects for technological interdependence to emerge in the ecosystem. Another example is given by Bohemiken:

> *"Since 2017, is the company that most does business with ecosystems, because we outsourced everything. So, since the 90's with an advertising agency and now with technology startups". (Innovation Director at Bohemiken, 2021).*

Another technological modularity mechanism it was observed is when focal continuously seeks ways to integrate technologies from the ecosystem partners. I labeled this activity as *absorbing technology*, and it occurs when the focal firm can continuously absorb and use technologies or know-how from other partners in the ecosystem. An example can be seen in the excerpt below with a report from uHappy:

> *"So you start to increase the frequency of the user more and more, and on the other hand, you also create a robust services platform. So, today uHappy offers a digital account, offers an acquirer, offers a marketplace for the restaurant's products" (Co-founder of uHappy).*

This excerpt shows that uHappy mobilized external actors to integrate a greater offer of products/services within its ecosystem, such as the aggregation of logistical services, digital accounts, and other functionalities, to improve the composition of products and services within its platform, to increase the number and frequency of customers.

The second set of activities is to initiate **co-development** with the ecosystem. Co-development is where the focal firm uses technological expertise from ecosystem partners to develop products or services with other organizations in the ecosystem. Unlike technological decentralization, where the focal firm seeks to create mechanisms and incentives so that third parties can complement the technological offerings of the ecosystem, in co-development the focal firm seeks to develop technologies, products, or services together with the actors of its ecosystem, aiming to create the best composition of products or services for the ecosystem's focal value proposition.

It was observed four main sets of activities that focal firms employed co-development with the ecosystem. The first activity that focal firms employed to begin carrying out deepening the co-development with other ecosystem organizations began when focal firms recognized that they need to continuously adapt their solutions to allow partners to develop innovations that complement theirs. It was labeled this activity as an *adaptation for complements*. Tech Master's head of Innovation presented an example of how they did this:

> *"We make this platform available to these startups so that they can make their app available or anything on top of that, it's a very broad platform that runs several programming languages there" (Head of Innovation in Latin America of Tech Master, 2021).*

This excerpt shows that Tech Master makes its development platform available so that third parties can develop applications, and those that are attractive and complement the focal firm are then integrated into the Tech Master ecosystem. The second activity is focused on acquiring new technological skills. An example of this is in the case of Dockit:

> *"We work with other countries. We work with South Korea, China, and the United States. So we developed these softwares together with them" (Chief Financial Officer at Dockit, 2020).*

This excerpt shows that the focal firm sought to co-develop with companies located in other countries to acquire technological know-how that it did not have. Dockkit used co-development with companies from other countries. Another example of co-development is given by an Innovation Director of Innovare Hospital "*There are 40 projects happening at the moment with startups from all over Brazil, Latin America, the United States, Canada, and Israel, in short, we have a proliferation of projects*". This excerpt shows that the hospital manages its co-development with its ecosystem partners.

The third set of activities for co-development is *co-developing products/services* with the ecosystem partners, where the focal firm seeks to continuously initiates the co-development of products or services with other organizations in the ecosystem. An example of this is given by EnergyPlus:

> *"Today we have several R&D projects... and they're all done with partners (...). So we access the ecosystem to be able to develop products." (Innovation specialist at EnergyPlus, 2020).*

Another example is given by FinFuture, which seeks to integrate technologies and solutions from external partners:

> *"Stimulating innovation with startups and also improving their process, so today we have companies there in... in the Lab like [name of the company], which... bring proposals to the bank of what they are developing". (Senior Researcher at Innovation Department in FinFuture, 2020).*

In addition, there is a last activity that I observed to be central, which I named *locking mechanisms*. This activity is where focal firms provides and absorbs technologies or know-how of ecosystem partners, creating mechanisms so that ecosystem actors have incentives to remain within it. These activities are important for the maintenance of the ecosystem, increasing the interdependence between its actors and offering incentives for them to remain operating together, making it difficult to access rival ecosystems.

To develop these mechanisms, some focal firms developed an activity focused on continuously providing technologies or know-how for ecosystem partners to develop complementary products or services. Builders Gateway presents an example of how it uses its platform to help its partners sell more and develop:

> *"So, when we place, for example, (name of the company) as a participant in the program, we help small retailers to be closer to (name of the company) and, consequently, have a super strong brand that, on the other hand, gives greater relevance to our platform". (Founder & CEO at Builders Gateway, 2021).*

In this way, partners affiliated with the Builders Gateway platform have incentives to remain within the platform. The development platforms such as those developed by Software House and Tech Master also work as locking mechanisms. In Paytech, for example, the company is aimed to develop long-term relationships with its ecosystem partners to add solutions that can generate value for its customers:

> *"I create a relationship of dependence, depending on his knowledge, I depend on the structure operational, once he enters, it is very difficult for me to make an exchange". (New Product Development Coordinator at Paytech, 2020).*

In this way, Paytech can maintain relevant actors in its ecosystem adding to the ecosystem's focal value proposition.

From this qualitative stage, it was identified in the multiple case study that the focal firms developed the ability to continuously perform the following activities to develop the technological interdependence management capability:

Table 15: Activities for the technological interdependence management. capability.

Activity	Actions
Co-developing products/services	Seeks to develop technologies jointly with business ecosystem partners that have complementary technologies to those of my company.
Co-developing products/services	Develops close relationships with other companies that have knowledge or technologies that mine does not have.
Co-developing products/services	Conduct pilots, MVPs or POCs with business ecosystem partners.
Locking mechanisms	Provides technologies and/or knowledge for partners to develop complementary products/services.
Acquiring new technological skills	Absorb technologies and/or knowledge from other business ecosystem partners.
Technological decentralization	Depends on technological specialties that my company does not develop internally.
Absorbing technology	Relies on unique technology from business ecosystem partners.
Adaptation for complements	Adapts its solutions to enable partners to develop innovations complementary to my company's mix of products and services.

Source: the author.

These findings evidenced that the technological interdependence in ecosystems did not emerge autonomously but was the result of a series of activities coordinated by the focal firms. The focus was to assess the set of actions that the focal firms executed that allowed the emergence of technological interdependence in its ecosystem. The analysis indicated that all ecosystems have some degree of technological interdependence, however, the actions to develop it were different among the focal firms. That said, I argue that to develop technological interdependence in the ecosystem, focal firms needed to develop a new capability that they did not have before in the context of competition via ecosystems.

5.2 EXPLORATORY PRINCIPAL COMPONENT FACTOR ANALYSIS

The exploratory principal component factor analysis was used to identify correlations between the original variables, aiming at the creation of factors to represent the linear combination of these variables (structural reduction) and to verify the internal validity of the elaborated construct (Fávero & Belfiore, 2019). The main results obtained are described below. Table 16 shows the overall suitability of factor analysis, including Kaiser-Meyer-Olkin (KMO) statistics and Bartlett's test of sphericity.

Table 16: Overall suitability of factor analysis for the technological interdependence management capability.

```
Determinant of the correlation matrix
Det                   =     0.068


Bartlett test of sphericity

Chi-square            =           729.005
Degrees of freedom =                   28
p-value               =             0.000
H0: variables are not intercorrelated


Kaiser-Meyer-Olkin Measure of Sampling Adequacy
KMO                  =     0.812
```

Source: obtained from Stata 13 software.

The KMO statistic (0.812) indicates the existence of high correlations between the variables, which is conducive to factor extraction, and Bartlett's test of sphericity (p-value 0.000) indicates that the correlation matrix is statistically different from the identity matrix. Cronbach's alpha resulted in a scale reliability coefficient of 0.7883. These results indicate that I can proceed with the factorial analysis. The next table shows the results of the eigenvalues extracted from the factorial analysis by principal components:

Table 17: Factor analysis by principal components for the technological interdependence management capability.

```
Factor analysis/correlation                        Number of obs    =      275
    Method: principal-component factors            Retained factors =        2
    Rotation: (unrotated)                          Number of params =       15
```

Factor	Eigenvalue	Difference	Proportion	Cumulative
Factor1	3.45844	1.94489	0.4323	0.4323
Factor2	1.51355	0.75937	0.1892	0.6215
Factor3	0.75418	0.13869	0.0943	0.7158
Factor4	0.61549	0.10538	0.0769	0.7927
Factor5	0.51011	0.06071	0.0638	0.8565
Factor6	0.44940	0.07103	0.0562	0.9126
Factor7	0.37837	0.05789	0.0473	0.9599
Factor8	0.32047	.	0.0401	1.0000

```
LR test: independent vs. saturated:  chi2(28) =  731.70 Prob>chi2 = 0.0000
```

```
Factor loadings (pattern matrix) and unique variances
```

Variable	Factor1	Factor2	Uniqueness
it1	0.8307	-0.2007	0.2696
it2	0.7610	-0.1306	0.4038
it3	0.7709	-0.0257	0.4051
it4	0.3341	0.8116	0.2296
it5	0.2445	0.8534	0.2120
it6	0.6702	-0.0273	0.5501
it7	0.7703	-0.0200	0.4063
it8	0.6173	-0.2596	0.5516

Source: obtained from Stata 13 software.

Starting from the Kaiser criterion (eigenvalues greater than or equal to 1), 2 factors can be extracted from the data set. For a better visualization of the variables that will compose each of the two factors, it was performed a rotation using the Varimax method (Fávero & Belfiore, 2019). The new rotated factors can be seen below in Figure 18:

Table 18: Orthogonal varimax rotation for the technological interdependence management capability.

```
Factor analysis/correlation                        Number of obs    =      275
    Method: principal-component factors            Retained factors =        2
    Rotation: orthogonal varimax (Kaiser on)       Number of params =       15
```

Factor	Variance	Difference	Proportion	Cumulative
Factor1	3.34239	1.71280	0.4178	0.4178
Factor2	1.62960	.	0.2037	0.6215

```
    LR test: independent vs. saturated:  chi2(28) =  731.70 Prob>chi2 = 0.0000

Rotated factor loadings (pattern matrix) and unique variances
```

Variable	Factor1	Factor2	Uniqueness
it1	0.8546	0.0083	0.2696
it2	0.7699	0.0593	0.4038
it3	0.7538	0.1634	0.4051
it4	0.1257	0.8687	0.2296
it5	0.0286	0.8872	0.2120
it6	0.6565	0.1373	0.5501
it7	0.7518	0.1688	0.4063
it8	0.6620	-0.1010	0.5516

```
Factor rotation matrix
```

	Factor1	Factor2
Factor1	0.9697	0.2443
Factor2	-0.2443	0.9697

Source: obtained from Stata 13 software.

From the rotation, it can be seen that variables it1, it2, it3, it6, it7 and it8 will be within factor 1, while variables it4 and it5 will be in the second factor. Additionally, Figure 8 shows the loading plot graph, which plots the factor loadings of each variable on the orthogonal axes that represent the two generated factors.

This is important because as the concept of interdependence implies, firms cannot generate value alone. For this, one of the most relevant elements for focal firms to develop technological interdependence in its ecosystem is modularity. Technological modularity allows interdependent components to be produced by different parts, granting autonomy to the way organizations design, assess and operate their respective modules, although this process requires coordination of a central link (Jacobides et al., 2018), as the focal firm of the ecosystem. Technological modularization reduces the need for tight control and coordination, and it simplifies the coordination of innovation across firm boundaries (Holgersson et al., 2022). Ecosystems facilitate the collective generation of ecosystem outputs. One such output comprises products and services that are compatible with one another, often adhering to a modular product architecture that allows the user to assemble a customized composition of modules to suit individual references (Thomas & Autio, 2020). Given these results, the technological modularity construct is composed of the following variables:

Figure 10: Technological modularity variables.

IT5	Relies on unique technology from business ecosystem partners.
IT6	Adapts its solutions to enable partners to develop innovations complementary to my company's mix of products and services.

Source: the author.

After developing technological modularity, firms need to co-develop in ecosystems. The creation of value in an ecosystem is made possible by the presence of interdependencies and complementarities between actors, however, there are many possibilities regarding how offers can be organized in an ecosystem (Kapoor, 2018). For this, I argue that co-development is key in developing technological interdependence among ecosystem partners. Co-development supports interactions and relationships with external parties, allowing companies to align activities and products, resources and capabilities, investments and objectives with their ecosystem partners (Chen et al., 2017; Tiberius et al., 2020). Co-development also facilitates the inclusion of organizations, robust levels of innovation, the orchestration of assets and the identification of complementarities among other members of the ecosystem (Heaton et al., 2019). With co-development, the focal company connects and exploits the strengths of each complementary value provider, coordinating production and delivery between companies to deliver value to a specific customer segment, giving greater market power to the ecosystem (Autio & Thomas, 2014). Given these results, the co-development construct is composed of the following variables:

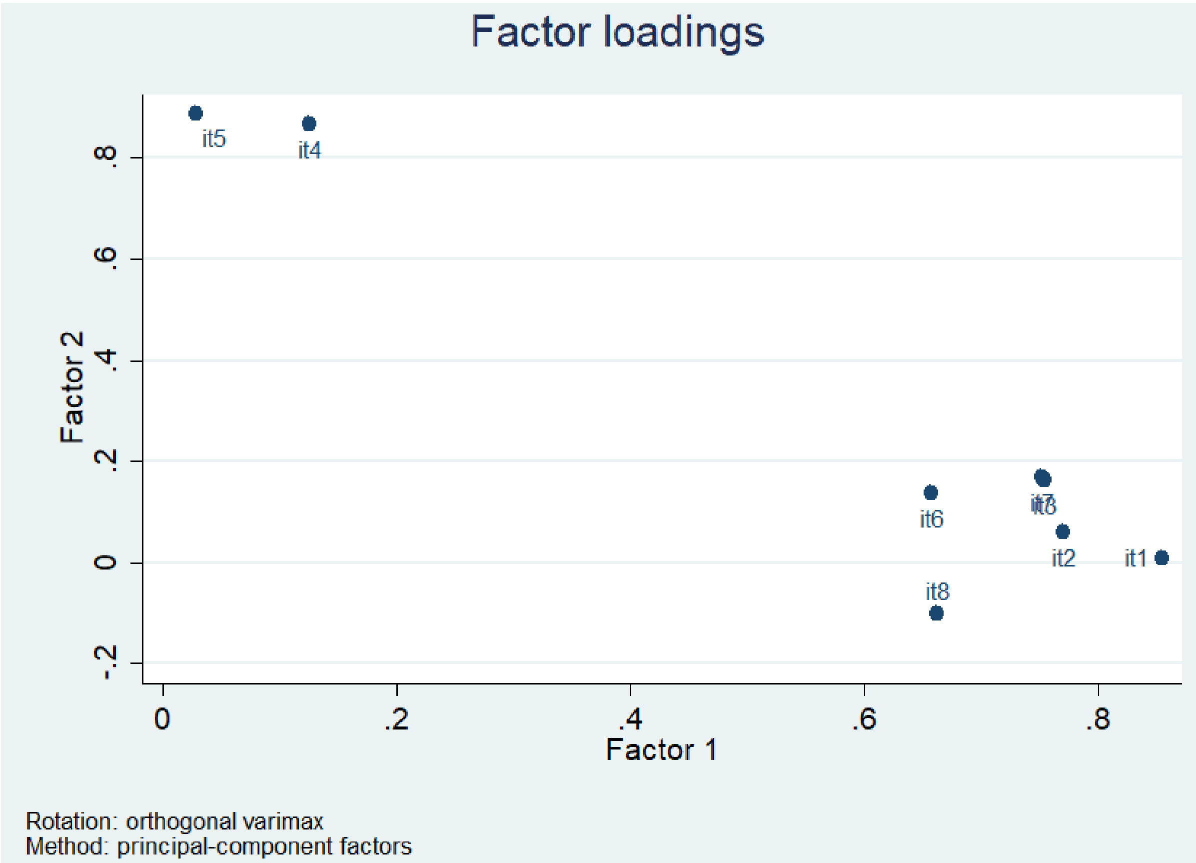
Figure 11: Co-development variables.

IT1	Seeks to develop technologies jointly with business ecosystem partners that have complementary technologies to those of my company.
IT2	Provides technologies and/or knowledge for partners to develop complementary products/services.
IT3	Absorb technologies and/or knowledge from other business ecosystem partners.
IT6	Adapts its solutions to enable partners to develop innovations complementary to my company's mix of products and services.
IT7	Develops close relationships with other companies that have knowledge or technologies that mine does not have.
IT8	Conduct pilots, MVPs or POCs with business ecosystem partners.

Source: the author.

Additionally, Figure 12 shows the loading plot graph, which plots the factor loadings of each variable on the orthogonal axes that represent the two generated factors.

Figure 12: Loading plot for the technological interdependence management capability.



Source: obtained from Stata 13 software.

5.3 STRUCTURAL EQUATION MODELING

The structural equation modeling was based on Ringle et al. (2014) using the two factors generated in the exploratory factor analysis (technological modularity and co-development) as first-order variables that make up the second-order construct "Technological interdependence management capability", which was related to innovation (Figure 5). The evaluation of the results of the structural equations modeling was developed from the steps of measurement and evaluation of the structural model. In the measurement, quality criteria are evaluated, including the evaluation of validity and reliability. Table 19 presents the coefficients of the validity and reliability parameters of the proposed general model.

Table 19: Construct reliability and validity for the technological interdependence management capability.

	Cronbach's alpha	Composite reliability (rho_a)	Composite reliability (rho_c)	Average variance extracted (AVE)
Interdependence_	0,792	0,839	0,847	0,432
Innovation	0,751	0,760	0,842	0,572
Co-development	0,840	0,849	0,883	0,560
Technological modularity	0,729	0,774	0,878	0,783

Source: obtained from SmartPLS 4 software.

All estimated values are adequate to what is recommended in the literature. Extracted Mean-Variance (AVE) values greater than 0.50, except for Interdependence. Cronbach's Alpha (AC) greater than 0.70, and Composite Reliability (CC) greater than 0.70 (Hair Jr. et al., 2009; Ringle et al., 2014). Discriminant validity is also presented below in Table 20 and, following the criteria of Fornell and Larcker (1981), the values of the diagonal (square root of the AVE) are higher than the others, meeting the prerogatives of this method that validates the difference between the constructs.

Table 20: Fornell-Larcker criterion for the technological interdependence management capability.

	Co-development	Innovation	Technological interdependence	Technological modularity
Co-development	**0,748**			
Innovation	0,674	**0,756**		
Technological interdependence	0,987	0,650	**0,657**	
Technological modularity	0,191	0,039	0,350	**0,885**

Source: obtained from SmartPLS 4 software.

The adjustment indices of the structural model are checked (multicollinearity, effect size, and explanatory power). All VIF values were below the threshold of 5 (Hair Jr. et al., 2017) and therefore collinearity between prediction constructs is not a critical issue in the structural model. The analysis of effect size and explanatory power is presented in Table 21.

Table 21: Effect Size (f^2) and Explanatory Power (R^2) for the technological interdependence management capability.

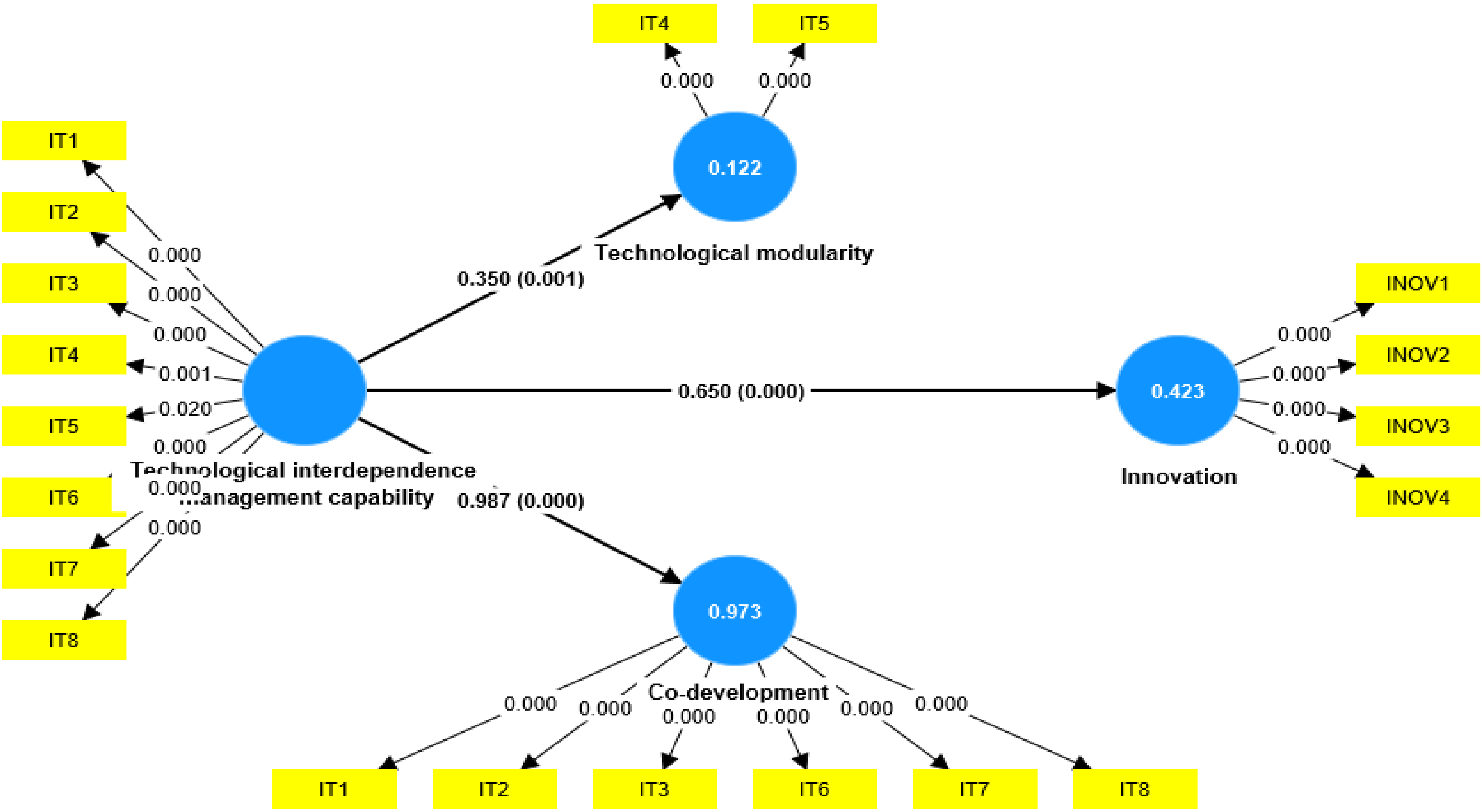
	F^2	R^2
technological interdependence	*	*
Technological modularity	0,139	0,122
Co-development	36,291	0,973
Innovation	0,732	**0,422**

Source: obtained from SmartPLS 4 software.

In (f^2), it is noted that the construct considered large effect values (above 35%) (Hair Jr. et al., 2017). As for the R^2 values of the construct of interest (innovation), it corresponds to 42.2%, that is, 42.2% of the variations that occurred in the dependent construct can be explained by variations in the explanatory constructs (technological interdependence management capability) so that this value reflects the existence of the effect.

After verifying the fit of the model, the path coefficients and the statistical significance of the direct relationships are shown in Figure 13. All model constructs showed statistical significance (p-value less than 5%) and positive β coefficients. Therefore, the results of structural equation modeling supported the existence of a relationship between the variables.

Figure 13: Path coefficients and statistical significance of the model for the technological interdependence management capability.



Source: obtained from SmartPLS 4 software.

These results support the hypothesis 2 of this study witch states that the technological interdependence management capability is associated with innovation in focal firms:

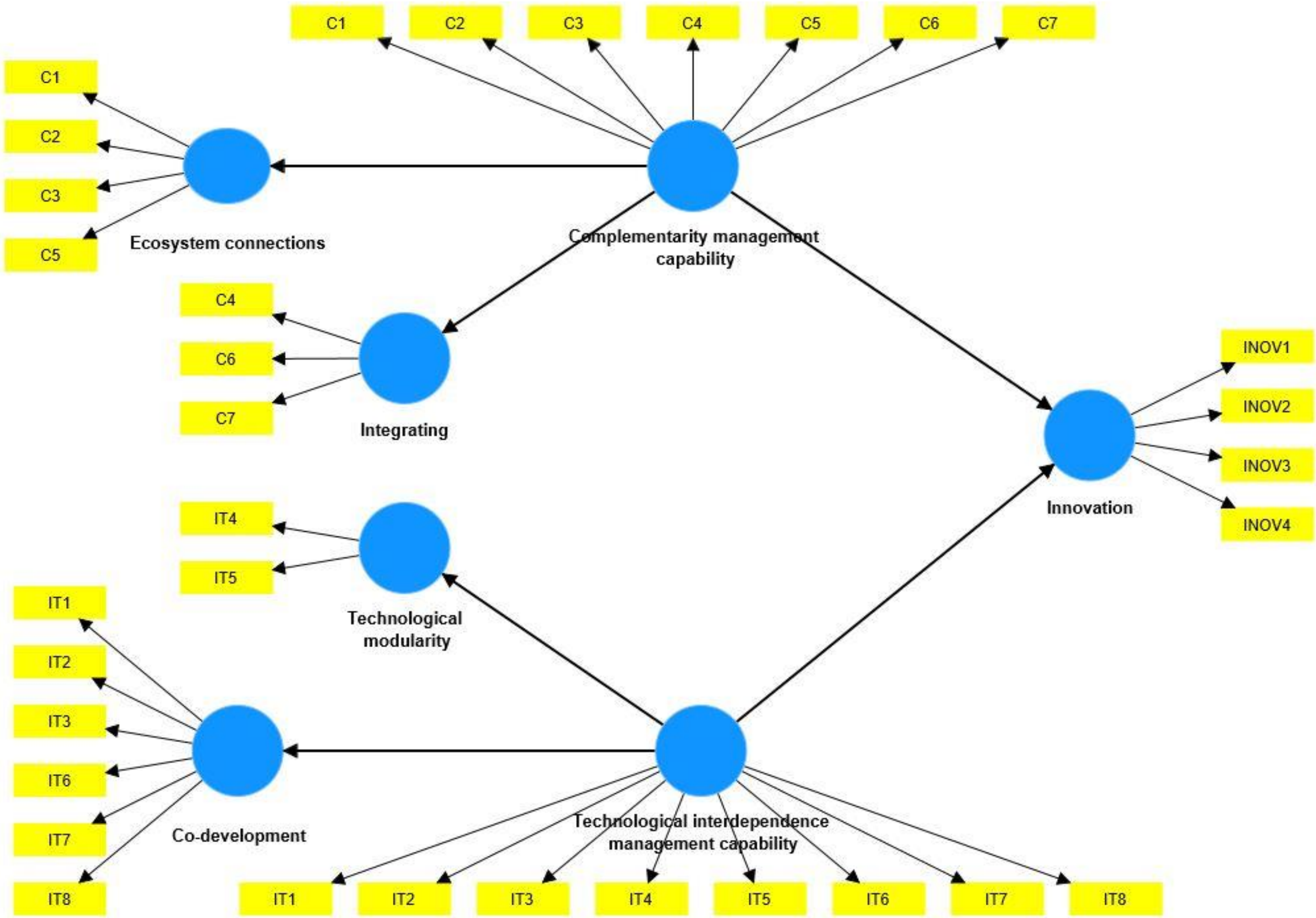
Hypothesis 2*: The technological interdependence management capability is positively associated with innovation in focal firms.*

The notion that ecosystems are associated with innovation is so well documented in the academic literature that the innovation ecosystem construct has emerged as a promising approach in the literature on strategy, innovation, and entrepreneurship (Gomes et al., 2018). To achieve a complex value proposition, firms often need to rely on other actors in their ecosystem to innovate, which raises many new challenges for the managers of these firms (Talmar et al., 2020). As firms are faced with increased dynamism due to rapid technological development, digitalization, and sustainability requirements, ecosystems provide firms with novel opportunities for innovation (Linde et al., 2021). Grandstrand and Holgersson (2020) identified in a literature review on innovation ecosystems that complementarity and interdependence are elements present in academic conceptualizations of innovation ecosystems. The proposed hypotheses 1 and 2 add to that by empirically supporting that ecosystem management capabilities for focal firms are positively associated with innovation in the firms participating in our survey. The hypothesis 2 specifically show the link between technological interdependence and innovation in focal firms.

5.4 COMBINED STRUCTURAL EQUATION MODEL

In addition to the individual models of the complementarity management capability and the technological interdependence management capability, a combined model was also done with both capabilities together, to verify the combined effects of the ecosystem management capabilities on the innovation of the focal firms participating in the study. The combined structural equation model can be seen in the image below:

Figure 14: Combined structural model of ecosystem management capabilities.



Source: obtained from SmartPLS 4 software.

The structural equation modeling was also based on Ringle et al. (2014) using the two factors capabilities obtained in the qualitative case study (complementarity management capability and technological interdependence management capability), which was related to innovation. The evaluation of the results of the structural equations modeling was developed from the steps of measurement and evaluation of the structural model. In the measurement, quality criteria are evaluated, including the evaluation of validity and reliability. Table 22 presents the coefficients of the validity and reliability parameters of the proposed general model.

Table 22: Construct reliability and validity for the ecosystem management capabilities.

	Cronbach's alpha	Composite reliability (rho_a)	Composite reliability (rho_c)	Average variance extracted (AVE)
Co-development	0,840	0,849	0,883	0,560
Complementarity management_ capability	0,855	0,859	0,890	0,538
Ecosystem connections	0,836	0,845	0,892	0,675
Innovation	0,751	0,756	0,842	0,572
Integrating	0,778	0,784	0,872	0,695
Technological interdependence_ management capability	0,792	0,839	0,847	0,432
Technological_ modularity	0,729	0,774	0,878	0,783

Source: obtained from SmartPLS 4 software.

All estimated values are adequate to what is recommended in the literature. Extracted Mean-Variance (AVE) values greater than 0.50, except for Interdependence. Cronbach's Alpha (AC) greater than 0.70, and Composite Reliability (CC) greater than 0.70 (Hair Jr. et al., 2009; Ringle et al., 2014). Discriminant validity is also presented below in Table 23 and, following the criteria of Fornell and Larcker (1981), the values of the diagonal (square root of the AVE) are higher than the others, meeting the prerogatives of this method that validates the difference between the constructs.

Table 23: Fornell-Larcker criterion for the ecosystem management capabilities.

	Co-development	Complementarity management_ capability	Ecosystem connections	Innovation	Integrating	Technological interdependence	Technological_ modularity
Co-development	0,748						
Complementarity management_ capability	0,705	0,733					
Ecosystem connections	0,655	0,921	0,821				
Innovation	0,672	0,599	0,582	0,756			
Integrating	0,585	0,844	0,568	0,463	0,834		
Technological interdependence_ management capability	0,987	0,681	0,626	0,648	0,575	0,657	
Technological_ modularity	0,191	0,050	0,004	0,037	0,099	0,349	0,885

Source: obtained from SmartPLS 4 software.

The adjustment indices of the structural model are checked (multicollinearity, effect size, and explanatory power). All VIF values were below the threshold of 5 (Hair Jr. et al., 2017) and therefore collinearity between prediction constructs is not a critical issue in the structural model. The analysis of explanatory power is presented in Table 24.

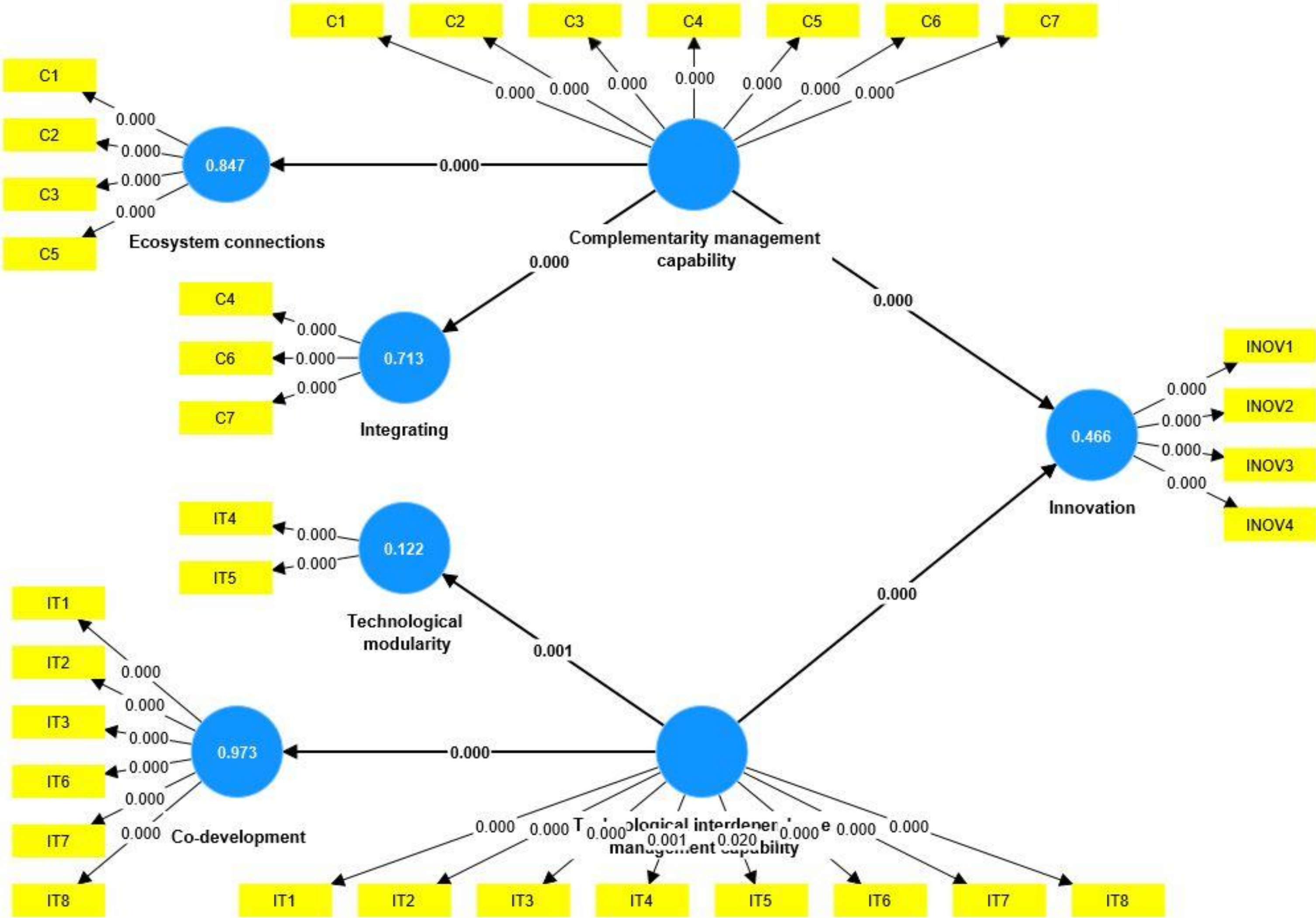
Table 24: Explanatory Power (R^2) for the ecosystem management capabilities.

	R-square	R-square adjusted
Co-development	0,973	0,973
Ecosystem connections	0,847	0,847
Innovation	0,466	0,462
Integrating	0,713	0,712
Technological_ modularity	0,122	0,119

Source: obtained from SmartPLS 4 software.

After verifying the fit of the model, the path coefficients and the statistical significance of the direct relationships are shown in Figure 15. All model constructs showed statistical significance (p-value less than 5%) and positive β coefficients. Therefore, the results of structural equation modeling supported the existence of a relationship between the variables.

Figure 15: Path coefficients and statistical significance of the model for the ecosystem management capabilities.



Source: obtained from SmartPLS 4 software.

6. DISCUSSION AND IMPLICATIONS

6.1 PROPOSING THE ECOSYSTEM MANAGEMENT CAPABILITIES

This thesis aimed to investigate how focal firms developed complementarity and technological interdependence for ecosystem management. Through a multiple case study in 10 ecosystems and a survey with 275 executives, I identified and presented empirical evidence about the sets of activities that the focal firms employed to develop both features in their ecosystem, and I translated these activities into two new capabilities, which before these firms started the process of ecosystem development, was not necessary. It was also showed that, contrary to the ecosystem literature which treats complementarity (Autio, 2022; Gueler & Schneider, 2021; Hannah & Eisenhardt, 2018; Holgersson et al., 2022; Jacobides, 2018) and interdependence (Adner & Kapoor, 2010; Jacobides et al., 2018; Kapoor, 2018; Nambisan et al., 2019) implicitly as features that emerge spontaneously within ecosystems, my results showed that this process is neither spontaneous nor automatic, but the result of a series of activities managed by the focal firms to develop and manage their ecosystem. This thesis also described the sets of activities and sub-activities performed by different focal firms that resulted in the emergence of complementarity and technological interdependence within the ecosystem. The complete mensuration scale for the complementarity and the technological interdependence management capability for focal firms can be seen in the Appendix A - Survey Questionnaire session at the end of this thesis.

For complementarity management, the research has shown that there are two outcomes that the focal firm needs to produce in its ecosystem: (i) fostering ecosystem connections; (ii) integration. Ecosystem connections is where the focal firm implemented new activities seeking to bring in new actors that could complement the ecosystem focal value proposition. I highlight four main activities that ecosystem focal firms perform to increase connections: (i) scouting, which involves searching for actors that can complement the ecosystem value proposition; (ii) ecosystem events, including challenges, demodays, mentoring, projects, and others; (iii) innovation vehicles; which is the participation or creation of startup incubators and accelerators; (iv) platformization, which is the creation of platforms to connect with partners and clients. The second step was integrating, in which the focal firm seeks to combine resources/technologies between ecosystem partners. I highlighted three activities here: (i) market access, offered through the focal firm marketplace/platform for partner products/solutions; (ii) co-branding, which is the development and commercialization of new solutions with ecosystem partners; (iii) technology share from focal firm to other actors in the ecosystem. Based on the results, I define the complementarity management capability as "*the management of the activities to connect actors and integrate their solutions in the ecosystem with the purpose to create the best combination of products/services for customers*".

For the technological interdependence management capability this research has shown that there are two outcomes that the focal firm needs to produce in its ecosystem: (i) technological modularity; (ii) co-development. Technological modularity is where the focal firm adapts its value proposition to allow partners to develop innovations that complement it. I highlight two main activities that ecosystem focal firms perform to increase modularity: (i) technological decentralization, where the focal firm continuously employ unique technology from ecosystem partners; (ii) absorbing technology, where the focal firm continuously absorbs and use technologies from other partners in the ecosystem. The second step was co-development, in which the focal firm uses technological expertise from ecosystem partners to develop products or services with other organizations in the ecosystem. There were four main activities that ecosystem focal firms perform to increase co-development: (i) adaptation for complements, where focal firm continuously adapt its solutions to allow partners to complement it; (ii) acquiring new technological skills, which is when the focal firm co-develop to acquire technological know-how that it did not have; (iii) co-developing products/services, which is when the focal firm continuously co-develops products or services with other organizations in the ecosystem; (iv) locking mechanisms, which is when the focal firm continuously provides technologies for ecosystem partners to develop complementary products or services. Based on the results, I define the and the technological interdependence management capability for focal firms as "*the management of the activities to continuously adapt the value proposition and co-develop in the ecosystem with the purpose to develop new products/services with partners*".

6.2 ECOSYSTEM MANAGEMENT CAPABILITIES FRAMEWORK

Not all focal firms in the multiple case study fully developed all activities, and some focal firms did not even recognize the importance of some of them, while others that are more advanced in the management of their ecosystem are already able to manage all activities and can make the ecosystem management. Figure 16 presents a cross-case analysis from the multiple case study.

Figure 16: Cross-case analysis.

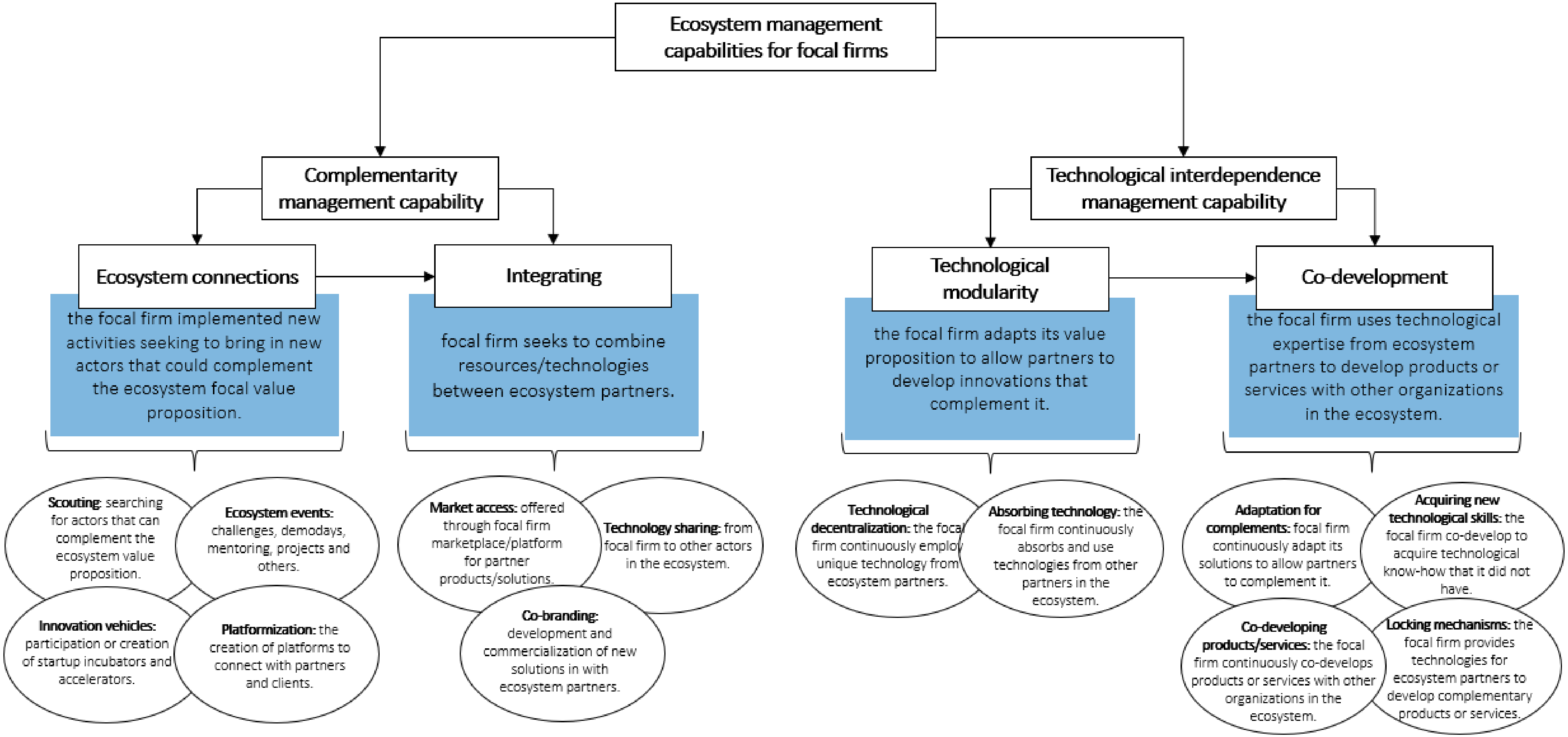
Activities	Bohemiken	Builders Gateway	Dockit	Energy Plus	FinFuture	Innovare Hospital	PayTech	Software House	Tech Master	uHappy
Complementarity management capability										
Ecosystem connections										
Scouting	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Ecosystem events	Y	Y	N	Y	Y	Y	Y	Y	Y	Y
Innovation vehicles	Y	Y	N	Y	Y	Y	Y	Y	Y	Y
Platformization	Y	Y	N	Y	Y	Y	Y	Y	Y	Y
Integrating										
Market access	Y	Y	N	N	Y	Y	Y	Y	Y	Y
Technology sharing	Y	Y	N	N	Y	N	Y	Y	Y	Y
Co-branding	Y	Y	N	N	Y	Y	Y	Y	Y	Y
Technological interdependence management capability										
Technological modularity										
Technological decentralization	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Absorbing technology	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Codevelopment										
Adaptation for complements	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Acquiring new technological skills	Y	Y	Y	N	Y	Y	Y	Y	Y	Y
Codeveloping products/services	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Locking mechanisms	Y	Y	N	N	Y	N	Y	Y	Y	Y

Legend: Y = activity sufficiently achieved, N = activity not sufficiently achieved.

Source: author.

Figure 17 summarizes the main activities that focal firms articulated to develop and manage their ecosystem through two new capabilities for ecosystem management. The capabilities are presented in the framework organized by the result that its respective set of activities aimed to develop.

Figure 17: Ecosystem management capabilities.



Source: author.

6.3 THEORETICAL IMPLICATIONS

The main contribution is to the capabilities-based view by presenting a broader capability debate that considers not just the value creation for the individual firm, but for the ecosystem. I did this by characterizing a new type of capability specific to ecosystem management, which I named ecosystem management capabilities, and I've proposed two and discussed the main activities that composes then. While there is previous research that has tried to address capabilities for ecosystems value creation (Hannah and Eisenhardt, 2018; Heaton et al.; 2019; Helfat and Raubitschek, 2018; Hou & Shi, 2020; Kay, Leih & Teece, 2018; Kindstrom et al., 2013; Nenonen et al., 2019; Linde et al., 2021), the originality of this study is in that it was explored in depth the capability focused on the most central features of ecosystems, which is complementarity (Pitelis & Teece, 2018; Shipilov & Gawer, 2020) and interdependence (Adner & Kapoor, 2010; Jacobides, 2018; Kapoor, 2018; Nambisan et al., 2019). In this sense, this study extends the current knowledge by making a fundamental theoretical contribution: a definition, development, and mensuration of two scales for two new capabilities that are specific to the context of ecosystems and can explain the emergence of the most central features of ecosystem management.

The second main contribution I make is to the ecosystem's literature (Shipilov & Gawer, 2020), by enhancing the understanding of how focal firms develop and manage the most central feature of ecosystems (i.e., the complementarity and technological interdependence) into two new capabilities: complementarity management capability and the technological interdependence management capability. This contribution is relevant, as the literature implicitly treats complementarity and interdependence as if it were a phenomenon that emerges spontaneously or automatically within ecosystems. While there are articles dealing with these elements (Adner & Kapoor, 2010; Jacobides, 2018; Kapoor, 2018; Nambisan et al., 2019; Pitelis & Teece, 2018; Shipilov & Gawer, 2020), these authors fail to empirically articulate the development and understanding of complementarity and interdependence in the light of a capability. I contribute by empirically highlighting the activities effectively employed by focal firms to develop these features in their ecosystem, characterizing this through a new ecosystem management capability. I not only define what these capabilities are, but also developed and validated a measurement scale for each. These contributions change the ecosystem discussion since now its most central features, which is complementarity and interdependence, can no longer be seen as spontaneous, as the literature implicitly describes them. On the contrary, there are new capabilities and from now on, I argue that complementarity and interdependence needs to be seen as an ecosystem feature that can be developed and managed by the focal firms, and as complementarity and interdependence are both features that are hard to obtain, it can be developed by focal firms or even fade away if not properly managed.

6.4 IMPLICATIONS FOR THE PRACTICE

This thesis has some significant contributions to focal firms engaged in ecosystem management. The proposed framework starts from the moment the focal firm recognizes the importance and need to develop and manage its ecosystem. Invariably, all firms engaged in ecosystem management at some point or another have gone through this reflection. From the moment these firms decide to manage their ecosystem, they need to develop and start a new set of activities that they didn't do before, aimed at producing certain results within the ecosystem. These activities are new to the focal firm and require a new set of knowledge and resources to be executed effectively. For this, I argue that focal firms need to develop a capability that is specific to the context of ecosystems and that was not previously necessary. The main contribution to the practice is that it was demonstrated how focal firms developed complementarity and technological interdependence, which are the most referenced features in ecosystem literature (Jacobides, 2022; Shipilov & Gawer, 2020; Gomes et al., 2022), to manage their ecosystem. I show the set of activities that focal firms need to develop for these features, which can be very useful for firms that are still starting or even at a more advanced level of ecosystem development and management. Thus, these results are important for innovation directors, ecosystem managers, community managers, and any other ecosystem-oriented positions.

The results of this thesis have several implications for executives engaged in the practice of ecosystem management. First, the managerial framework gives an overview of the activities that a focal firm needs to continuously perform in order to develop specific capabilities for competition via ecosystems. These activities for firms that are starting to engage in ecosystems are new and require investments and people to materialize. Our research shows that it's not enough to just run these new activities once. The focal firm needs to continually seek ways to develop and improve each of its activities in order to develop its ecosystem management capabilities. From the results of this thesis, it is possible to have an overview of the set of activities that need to be performed over time to develop ecosystem management capabilities, giving executives a path to execute an action plan. Second, this thesis contributes by developing and measuring an ecosystem management capability scale, which allows executives not only to know the activities they need to carry out to develop and manage their ecosystem, but also presents an instrument that executives can adapt to measure the degree of development of these activities.

7. FINAL CONSIDERATIONS

This thesis achieved the proposed objective which was unveil how focal firms develop complementarity and technological interdependence for ecosystem management through a capability lens. Based on the qualitative case studies and the development and mensuration of a scale, this thesis advances the current scholarship by proposing new constructs that explains the set of activities and results that a focal firm must pursue to develop complementarity and technological interdependence in its ecosystem. One of the main contributions of this thesis is the proposition of measurement scales for the complementarity management capability for focal firms and for the technological interdependence management capability. From this scale, academics and executives can measure the level of development of complementarity and technological interdependence for focal firms. This contribution is relevant to the ecosystem's literature, as it shows that the main characteristics of ecosystems, which is complementarity and interdependence, can be developed in the ecosystem through coordinated actions by the focal firms. This thesis contributes to the theory by showing the actions that focal firms effectively employed to develop these characteristics in their ecosystem, and that these two characteristics need to be managed and developed by focal firms, and not just automatically appear in ecosystems. This thesis demonstrates that complementarity and interdependence can be created, developed, and even regressed if not managed through ecosystem management capabilities. For the ecosystems literature, this thesis contributes by proposing two new capabilities for the context of ecosystem competition, where capabilities go beyond the boundaries of the firm, and need to consider the entire ecosystem in which the company is inserted. It was also evidenced that both proposed capabilities are positively associated with innovation in the focal firms participating in the study, showing that complementarity and technological interdependence have effects on the degree of innovation, and therefore, have relevance for firms and executives who seek to understand innovation.

My work has many limitations, among which I've highlight that as it is still early exploratory work, and I did not delve as deeply as I would like to in many of the activities mentioned. A future recommendation due to this limitation is for more research trying to address the specific capabilities for ecosystem management that can develop more deeply the advances of this thesis or that highlight other aspects that I may have missed. While complementarity and interdependence are main features of the ecosystem, there are others such as governance, and much more that I did not address, and I believe to be a promising avenue for future research. Another limitation was the use of mostly Brazilian companies and executives, which limits the potential for generalizing the results, that is, other focal firms in other contexts can perform different activities than the ones it was described to develop complementarity and technological interdependence. Again, there is a need of further research to highlight these aspects and find similarities and discrepancies in the results. Also, I did not highlight the role that other actors may play in the development and management of the ecosystem, as my focus was only on the focal firm. Another limitation of the study was that the scales developed and measured were not validated. I intend to validate the scales in a future study.

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APPENDIX A - SURVEY QUESTIONNAIRE

1. Complementarity management capability

For the creation of new products/services in our business ecosystem, my company constantly:		Strongly disagree 1	2	3	4
C1	Perform events (such as hackathons, challenges, demodays, mentorships, design sprints, projects and others) to identify/attract new partners in the business ecosystem.	☐	☐	☐	☐
C2	Creates or participates in innovation vehicles (hubs, incubators, or accelerators) to identify/attract new partners in the business ecosystem.	☐	☐	☐	☐
C3	Develops different ways (hubs, hackathons, mentorships) to identify/attract new partners in the business ecosystem.	☐	☐	☐	☐
C4	Develop platforms/marketplaces to connect with partners, suppliers and/or customers.	☐	☐	☐	☐
C5	Shares technology components with business ecosystem partners.	☐	☐	☐	☐
C6	Offers through marketplace/platform, market access to partner solutions.	☐	☐	☐	☐
C7	Offers solutions in cobranding with business ecosystem partners.	☐	☐	☐	☐

2. Technological interdependence management capability

To develop our new products/services and of partners, my company continuously:		Strongly disagree 1	2	3	4
IT1	Seeks to develop technologies jointly with business ecosystem partners that have complementary technologies to those of my company.	☐	☐	☐	☐
IT2	Provides technologies and/or knowledge for partners to develop complementary products/services.	☐	☐	☐	☐
IT3	Absorb technologies and/or knowledge from other business ecosystem partners.	☐	☐	☐	☐
IT4	Depends on technological specialties that my company does not develop internally.	☐	☐	☐	☐
IT5	Relies on unique technology from business ecosystem partners.	☐	☐	☐	☐
IT6	Adapts its solutions to enable partners to develop innovations complementary to my company's mix of products and services.	☐	☐	☐	☐
IT7	Develops close relationships with other companies that have knowledge or technologies that mine does not have.	☐	☐	☐	☐
IT8	Conduct pilots, MVPs or POCs with business ecosystem partners.	☐	☐	☐	☐

3. Innovation

In the last 3 years my company implemented innovations related to:		Strongly disagree 1	2	3	4
INOV1	Processes.	☐	☐	☐	☐
INOV2	Products.	☐	☐	☐	☐
INOV3	Services.	☐	☐	☐	☐
INOV4	Platforms.	☐	☐	☐	☐