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Business ecosystem embeddedness to enhance supply chain competence: the key role of external knowledge capacities

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ABSTRACT

Interest in business ecosystems has grown exponentially over the last decade. This article focuses on the operational benefits of business ecosystems by investigating how embeddedness in business ecosystems influences supply chain competence. Specifically, it considers the mediating effect of external knowledge capacities (i.e. absorptive, desorptive and connective capacity). Data from 271 European firms in business ecosystems was collected to test the paper's hypotheses using regression analysis with bootstrapping. Results indicate that business ecosystem embeddedness does not in itself improve supply chain competence. Rather, the relationship is explained through (i) absorptive and desorptive capacity as direct mediators; and (ii) connective capacity, which enhances supply chain competence indirectly by improving external knowledge retention for absorptive and desorptive capacity. To the best of our knowledge, this is the first paper to demonstrate benefits of being embedded in business ecosystems other than in terms of innovation. Newly validated scales for business ecosystem embeddedness and connective capacity are provided.

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1. Introduction

Business ecosystems play an important role in responding to today's increasingly complex and challenging environment. For instance, Airbus relied upon an ecosystem of inter-dependent companies that extended far beyond its traditional supply chain, including authorities, information technology firms and customers, to design and manufacture the A380 aircraft (Adner and Kapoor 2010; Ketchen, Crook, and Craighead 2014). More recently, the COVID-19 crisis has demonstrated how health ecosystems can facilitate coordination between a wide array of stakeholders in responding to the pandemic, producing medical equipment, providing 3 D printing capacity and introducing new software to track and trace the virus. Through these shared endeavours, ecosystem members mutually adapt to provide joint solutions that exceed organisational boundaries; and, in doing so, they co-evolve their capabilities, creating value that no single firm could achieve in isolation (Moore 1993). Despite the broad potential of business ecosystems, the extant literature has mainly focussed on the benefits for co-creating innovation (see, e.g. Adner and Kapoor 2010; Radziwon, Bogers, and Bilberg 2017). Other organisational areas may also benefit from being part of business ecosystems yet remain under-studied, including operations and supply chain management. The specific focus of this paper is therefore on investigating how being part of a business ecosystem affects supply chain competence, considering the role of external knowledge capacities as mediators.

In general terms, belonging to networks can enhance coordination, enable resource sharing, and provide wide access to diverse knowledge, depending on the degree of embeddedness (Uzzi 1996). For instance, strategic collaborative networks benefit a firm's flexibility, agility, market positioning, patent productivity and costs, among other advantages (Camarinha-Matos and Abreu 2007; Alletto et al. 2017). Business ecosystems represent bigger structural entities than networks (Wulf and Butel 2017), creating an even wider array of opportunities for members. Thus, successfully engaging in business ecosystems could lead to even greater benefits, and this could be particularly relevant for improving supply chain competences since they are based on collective learning experiences (Chow et al. 2008). This is supported by Millar (2015) who argued that supply ecosystems should allow firms to trade more effectively and efficiently.

Being embedded in business ecosystems facilitates access to a greater pool of diverse knowledge, which is key to co-creating value (Roper, Love, and Bonner 2017) and building competences in business ecosystems (Ketchen, Crook, and Craighead 2014). However, the complex knowledge exchanges that take place within business ecosystems cannot be undertaken using the same mechanisms as in traditional, hierarchical structures (Wulf and Butel 2017; Jacobides, Cennamo, and Gawer 2018). Ecosystems are

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dynamic, network-oriented, externally focussed (i.e. activities extend beyond the individual firm), and driven by collaborative and competitive relationships; meanwhile, no member has full control or ownership, implying that firms must deploy a new range of capabilities so that they are able to coordinate and leverage value (Fuller, Jacobides, and Reeves 2019). Otherwise, firms cannot create healthy ecosystems and the benefits may not materialise, as demonstrated, for example, by the failings of the Google + and Uber China ecosystems. In fact, little is known about the mechanisms through which firms can enhance joint competences and capitalise on the opportunities available to them from being embedded in business ecosystems. Given the importance of ecosystems for facilitating knowledge exchange between members (see. e.g. how the Norwegian Electric Vehicle (EV) Association facilitated knowledge among many stakeholders in the EV ecosystem promoting the development of EVs in Norway; Rong et al. 2017), we argue that knowledge management capacities should play a key role in enhancing certain competences, including those relevant to operations and supply chains.

Lichtenthaler and Lichtenthaler (2009) identified three capacities for managing knowledge externally: absorptive, desorptive and connective capacity. Absorptive and desorptive capacity have been regarded as components of dynamic capabilities (Hu, McNamara, and McLoughlin 2015), which allow for the creation or transformation of operational capabilities (Winter 2003). For instance, to be more responsive and flexible, ecosystem participants combine and recombine existing capabilities with those of other external participants, instead of doing so entirely in-house (Fuller, Jacobides, and Reeves 2019). This process can become highly reliant on the effective inward/outward knowledge coordination and integration among them. Thus, although being embedded in a business ecosystem should enable a firm to access greater knowledge, only with absorptive capacity can this knowledge be successfully integrated and utilised. Similarly, through effective knowledge transfer, i.e. desorptive capacity, members may benefit from establishing ecosystem standards, the development of joint solutions, or access to a partner's knowledge (Ziegler et al. 2013; Ritala et al. 2015). As a result, both capacities could be critical mechanisms in business ecosystems for improving competences towards the supply chain, through effective knowledge exploration and exploitation; however, further evidence is needed.

Connective capacity meanwhile has received far less attention than absorptive and desorptive capacity. Empirical studies are practically non-existent, although Albesher and De Coster (2012) claimed that connective capacity enables a firm to gain a better understanding of its environment and enhances the richness and reach of its linkages with other members. In fact, connective capacity was introduced to complement other external knowledge management capacities and gain a better understanding of dynamic capabilities (Lichtenthaler and Lichtenthaler 2009). It ensures privileged access to knowledge, extending a firm's knowledge base beyond its boundaries (Lichtenthaler and Lichtenthaler 2009). This is particularly relevant for knowledge exchanges between members of business ecosystems that are characterised by complex interdependences (Kapoor 2018). Consequently, connective capacity might: (i) facilitate relationships with other ecosystem members by promoting knowledge exchanges that can be used to improve supply chain competences; and, (ii) boost absorptive and desorptive capacity by establishing and enhancing the linkages upon which they are built. However, to the best of our knowledge, no single research study has simultaneously analysed the influence of all three capacities. In summary, we ask:

> **RQ:** How does business ecosystem embeddedness affect supply chain competence, and do external knowledge capacities mediate this relationship?

The three external knowledge capacities are considered mediators —instead of moderators— to show the mechanisms (i.e. knowledge exploration, exploitation and retention, respectively; Lichtenthaler and Lichtenthaler 2009) through which business ecosystem embeddedness influences supply chain competence. This responds to Schilke, Hu, and Helfat's (2018) call for more mediation and empirical analysis that explores the components of dynamic capabilities. Drawing on a recent perspective that incorporates ecosystems within the capability-based view (i.e. that resource-based theory must include stakeholder perspectives; Barney 2018), regression analysis with bootstrapping is applied to test three hypotheses using data from 271 firms participating in business ecosystems.

The research enriches the literature in three ways. First, it complements the literature on innovation and business ecosystems theory to determine whether operational aspects of a firm can also benefit from embeddedness in business ecosystems, with a particular focus on the enhancement of supply chain competence. Second, it considers the role of external knowledge capacities as mechanisms through which supply chain competences can be increased in business ecosystems, establishing a hierarchy amongst them in which knowledge retention (connective capacity) eases knowledge exploration and exploitation (i.e. absorptive and desorptive capacity). This contributes to superior supply chain competence, which has been shown to have a positive influence on organisational performance (Chow et al. 2008). Thus, the paper responds to Schilke, Hu, and Helfat's (2018) calls to demonstrate how certain components of dynamic capabilities influence more proximate outcomes (e.g. supply chain competence), rather than solely performance, while advancing their relevance to the business ecosystems literature. Third, it provides new measures for connective capacity and business ecosystem embeddedness, with the latter based on three dimensions – interdependence, value potential, and shared components.

The remainder of this paper is organised as follows. Section 2 presents the literature review and three hypotheses before Section 3 describes the research method. The results are presented in Section 4 followed by a discussion in

Section 5. Finally, Section 6 addresses the theoretical and managerial implications, limitations, and future research directions.

2. Literature review and hypotheses

2.1. Business ecosystem embeddedness

Business ecosystems were first described as intentional communities of economic actors (Moore 1993) and later as complex networks (Clarysse et al. 2014; Wulf and Butel 2017). The actors in business ecosystems "*co-evolve capabilities around a new innovation: they work cooperatively and competitively to support new products, satisfy customer needs, and eventually incorporate the new round of innovations*" (Moore 1993, 76). Establishing an analogy with biological ecosystems, Iansiti and Levien (2004) extended the concept of business ecosystems, depicting them as a "*large number of loosely interconnected participants who depend on each other for their mutual effectiveness and survival*". This implies that business ecosystem members have a shared fate whilst simultaneously competing for resources in the same way that species compete for water or food (Iansiti and Levien 2004; Ketchen, Crook, and Craighead 2014). Accordingly, when a member enters or exits the business ecosystem, the value of the whole ecosystem increases or decreases, respectively (Sloane and O'Reilly 2013). Hence, value-adding processes go beyond the individual reach of a company to broader collaborative agreements between participants embedded in the ecosystem.

According to Uzzi (1997), embeddedness creates economic opportunities that cannot be easily replicated in markets, contracts, or through vertical integration. Moreover, and opposite to the individual level, embeddedness among organisations is characterised by trust, knowledge exchange, and joint problem-solving (Uzzi 1996; Gulati, Lavie, and Madhavan 2011). At the business ecosystem level, embeddedness may favour interaction with other members to create opportunities for exchange and value co-creation. It can facilitate access to resources, knowledge, information, support and other benefits that are not available individually but are linked together in the networks (Uzzi 1996) of the ecosystem. Thus, drawing on Granovetter's (1985) concept of embeddedness and other research streams that emerged to define inter-actor embeddedness (Dacin 1999), we define business ecosystem embeddedness as the extent to which firms are integrated and become part of business ecosystems. Being embedded means that a firm depends on and is influenced by other ecosystem actors when creating value. It can be subject to three key dimensions: interdependence, value potential (or creation), and shared components.

First, interdependence among members differentiates a business ecosystem from related terms such as supply networks or industry sectors, and is one of the key features of business ecosystems (Zhong and Nieminen 2015; Kapoor 2018). They are far-reaching environments that normally exceed the boundaries of an industry (Iansiti and Levien 2004). In fact, they are generally understood as larger and more complex communities embedded and structured in several networks, each valuable for a different purpose (e.g. to access new knowledge or for resource exchanges; Millar 2015; Wulf and Butel 2017). Thus, members are not necessarily linked through direct buyer-supplier relationships. For instance, they include relationships with financing institutions, business associations, universities, research institutes, government organisations, or even competitors and customers (Iansiti and Levien 2004). These relationships can be formal or informal, and members may depend on each other even if they do not transact or directly interact (Wulf and Butel 2017).

Second, the specific characteristics of business ecosystems mean that they offer many opportunities for creating value. This is what Moore (2006) described as "space" for business opportunities. Consistent with the first dimension (i.e. interdependences), Clarysse et al. (2014) claimed that value creation in business ecosystems is not the outcome of individual efforts in a linear process. Rather, members work as an interrelated system of interdependent companies (Kapoor 2018) in which they must ensure the overall health of the ecosystem while achieving individual firm goals (Ketchen, Crook, and Craighead 2014). Moreover, business ecosystems offer room to create markets, technologies, products, or services that may not exist today (Hazlett et al. 2011). Similarly, they ease the identification of critical and potential partners that are important to success (e.g. suppliers, distributors, subcontractors, or technology providers; Iansiti and Levien 2004; Moore 2006).

Third, there are shared components among members, who often conduct their business on the same infrastructure or platform (i.e. clusters, services, tools, or core technologies; Li 2009; Graça and Camarinha-Matos 2017). Mostly, they involve digital platforms like Apple, Google or Facebook, but this is not the only option (see e.g. Novo Nordisk's nondigital ecosystem around diabetes; Fuller, Jacobides, and Reeves 2019). Further, shared components may also be intangible. For instance, ecosystem members share a similar vision (Moore 2006) or pursue mutual objectives, even if these objectives sometimes contradict the firm's individual goals, to maintain the overall health of the ecosystem (Ketchen, Crook, and Craighead 2014; Wulf and Butel 2016).

2.1.1. Business ecosystem embeddedness and supply chain competence

In contrast to other types of ecosystems (e.g. knowledge or innovation ecosystems), business ecosystems involve the demand-side (Clarysse et al. 2014; Kapoor 2018), which means firms collaborate to offer a full package of solutions to their customers. In doing so, firms benefit from both cost and risk sharing, increased flexibility, agility, and/or improved market positioning, among other advantages (Camarinha-Matos and Abreu 2007). According to Ramezani and Camarinha-Matos (2020), ecosystems leverage the benefits of sharing and collaboration, making business operations more efficient and agile. In fact, much of the knowledge that promotes growth opportunities in ecosystems is embedded in people, systems, and cultures of external organisations (Williamson and De Meyer 2012). Overall, embeddedness facilitates certain exchanges that contribute to reducing monitoring costs and improving decision-making, organisational learning and adaptation, which not only benefit the firm but also the networks in which it is embedded (Uzzi 1996). When firms capture value from the ecosystem, this should enable knowledge sharing to the benefit of potential partners and customers, potentially involving the creation of new products and/or improved financial outcomes (Radziwon, Bogers, and Bilberg 2017).

All these benefits can contribute to the development of a portfolio of organisational, managerial, technical, and strategic capabilities and skills over time, defined as supply chain competences (Chow et al. 2008). According to Millar (2015), operating in supply ecosystems allows firms to trade more effectively and efficiently, with supply chain management capabilities becoming a source of competitive advantage. In certain sectors, the ecosystem facilitated collaboration with other stakeholders to create effective supply chains (see e.g. Parente, Geleilate, and Rong 2018; Rong, Patton, and Chen 2018). Thus, when firms are embedded in business ecosystems, they gain expertise to manage relationships with other members and they can simultaneously combine skills to create a system of capabilities (Moore 2006; Fuller, Jacobides, and Reeves 2019). Along with the ecosystem's structure and coordination mechanisms (Jacobides, Cennamo, and Gawer 2018), this enables participants to increase competences towards the supply chain in order to respond to market demands at the right place and time, and with the right variety. Thus, we propose:

> ***H1*:** Business ecosystem embeddedness is positively linked to the development of supply chain competence.

2.2. External knowledge capacities and business ecosystems

Knowledge is an important input to the development and enhancement of supply chain competences. For instance, Wal-Mart is better able to match supply and demand by sharing information with other partners in its ecosystem, which makes all members more productive and responsive (Iansiti and Levien 2004). Equally, Luo, Shi, and Venkatesh (2018) highlighted the relevance of interactions and collaboration with partners to enhance integration and information exchange, which are key factors for supply chain excellence. Business ecosystems allow firms to share knowledge beyond enterprise boundaries through the establishment of ties with a vast assortment of different partners (Barile et al. 2016) and network structures that provide diverse types and ways of sharing knowledge (Wulf and Butel 2017).

However, embeddedness in business ecosystems may not be sufficient. Firms should ensure that they possess the right capacities to manage knowledge so that they can promote relevant flows and build the required competences. According to Cepeda and Vera (2007), knowledge management processes and organisational knowledge configurations act as the foundation of dynamic capabilities, which create or transform operational capabilities (Winter 2003). Thus, we argue that knowledge capacities could have a relevant role to play in successfully improving certain operational competences in business ecosystems. Specifically, based on a capability-based view, we analyse three constructs described by Lichtenthaler and Lichtenthaler (2009) framework for interfirm knowledge capacities: absorptive, desorptive and connective capacity.

2.2.1. The mediating effect of absorptive capacity

Business ecosystems provide collaborative environments with common processes and infrastructures that facilitate trust among members (Camarinha-Matos and Abreu 2007), thereby promoting both resource and information sharing. This alone however may not be enough to facilitate knowledge transfer or build new competences. Wang and Hu (2017) stated that access to new knowledge does not guarantee greater innovative capabilities; rather, the degree to which firms can absorb external knowledge is important. Similarly, it is argued here that improved supply chain competence in business ecosystems may rely on the level of a firm's absorptive capacity.

Absorptive capacity is described as "*a set of organisational routines and processes by which firms acquire, assimilate, transform, and exploit knowledge to produce a dynamic organisational capability*" (Zahra and George 2002, 185). Since Cohen and Levinthal (1990) introduced the concept of absorptive capacity, it has gained increased attention for its role in gaining and sustaining competitive advantage. In fact, it has been considered a key component of dynamic capabilities (Wang and Ahmed 2007), meaning it helps to build other operational capabilities (Winter 2003; Cepeda and Vera 2007). Through greater absorptive capacity, firms learn how to integrate and apply external knowledge to re-engineer their processes (Liu et al. 2013). Thus, absorptive capacity may play a mediating role in increasing supply chain competence for firms embedded in business ecosystems.

First, being embedded in business ecosystems offers numerous opportunities to access greater amounts of external knowledge (Wulf and Butel 2017), which becomes an incentive for building absorptive capacity (Cohen and Levinthal 1990). In fact, embeddedness has been identified as a critical factor influencing access to external knowledge in networks (Wulf and Butel 2017). Second, firms with high levels of absorptive capacity are better able to learn from other partners and integrate external knowledge with the current knowledge base (Wang and Ahmed 2007). Further, the successful absorption of knowledge eases the development of a shared understanding with channel partners (Liu et al. 2013), which may be important to building supply chain competence. Finally, absorptive capacity not only involves the acquisition and assimilation of capabilities (i.e. potential absorptive capacity), it also facilitates knowledge transformation and exploitation (i.e. realised absorptive capacity; Zahra and George 2002). Thus, absorptive capacity ensures that firms actually integrate new knowledge with existing knowledge and incorporate it into their systems, processes, routines and operations to develop both current and new competences (Zahra and George 2002; Wang and

Ahmed 2007). As a result, firms embedded in business ecosystems may improve supply chain competences through absorptive capacity. This leads to the following hypothesis:

> ***H2a:*** Absorptive capacity positively mediates the relationship between business ecosystem embeddedness and supply chain competence.

2.2.2. The mediating effect of desorptive capacity

In the same way that business ecosystems offer opportunities for acquiring external knowledge, firms also find numerous possibilities for transferring knowledge externally. This capability, which is the opposite to knowledge absorption, is referred to as desorptive capacity. Lichtenthaler and Lichtenthaler (2009, 1322) defined desorptive capacity as a "*firm's ability to externally exploit knowledge"* (i.e. outward knowledge transfer). It involves two processes: (i) the identification of knowledge transfer opportunities; and, (ii) the effective transfer of knowledge (Meinlschmidt et al. 2016).

The process of desorbing knowledge has been considered a component of dynamic capabilities (Hu, McNamara, and McLoughlin 2015), which means that, beyond being a source of possible income through patents or licences, transferring knowledge could help to build other capabilities. For instance, Ziegler et al. (2013) highlighted various strategic motives behind transferring knowledge, such as the further external development of technologies/products, achieving additional revenues to reinvest, or supporting long-term alliances. In any case, pooled knowledge is a prerequisite to building competences in business ecosystems (Ketchen, Crook, and Craighead 2014). Therefore, knowledge desorption may mediate the relationship between business ecosystem embeddedness and the improvement of supply chain competence.

On the one hand, when a firm is able to identify and transfer knowledge that is relevant to other members, partners can utilise it to improve their own processes and capabilities. The development of a partner's capabilities may indirectly benefit the firm since success and value creation in business ecosystems does not rely on the firm and its nearest supply chain, but on interrelated systems of interdependent participants (Adner et al. 2013; Ketchen, Crook, and Craighead 2014; Millar 2015). Moreover, literature has posited that firms often transfer knowledge to access a partner's knowledge in return (Ziegler et al. 2013; Ritala et al. 2015). Yet, the benefits of accessing partners' complementary capabilities might not materialise if skills, capabilities, and knowledge cannot be smoothly transferred and integrated with other organisations (Puranam, Singh, and Chaudhuri 2009). According to these authors, shared knowledge with other partners creates common ground to coordinate interdependence.

On the other hand, firms with a strong desorptive capacity codify and share knowledge effectively within the ecosystem's network structures (Gassmann and Enkel 2004). Thus, the transfer of knowledge and its successful integration allows for the creation of a common language and understanding among ecosystem members that often results in collective problem solving (Myers and Cheung 2008). This understanding may allow them to better respond to markets and the competitive environment. Further, by transferring knowledge a firm can establish standards to support coordination mechanisms and interdependences among partners, providing joint solutions to problems (Jacobides, Cennamo, and Gawer 2018). As a result, better integration and rapport with other partners may be relevant to the improvement of a firm's supply chain competence, which would allow it to respond in a timely manner, fill orders with improved accuracy, or make high-quality products/services with external support. In fact, Roldán Bravo, Ruiz-Moreno, and Lloréns Montes (2018) provided positive empirical evidence on the impact of desorptive capacity on supply chain competence. We thus propose that desorptive capacity not only becomes essential to improving supply chain competences, but also that it acts as a mediator in transferring knowledge effectively amongst ecosystem members and improving joint competences. Therefore, we posit that:

> ***H2b*:** Desorptive capacity positively mediates the relationship between business ecosystem embeddedness and supply chain competence.

2.2.3. The mediating effect of connective capacity

Accessing external knowledge often relies on a firm's ability to establish and maintain relationships with other partners. This is particularly challenging in business ecosystems because they involve complex interdependences between participants (Iansiti and Levien 2004). If this can be achieved, firms may leverage partners' complementary knowledge and resources, enabling them to survive in today's competitive and uncertain environment. A firm's ability to retain knowledge from outside its boundaries is referred to by Lichtenthaler and Lichtenthaler (2009) as connective capacity, which involves the processes of: (i) maintaining knowledge in inter-firm networks; and subsequently, (ii) reactivating this knowledge. This means that the firm can effectively access and preserve external knowledge (e.g. through the management of alliance portfolios that facilitate privileged access to other partners' knowledge). As a result, the firm can count on a larger knowledge base that surpasses its boundaries.

Connective capacity complements external knowledge exploration and exploitation (i.e. absorptive and desorptive capacity) through external knowledge retention, which enables inter-temporal knowledge transfer (Lichtenthaler and Lichtenthaler 2009). This may play a vital role for firms in business ecosystems since they are dynamic, constantly evolving systems (Fuller, Jacobides, and Reeves 2019). To illustrate connective capacity, Lichtenthaler and Lichtenthaler (2009) referred to Cisco, as described in Bunnell and Brandt (2000), where the company ensured access to its partner's knowledge without immediately acquiring it through network alliances. In fact, Cisco is one of the main success cases in the business ecosystems literature, developing its own ecosystem and becoming a technology leader in the Internet infrastructure market (Li 2009). We argue that connective capacity could potentially improve firm responsiveness to customer demands along with other supply partners, mediating the relationship between business ecosystem embeddedness and supply chain competence.

On the one hand, connective capacity comprises alliance management capabilities (Lichtenthaler and Lichtenthaler 2009); that is "*a firm's ability to effectively manage multiple alliances*" (Rothaermel and Deeds 2006). Alliances can contribute to accessing external knowledge (Grant and Baden-Fuller 2004) and facilitating stronger learning processes that enhance partnering skills (Kale and Singh 2007). Moreover, it has been suggested that alliance management is a dynamic capability that allows a firm to "*integrate, build and reconfigure internal and external competences to address rapidly changing environments*" (Teece, Pisano, and Shuen 1997, 516). On the other hand, connective capacity also encompasses relational capabilities (Lichtenthaler and Lichtenthaler 2009), which describe the capacity of the organisation to create, extend, or modify a firm's resource base through access to an alliance partner's resources (Kale and Singh 2007). Lorenzoni and Lipparini (1999) argued that relational capability is a strategic asset that can shape inter-firm networks over time, facilitating different benefits such as lowering exchange costs, optimising the election of governance structures, absorbing knowledge across inter-firm networks and increasing flexibility in terms of the combination and coordination of resources between partners.

Consistent with the above, Albesher and De Coster (2012) stated that connective capacity enhances the ability of firms to rapidly adapt to changes in the environment and facilitates access to valuable, rare, inimitable, and non-substitutable (VRIN) resources (Barney 1991). If firms in business ecosystems are better able to connect with other partners, they will obtain more opportunities to access relevant knowledge that can be used to improve and develop their supply chain competence. Thus, we propose:

> ***H2c:*** Connective capacity positively mediates the relationship between business ecosystem embeddedness and supply chain competence.

2.3. Serial mediation of connective capacity via absorptive and desorptive capacity

Connective capacity may also have positive but indirect effects on the improvement of supply chain competences through its impact on absorptive/desorptive capacity. In fact, there is wider literature that views inter-firm relationships as important vehicles for absorbing or transferring knowledge externally, especially in dynamically competitive contexts (Lorenzoni and Lipparini 1999; Grant and Baden-Fuller 2004), such as business ecosystems.

First, the effect on absorptive capacity seems to be more evident since connective capacity directly impacts a firm's access to knowledge. Firms with strong connective capacity are better able to reactivate knowledge that has been maintained in inter-firm networks (Lichtenthaler and Lichtenthaler 2009); for example, Cisco's access to privileged external knowledge through alliances without immediately acquiring it (Bunnell and Brandt 2000). Thus, according to Lichtenthaler and Lichtenthaler (2009), this capacity does not presume inward knowledge transfer, rather it can ease the absorption of potential knowledge into the firm through the establishment of connections with other members in the ecosystem. As a result, connective capacity eases tasks and processes regarding external knowledge exploration (e.g. knowledge acquisition; Albesher and De Coster 2012) by facilitating access to and retention of knowledge externally.

Second, although the impact of connective capacity on desorptive capacity may be less evident in the literature, firms can potentially take advantage of the same alliances in which knowledge was retained to externally exploit their own knowledge. For instance, in the bio-pharmaceutical sector, Hu, McNamara, and McLoughlin (2015) established that a greater number of prior commercial alliances leads to achieving a greater number of out-licensing deals. Indeed, connective capacity provides a better understanding of a firm's market opportunities and the reach and richness of its relationships with other organisations (Albesher and De Coster 2012). Thus, it can facilitate the external transfer of knowledge and the establishment of future alliances.

In conclusion, connective capacity may stimulate absorptive and desorptive capacity by establishing and enhancing the linkages upon which they are built. Therefore, we propose that connective capacity does not directly involve the successful exploration and exploitation of external knowledge; rather, that it can positively impact the way in which a firm absorbs and desorbs knowledge with other members of the business ecosystem. These inflows and outflows would allow a firm to utilise its knowledge for improving joint competences with other partners, i.e. supply chain competence. Therefore, we propose:

> ***H3a:*** The relationship between business ecosystem embeddedness and supply chain competence is serially mediated by connective capacity and absorptive capacity.

> ***H3b:*** The relationship between business ecosystem embeddedness and supply chain competence is serially mediated by connective capacity and desorptive capacity.

3. Research method

3.1. Sample and data collection

Data were drawn from European business clusters that accounted for a total of 2300 firms covering a wide range of industry sectors, firm sizes and ages (see Table 1). Although these clusters cannot be objectively described as business ecosystems, they enable access to firms that participate in business ecosystems.

A questionnaire was designed for CEOs and top managers since they hold a broad perspective of a firm's interactions with other ecosystem members. To assess whether the company was, in fact, involved in business ecosystems, prior to filling in the questionnaire respondents were given information on the research topic using the exploratory study of Wulf and Butel (2017), which described ecosystems from a manager's point of view. In addition, this was established by also objectively analysing the degree of embeddedness of

Table 1. Sample demographics.

Variables	Frequency (*N*)	Percentage (%)
Age		
<10	101	37.3
10–29	105	38.7
30–49	35	12.9
>50	30	11.1
Size		
Micro enterprises (<10)	73	26.9
Small enterprises (10–49)	77	28.4
Medium-sized enterprises (50–249)	60	22.2
Large enterprises (>250)	61	22.5
Scope		
Local	12	4.4
National	55	20.3
International	204	75.3
Industry		
1. Agriculture, Forestry And Fishing	1	0.4
2. Manufacturing	59	21.8
3. Electricity, Gas, Steam and Air Conditioning Supply	12	4.4
4. Water Supply; Sewerage, Waste Management and Remediation Activities	4	1.5
5. Construction	3	1.1
6. Wholesale and Retail Trade; Repair of Motor Vehicles and Motorcycles	16	5.9
7. Transportation and Storage	12	4.4
8. Accomodation and Food Service Activities	1	0.4
9. Information and Communication	77	28.4
10. Financial and Insurance Activities	12	4.4
11. Professional, Scientific and Technical Activities	54	19.9
12. Administrative and Support Service Activities	1	0.4
13. Education	1	0.4
14. Human Health and Social Work Activities	3	1.1
15. Arts, Entertainment and Recreation	2	0.7
16. Other Service Activities	12	4.4
17. Activities of Extraterritorial Organisations and Bodies	1	0.4
Ecosystem Dimensions		
1. Interdependencies		
Low	26	9.6
Medium	111	41.0
High	134	49.4
2. Value Potential		
Low	11	4.1
Medium	63	23.2
High	197	72.7
3. Shared components		
Low	10	3.7
Medium	117	43.2
High	144	53.1
Business Ecosystem Embeddedness		
Low	5	1.8
Medium	108	39.9
High	158	58.3

Notes. $N = 271$. Statistical Classification of Economic Activities in the European community NACE Rev. 2 was adopted for industry. From 21 sectors, 17 were represented in our sample.

these firms in business ecosystems (see Section 3.2.1). Digital and paper versions were made available in English and Spanish using Brislin's (1980) procedure to ensure equivalent translations. Moreover, we launched a pilot questionnaire with five top managers and used their comments to improve comprehensibility, avoiding ambiguous and complex questions.

Prior to and after the questionnaire launch, we controlled for common method bias using Podsakoff et al. (2003). First, variables were arranged in a different order to the hypotheses so the model was unpredictable to the respondents. Second, during the process of data collection, we were able to give examples, explain complex syntax and define unfamiliar concepts to informants. Third, to avoid positively biased responses, we guaranteed the respondent's anonymity and ensured them that there were no right/wrong answers. Fourth, after data were collected, Harman's one-factor test was conducted to show that none of the factors accounted for more than 50% of the variance (see Appendix 1). Fifth, to complement Podsakoff et al. (2003), we followed Chang, van Witteloostuijn, and Eden (2010) by constraining all items to one single factor in the confirmatory factor analysis (CFA). Results showed poor fit (RMSEA = 0.108, NFI = 0.578, CFI = 0.609, IFI = 0.613, $\chi^2 = 1459.757$ with 350 d.f.; $p > 0.000$) meaning that a single factor did not account for all of the variance. Finally, we employed the marker variable technique (Lindell and Whitney 2001), which is believed to perform better compared to the previous remedies for common method bias (Craighead et al. 2011). We examined the correlations of relevant variables in our model with a theoretically unrelated variable (i.e. a marker variable) and found non-significant correlations with the dependent variable and most of the mediators of our model (see Appendix 2). Taken together, this led us to conclude that common method bias is not a major concern.

At the end of the data collection period, a total of 273 questionnaires were received, reduced to 271 usable questionnaires (response rate 11.78%). One response was removed due to incomplete values and another was assessed as an outlier. Non-response bias was evaluated by comparing early and late respondents (Armstrong and Overton 1977) in terms of demographic and model variables, where later respondents were considered a surrogate for non-respondents. The test results indicated no significant differences ($p > 0.05$) between the two groups (see Appendix 3) leading us to claim that non-response bias is not a major concern in this study.

3.2. Measures

We used seven-point Likert scales to measure the items of each construct (see Appendix 4), where 1 indicated "strongly disagree" and 7 "strongly agree". We calculated individual composite scores for each measure as the average of the items pertaining to each construct (Hair et al. 2014). While some constructs were adopted from previous literature, other variables have not, to the best of our knowledge, been empirically studied before (i.e. business ecosystems embeddedness and connective capacity). Thus, we developed and validated new scales by performing exploratory factor analysis (EFA) with a 149-firm sample, as described below, and using CFA as shown in Section 4.1.

3.2.1. Business ecosystem embeddedness

We initially developed an eleven-item construct for *business ecosystem embeddedness* (see Appendix 4), which is defined as the extent to which firms are integrated and become part of business ecosystems. Item ECO11 was dropped after EFA since it presented low inter-item and item-total correlations (<0.3 and <0.5, respectively), and Cronbach's alpha increased after removing it (Hair et al. 2014). This resulted in ten items that were grouped into three components using principal component analysis (see Appendix 1). The varimax factor rotation method and Kaiser Normalisation technique were applied. After the CFA was conducted (see Section 4.1), two further items (ECO01, ECO07) were dropped due to low factor loadings (>0.5; Hair et al. 2014). Therefore, we concluded that business ecosystem embeddedness is an eight-item, second-order construct based on three dimensions: interdependences (4 items), value potential (2 items), and shared components (2 items). Section 2.1 describes the literature basis for each dimension. The overall score of a firm's business ecosystem embeddedness was measured as a weighted average of the three dimensions, considering the number of items per dimension. Cronbach's alpha reached 0.77.

3.2.2. External knowledge capacities

We operationalised *absorptive capacity* based on the 4-item construct of Ettlie and Pavlou (2006). Cronbach's alpha was 0.80. For *desorptive capacity*, we adapted and extended a three-item scale developed by Roldán Bravo, Ruiz Moreno, and Llorens-Montes (2016) since they specifically focussed on buyers and supply network relationships rather than broader business ecosystems. We introduced four further items to describe the concept of desorptive capacity more accurately and to accommodate a wider range of relationships. After performing an EFA, we obtained a 7-item, unidimensional construct. Finally, we used Lichtenthaler and Lichtenthaler (2009) concept of external knowledge retention to develop a new 4-item construct for *connective capacity* since, to the best of our knowledge, no prior empirical study considered it. The results in Appendix 1 show all factor loadings for desorptive and connective capacity exceed the threshold of 0.45 (Hair et al. 2014), and that Cronbach's alpha coefficients were 0.88 and 0.90, respectively.

3.2.3. Supply chain competence

Supply chain competence was adapted from Chow et al. (2008) measure. According to these authors, supply chain competences are comprised of three areas, i.e. quality and service, operations and distribution, and design effectiveness. We limited our focus to *quality and service* since firms in the sample belong to a wide range of sectors, and the other two areas were not relevant to them all (e.g. many service companies do not generate physical inventories or design production processes). Thus, we adopted supply chain competence as a 7-item construct of one component (see Appendix 1). CFA removed items SCC02 and SCC07 due to low factor loadings that hampered the validity of the construct. Ultimately, supply chain competence was comprised of five items, with a Cronbach's alpha coefficient of 0.82.

3.2.4. Control Variables

We considered four control variables to remove the effect of alternative explanations of the relationships between the variables explaining supply chain competence, which also helps to reduce endogeneity problems caused by omitted variables (Lu et al. 2018). First, we controlled for *firm size* and *firm age*, which were measured by the natural logarithm of the number of firm employees (Ln size) and the number of years since foundation (Ln age), respectively. These variables were considered because: larger firms might be able to access more resources than small firms for developing competences; and older firms may exhibit accumulated knowledge, improved learning processes and past experience compared to younger firms. Second, *scope* (i.e. local, national and international) was analysed to assess whether the geographical area of the firm's activities impact on the reach of its linkages with other members, the opportunities for knowledge exchange or the degree of embeddedness within the ecosystem. Finally, *industry* was analysed since business ecosystem activities normally exceed the limits of any specific industry or sector (Iansiti and Levien 2004). We considered 21 industries based on the European Statistical Classification of Economic Activities (NACE Rev. 2).

3.3. Data Analysis

First, descriptive, correlational and EFA analyses were conducted using SPSS (Version 24). Second, EQS 6.1 (Byrne 2013) was employed to test CFA. Third, the PROCESS macro for SPSS (Hayes 2013) was used to test the hypothesised relationships through regression analysis with bootstrapping. According to van Jaarsveld, Walker, and Skarlicki (2010), this approach has the advantage of not only allowing the indirect effects of a simple mediation model to be isolated, but also enabling the indirect effects passing through two or more mediators in a series to be evaluated. It estimates confidence intervals through the bootstrapping procedure, addressing some weaknesses associated with the Sobel test (van Jaarsveld, Walker, and Skarlicki 2010). As a result, we were able to measure the indirect effects of business ecosystem embeddedness on supply chain competence through each of the three external knowledge capacities (i.e. H2a: absorptive capacity; H2b: desorptive capacity; and, H2c: connective capacity) and through multiple mediators (i.e. through the effect of connective capacity on absorptive and desorptive capacity; H3a and H3b, respectively).

4. Analyses and results

4.1. Construct Validation

Prior to hypothesis testing, we conducted CFA. First, to test the measurement model we used robustness indices and the Satorra-Bentler scaled chi-square test due to the non-normality of the data. CFA results showed acceptable goodness-of-fit for the measurement model ($\chi^2 = 564.071$; $df = 337$; $p > 0.000$; RMSEA = 0.050; NNFI = 0.910; CFI = 0.920; IFI = 0.921). Moreover, Cronbach's alpha, including all constructs in the model, was 0.911 (>0.70). Additionally, to prove that business ecosystem embeddedness is a second-order construct, we compared the measurement model above with business ecosystem embeddedness as a first-order construct. The overall fit statistics for the latter ($\chi^2 = 555.732$; $df = 329$; $p > 0.000$; RMSEA = 0.051; NNFI = 0.908; CFI = 0.920; IFI = 0.921) were slightly inferior and the chi-square difference test was in favour of the second-order construct model. Accordingly, the smallest AIC model (Burnham and Anderson 2004) was in favour of the second-order (AIC= −109.929) versus the first-order construct (AIC= −102.268). Overall, these results show that business ecosystem embeddedness is indeed a second-order construct with 3 dimensions: interdependences, value potential, and shared components.

Second, the reliability of each scale was assessed through Cronbach's alpha coefficients and composite reliability (both > 0.70; Fornell and Larcker 1981; Nunnally and Bernstein 1994). The average variance extracted (AVE) value was >0.5 for all constructs (Fornell and Larcker 1981; Hair et al. 2014). Overall, the results show acceptable values for reliability and internal consistency (see Table 2).

Third, convergent and discriminant validity were also examined. We assumed convergent validity since all factor loadings were statistically significant ($t \geq 1.96$; $\alpha = 0.05$; Anderson and Gerbing 1982) and >0.5 (Hair et al. 2014). Further, Hair et al. (2014) indicated that an AVE greater than 0.5 suggests adequate convergence and that reliability is an indicator of convergent validity. As for discriminant validity, it was assessed in two ways. First, we used Fornell and Larcker's (1981) procedure to check that the square root of the AVEs for each construct were greater than the correlations between constructs. Second, as suggested by Anderson and Gerbing (1982), we ran a new principal component analysis once the scales had been purified. It showed that all constructs were built by the items used to measure them (see Appendix 1). Consequently, all measures exceeded the recommended benchmarks for convergent and discriminant validity. Finally, Table 3 summarises the means, standard deviations, and correlations of all variables.

4.2. Hypothesis testing

We tested the hypotheses following Hayes (2013) regression analysis-based approach using the PROCESS macro for SPSS. Table 4 presents the results. H1 evaluated whether business ecosystem embeddedness is positively linked to supply chain competence, and the results showed positive and significant total effects ($\beta = 0.148$; SE = 0.052; CI: 0.014, 0.247), supporting Hypothesis 1. However, the direct effect was negative, and non-significant ($\beta = -0.031$). These results provide evidence of full mediation (i.e. the total effect of the predictor on the outcome is entirely indirect, and transmitted through one or more mediators). Therefore, we examined the indirect effects through absorptive capacity (H2a), desorptive capacity (H2b), and connective capacity (H2c); and the serial mediation effect of connective capacity on absorptive and desorptive capacity (H3a and H3b, respectively). Hence, we obtained the five-path mediation model depicted in Figure 1.

H2a stated that absorptive capacity positively mediates the relationship between business ecosystem embeddedness and supply chain competence. We found a significant indirect effect ($\beta = 0.077$; SE = 0.026; CI: 0.030, 0.132). Also, Table 4 shows that business ecosystem embeddedness predicts absorptive capacity ($\beta = 0.260$; $p < 0.000$) and that absorptive capacity positively affects supply chain competence ($\beta = 0.297$; $p < 0.001$). Thus, H2a is supported. Similarly, H2b established that desorptive capacity positively mediates the relationship between business ecosystem embeddedness and supply chain competence. The indirect effect was found to be statistically significant ($\beta = 0.031$, SE = 0.019, CI: 0.001, 0.073), thereby supporting H2b. Further, business ecosystem embeddedness presents a positive, significant effect on desorptive capacity ($\beta = 0.193$; $p < 0.001$) and the effect of desorptive capacity on supply chain competence is also positive and significant ($\beta = 0.158$; $p < 0.040$). In H2c, we expected connective capacity to positively mediate the relationship between business ecosystem embeddedness and supply chain competence. However, we obtained non-significant results as the 95% confidence interval for the indirect effect contains zero (β=-0.007; SE = 0.028; CI: −0.064, 0.047), meaning that H2c is rejected.

Table 2. Results of CFA results and goodness of fit statistics.

Variable	λ	Measurement model's goodness-of-fit statistics
1. Business Ecosystem Embeddedness ($\alpha = 0.767$; CR = 0.771; AVE = 0.531)		$\chi^2 = 564.071$
ECO_IN	0.658	with 337 d.f.
ECO_VP	0.738	RMSEA = 0.050
ECO_SC	0.784	NFI = 0.910
2. Connective Capacity ($\alpha = 0.899$; CR = 0.902; AVE = 0.700)		CFI = 0.920
CC01	0.700	IFI = 0.921
CC02	0.820	$\alpha = 0.911$
CC03	0.925	
CC04	0.881	
3. Absorptive Capacity ($\alpha = 0.799$; CR = 0.813; AVE = 0.700)		
AC01	0.736	
AC02	0.630	
AC03	0.801	
AC04	0.714	
4. Desorptive Capacity ($\alpha = 0.881$; CR = 0.883; AVE = 0.526)		
DC01	0.599	
DC02	0.615	
DC03	0.609	
DC04	0.745	
DC05	0.893	
DC06	0.875	
DC07	0.674	
5. Supply Chain Competence ($\alpha = 0.821$; CR = 0.835; AVE = 0.510)		
SCC01	0.713	
SCC03	0.637	
SCC04	0.733	
SCC05	0.888	
SCC06	0.553	

Notes. All *t*-values > 1.96. χ^2 is significant at $p < 0.000$. α: Cronbach's alpha ($\alpha > 0.7$); CR: Composite Reliability (CR > 0.7); AVE: Average Variance Extracted (AVE > 0.5).

Table 3. Means, standard deviations and correlations.

Variables	Mean	SD	1	2	3	4	5	6	7	8	9
1. Business Ecosystem Embeddedness	4.73	1.04	–								
2. Connective Capacity	4.61	1.51	0.40**	–							
3. Absorptive Capacity	5.17	1.20	0.41**	0.51**	–						
4. Desorptive Capacity	4.89	1.29	0.41**	0.60**	0.65**	–					
5. Supply Chain Competence	5.98	0.82	0.14*	0.22**	0.39**	0.34**	–				
6. Ln Age	2.57	1.24	−0.04	−0.05	−0.01	−0.04	−0.03	–			
7. Ln Size	4.01	2.63	0.22**	0.14*	0.09	0.11	−0.01	0.63**	–		
8. Scope	2.71	0.54	0.25**	0.06	0.09	0.12	0.05	0.10	0.29**	–	
9. Industry	9.04	4.48	−0.03	−0.06	−0.10	−0.09	0.16*	−0.22**	−0.21**	−0.16**	–

Notes. $N = 271$; *SD* = standard deviation; $^{**}p < 0.01$; $^{*}p < 0.05$; two-tailed test.

Table 4. Regression coefficients, standard errors and model summary of the serial multiple mediation model.

	Consequent											
		M1 (CC)			M2 (AC)			M3 (DC)			Y (SCC)	
Antecedent		Coeff.	*p*		Coeff.	*p*		Coeff.	*p*		Coeff.	*p*
X (ECO)	a_1	0.382 (0.088)	0.000	a_2	0.260 (0.073)	0.000	a_3	0.193 (0.068)	0.001	c′	−0.031 (0.060)	n.s.
M_1 (CC)		__	__	d_{21}	0.412 (0.054)	0.000	d_{31}	0.519 (0.051)	0.000	b_1	−0.018 (0.038)	n.s.
M_2 (AC)		__	__		__	__		__	__	b_2	0.297 (0.057)	0.001
M3 (DC)		__	__		__	__		__	__	b_3	0.158 (0.048)	0.040
Constant	i_{M1}	2.908 (0.565)	0.000	i_{M2}	2.349 (0.486)	0.000	i_{M3}	1.654 (0.459)	0.000	i_Y	4.869 (0.383)	0.000
Ln Age		−0.139 (0.113)	n.s.		0.046 (0.060)	n.s.		−0.008 (0.060)	n.s.		−0.010 (0.043)	n.s.
Ln Size		0.149 (0.050)	n.s.		−0.069 (0.031)	n.s.		−0.026 (0.031)	n.s.		−0.064 (0.024)	n.s.
Scope		−0.080 (0.157)	n.s.		0.010 (0.116)	n.s.		0.040 (0.121)	n.s.		0.012 (0.091)	n.s.
Industry		−0.067 (0.018)	n.s.		−0.066 (0.013)	n.s.		−0.052 (0.015)	n.s.		−0.129 (0.011)	0.039
		$R^2 = 0.181$			$R^2 = 0.317$			$R^2 = 0.397$			$R^2 = 0.181$	
		$F(5, 265) = 10.945$, $p = 0.000$			$F(6, 264) = 14.889$, $p = 0.000$			$F(6, 264) = 28.005$, $p = 0.000$			$F(8, 262) = 6.184$, $p = 0.000$	

Notes. $N = 271$. Standardised coefficients. Standard errors in parentheses. 95% confidence interval for all relationships, with 10,000 bootstrap samples. ECO: Business Ecosystem Embeddedness; CC: Connective Capacity; AC: Absorptive capacity; DC: Desorptive Capacity; SCC: Supply Chain Competence. Controls: Ln age, Ln size, scope, sector. M_1: First mediator; M_2: Second mediator; M_3: Third mediator; n.s: non-significant.

Finally, we analysed the multiple mediation effects. H3a stated that the relationship between business ecosystem embeddedness and supply chain competence is serially mediated by connective capacity and absorptive capacity, while H3b established the same relationship but with connective capacity and desorptive capacity as the serial mediators. Indirect effects were shown to be statistically significant for both hypotheses ($\beta = 0.047$; SE = 0.016; CI: 0.020, 0.082; and $\beta = 0.031$; SE = 0.017; CI: 0.002, 0.069, respectively), supporting H3a and H3b. Furthermore, business ecosystem embeddedness predicted

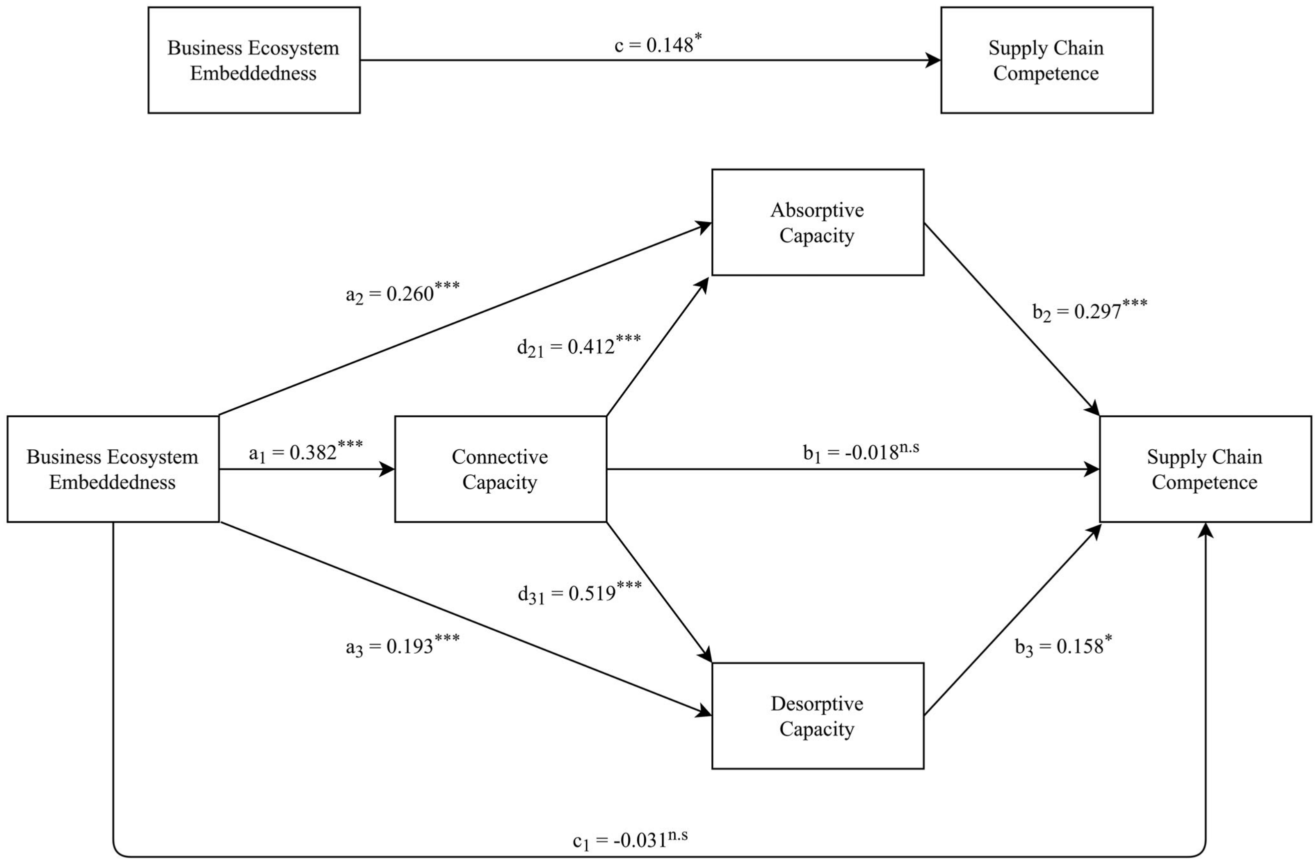

Figure 1. Total, direct and indirect effects of the serial mediation model. *Notes.* $N = 271$, $^{***}p < 0.001$; $^{**}p > 0.01$; $^{*}p > 0.05$.

connective capacity ($\beta = 0.382$; $p < 0.000$), which in turn predicted absorptive capacity ($\beta = 0.412$; $p < 0.000$) and desorptive capacity ($\beta = 0.519$; $p < 0.000$), and each of them positively affected supply chain competence ($\beta = 0.297$; $p < 0.001$; and $\beta = 0.158$; $p < 0.040$; respectively). In summary, H1, H2a, H2b, H3a and H3b were supported, and this remained unchanged irrespective of the inclusion/exclusion of control variables.

Additionally, to reduce endogeneity problems in the proposed model, a test of robustness was performed using two alternative models (see, e.g. Rojo, Llorens-Montes, and Perez-Arostegui 2016). Structural equation modelling (SEM) with partial least squares was employed to easily compare their global fits since the PROCESS macro for SPSS presents more limitations when comparing the fit of different models. First, we calculated the same model with a first-order construct for business ecosystems embeddedness instead. Second, we estimated a model that inverted the order of the mediator variables (i.e. business ecosystem embeddedness indirectly influences supply chain competence through the serial mediation of absorptive and desorptive capacity on connective capacity). The SRMR for both alternative models (i.e. 0.086 and 0.140, respectively) was higher than the proposed model, which presented a SRMR at the threshold of 0.08. As a result, the proposed model gives a better explanation of the data.

5. Discussion

The present study analyses whether the embeddedness of a firm in business ecosystems improves supply chain competence. Regardless of the emphasis of the literature on value co-creation and the co-evolution of capabilities in business ecosystems (Clarysse et al. 2014; Moore 1993), little is known about the mechanisms through which firms jointly increase their competences (Jacobides, Cennamo, and Gawer 2018). Thus, we sought to expand this idea through a capability-based view with three different knowledge capacities as mediators in the relationship, i.e. absorptive, desorptive, and connective capacity.

The results indicate that business ecosystem embeddedness has a positive effect on supply chain competence, but it does not directly improve it. That is, being embedded in business ecosystems does not directly guarantee that a firm is able to co-create value along with other partners and tap into the ecosystem. Although it is generally agreed that business ecosystems ensure access to a greater pool of diverse knowledge (Williamson and De Meyer 2012), which becomes essential to developing joint competencies (Ketchen, Crook, and Craighead 2014), they demand different mechanisms compared to those required in linear structures, as previously evidenced by Wulf and Butel (2017). Thus, the traditional view, where independent actors resolve problems, must change into a more interconnected view of businesses, which demands new tools and capabilities (Barile et al. 2016).

Given the above, additional capabilities explain the relationship and are needed to leverage knowledge. Our findings suggest that absorptive capacity acts as an enabler that increases supply chain competence for firms embedded in business ecosystems. First, business ecosystems provide numerous opportunities to access external knowledge (Wulf and Butel 2017), which becomes an incentive to increase absorptive capacity. Second, literature agrees that firms with high levels of absorptive capacity are better able to learn from other partners (Wang and Ahmed 2007). Therefore, absorptive capacity eases the creation of common knowledge bases with other partners through which they co-evolve their capabilities and build joint competencies. Finally, high levels of absorptive capacity facilitate the transformation and exploitation of external knowledge to produce a dynamic organisational capability (Zahra and George 2002) and reengineer firm processes. Recently, Helfat and Raubitschek (2018) highlighted the importance of dynamic capabilities in digital ecosystems and proposed that absorptive capacity is key to interpreting the breadth of information available to ecosystem leaders. Specifically, when the improvement of competencies depends on other partners (i.e. supply chain competence), the ability to absorb external knowledge becomes crucial as it ensures a shared understanding with them (Liu et al. 2013).

Similarly, results show that desorptive capacity improves supply chain competence for firms embedded in business ecosystems. First, business ecosystems provide access to networks of critical and potential partners that may be willing to acquire and apply the firm's knowledge. This may encourage desorptive capacity improvements. Second, literature has evidenced that, among other motives, firms transfer their knowledge to access a partner's knowledge in return (Ziegler et al. 2013; Ritala et al. 2015). Exchanges, and the integration of knowledge among partners in supply chains, facilitates a common language and understanding to solve problems that benefit organisations and the relationships between them (Myers and Cheung 2008), which may also apply to business ecosystems. Moreover, knowledge transfer can contribute to initiating ecosystem standards, easing the coordination mechanisms and interdependences among partners (Jacobides, Cennamo, and Gawer 2018). Third, the interdependence amongst business ecosystem members may explain the relevance of knowledge flows. That is, beyond a firm's absorptive capacity (i.e. inflows), desorptive capacity can serve to facilitate the effective integration of a firm's knowledge by other members (i.e. outflows), which can positively affect the firm itself through the improvement of overall supply chain competences. Overall, we have shown that desorptive capacity not only improves supply chain competence (see Roldán Bravo, Ruiz-Moreno, and Lloréns Montes 2018), but that it is also a mechanism through which firms embedded in business ecosystems effectively transfer knowledge, facilitating a better integration and rapport among interdependent partners to ultimately improve supply chain competence.

With regards to the mediating effect of connective capacity, our results reveal that it does not guarantee higher supply chain competences for firms embedded in business ecosystems. Although it complements absorptive and desorptive capacity through knowledge retention (Lichtenthaler and Lichtenthaler 2009), unlike these capacities, connective capacity showed no significant mediating effect. In fact, Lichtenthaler and Lichtenthaler (2009) established that privileged access to external knowledge and the ability to reactivate it (i.e. connective capacity) do not imply that this knowledge is actually acquired and integrated. Equally, the ability to effectively manage alliances and relations can be used to externally exploit a firm's knowledge, yet connective capacity does not assume the actual transfer of knowledge to other partners. Thus, the benefits of connective capacity in business ecosystems do not translate into improved supply chain competence.

Connective capacity appears, however, to indirectly enhance supply chain competence through the advancement of absorptive and desorptive capacity. On the one hand, it eases the processes of knowledge exploration through enabling access to and management of external relations. Moreover, connective capacity reactivates knowledge in inter-firm relations (Lichtenthaler and Lichtenthaler 2009), facilitating the subsequent integration and exploitation of this knowledge through absorptive capacity. On the other hand, connective capacity provides a good understanding of market opportunities and of the reach and richness of a firm's relationships with other members (Albesher and De Coster 2012). Thus, it can ease knowledge desorption through the effective management of multiple alliances and relations to exploit knowledge. As a result, connective capacity acts as a catalyst for the other two capacities, by establishing and enhancing the linkages upon which they are built. That is, it positively impacts knowledge exploration and exploitation, which enable improved supply chain competence.

Overall, the results demonstrate that being embedded in a business ecosystem might not be sufficient. Benefitting from this embeddedness relies on enhancing absorptive and desorptive capacity, with the effects of these two knowledge capacities being boosted by connective capacity. Thus, the hierarchy amongst the three external knowledge capacities eventually enables the improvement of supply chain competence.

6. Conclusions

6.1. Research implications

This study has four main research implications. First, previous research has mainly focussed on the influence of business ecosystems on the co-production of innovation (see, e.g. Adner and Kapoor 2010; Radziwon, Bogers, and Bilberg 2017). By explaining how embeddedness in business ecosystems can enhance supply chain competence we now demonstrate that other areas of a firm can also benefit. Second, the study demonstrates that belonging to a business ecosystem might not directly create value by itself as the complex knowledge exchanges cannot be conducted using the same mechanisms as in traditional, hierarchical structures (Wulf and Butel 2017). Thus, our research contributes to the capability and resource-based theory that incorporates a stakeholder perspective (Barney 2018) by providing evidence on how to effectively utilise ecosystem knowledge to improve competences. Specifically, it demonstrates that firms should increase external knowledge capacities (i.e. absorptive, desorptive and connective capacity) to improve supply chain competence. Of the three, only absorptive and desorptive capacity were found to mediate the relationship with business ecosystem embeddedness by directly increasing supply chain competence. Therefore, our work extends the OM literature and previous research on the effects of absorptive and desorptive capacity on supply chain competence (e.g. Roldán Bravo, Ruiz-Moreno, and Lloréns Montes 2018, Roldán Bravo et al. 2020). Further, the improvement of supply chain competence might be related to considering absorptive and desorptive capacity as components of dynamic capabilities (Hu, McNamara, and McLoughlin 2015; Zahra and George 2002). This responds to Schilke, Hu, and Helfat (2018), who called for more mediation and empirical analysis to explore dynamic capabilities. Although, based on our cross-sectional study, it would be presumptuous to claim that both capacities create or transform operational capabilities (Winter 2003), the results suggest that they might contribute to doing so. This is especially relevant for desorptive capacity, which has remained understudied compared to absorptive capacity yet may be a valuable component in the development of operational competences.

Third, our results show that connective capacity is not enough to enhance supply chain competence. That is, privileged access to knowledge does not automatically mean that this knowledge will be effectively acquired or transferred. Yet, connective capacity can increase supply chain competence indirectly through the improvement of knowledge absorption and desorption. Thus, the present work indicates that there is a hierarchy among the three knowledge capacities in which connective capacity boosts the other two capacities by establishing and enhancing the linkages upon which they are built. To the best of our knowledge, this is the first study that considers the three external knowledge capacities of Lichtenthaler and Lichtenthaler (2009) together. Fourth, the study provides new conceptual measures for connective capacity and embeddedness in a business ecosystem (based on three dimensions: interdependence, value potential, and shared components). Overall, members that are more embedded in a business ecosystem find more opportunities to retain external knowledge and connect with other members. This should ease knowledge exploration and exploitation to ultimately enhance supply chain competence.

6.2. Managerial Implications

Our findings provide important implications for managers whose firms are embedded (or are looking to become embedded) in business ecosystems. Managers must be aware that being embedded in business ecosystems is not sufficient. They must understand how to leverage their access and manage the complex knowledge flows that business ecosystems entail in order to achieve greater supply chain competence. Three specific implications are outlined below.

First, we encourage managers to acquire, but also exploit knowledge, from the ecosystem. For instance, they can maintain formal/informal meetings and build trust with ecosystem partners to acquire greater and more diverse information. Equally, we encourage managers to establish clear roles and responsibilities about the tasks to be performed, create adequate internal routines to analyse, interpret, and discuss the consequences of market and technological trends, be proactive, adopt a common language, involve employees in sharing experiences, and promote joint-problem solving (Cohen and Levinthal 1990; Jansen, Van Den Bosch, and Volberda 2005) – not only internally but also with ecosystem members.

Second, although less intuitive, our results indicate that transferring knowledge externally (e.g. through patents, licences or sharing information) can be beneficial to supply chain competence. By transferring knowledge, managers can access external knowledge in return (Ziegler et al. 2013) or set up ecosystem standards, which facilitate coordination and the co-development of complex solutions (Jacobides, Cennamo, and Gawer 2018). Moreover, sharing information benefits profitability and operating efficiency, especially in global firms (as is typical of firms in business ecosystems) due to the difficulties of obtaining relevant information and responding independently to challenges in a timely manner (Myers and Cheung 2008).

Finally, managers should understand that managing business ecosystem relationships effectively does not guarantee higher supply chain competence. But it does ease knowledge inflows/outflows, which can be used to improve supply chain competence. To achieve this, managers should focus on building large portfolios of alliances where they can easily access the desired knowledge while promoting relational and alliance management capabilities to transfer it. This way they can pre-establish the paths and connections needed to acquire and share knowledge with the ecosystem.

6.3. Limitations and future research

This study has relied on cross-sectional data, limiting cause-effect relationships. A future longitudinal study would allow business ecosystems to be investigated as dynamic systems, better address endogeneity (Lu et al. 2018), and clarify the hierarchy among the three knowledge capacities, adding to the insight provided in this paper. Moreover, this could provide further understanding of the role of external knowledge capacities as components of dynamic capabilities, which is important given that our results suggest that absorptive and desorptive capacity are linked to the improvement of supply chain competence.

Although we have controlled for common method bias, data is from a single informant per organisation. Future studies could analyse information from various members of the same organisation. This, along with the development of qualitative research, would provide valuable insight into how the processes related to knowledge capacities are effectively accomplished and realised, for instance, at intra-firm or inter-firm levels. Finally, we analysed the effects of absorptive, desorptive and connective capacity separately, whereas future research could analyse whether there are complementarities amongst them.

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Appendices

Appendix 1. EFA results: component matrix with varimax rotation.

Item	Component 1	Component 2	Component 3	Component 4	Component 5	Component 6	Component 7
ECO01				0.564			
ECO02				0.857			
ECO03				0.720			
ECO04				0.622			
ECO05				0.526			
ECO06						0.695	
ECO07						0.675	
ECO08						0.704	
ECO09							0.560
ECO10							0.548
CC01			0.698				
CC02			0.779				
CC03			0.852				
CC04			0.819				
AC01					0.734		
AC02					0.677		
AC03					0.761		
AC04					0.483		
DC01		0.581					
DC02		0.610					
DC03		0.657					
DC04		0.768					
DC05		0.806					
DC06		0.801					
DC07		0.504					
SCC01	0.681						
SCC02	0.682						
SCC03	0.816						
SCC04	0.745						
SCC05	0.837						
SCC06	0.514						
SCC07	0.725						
Variance explained	29.95	12.66	7.86	4.86	4.27	3.96	3.52
Cumulative variance	29.95	42.61	50.47	55.32	59.59	63.55	67.07

Notes. Extraction method: principal component with Kaiser normalisation. Bartlett's Test of Sphericity: χ^2 is significant at $p < 0.000$, 496 df. ECO: Business Ecosystem Embeddedness; CC: Connective Capacity; AC: Absorptive capacity; DC: Desorptive Capacity; SCC: Supply Chain Competence.

Appendix 2. Common method bias (marker variable technique).

Variables	1	2	3	4	5	6
1. Business Ecosystem Embeddedness	–					
2. Connective Capacity	0.40**	–				
3. Absorptive Capacity	0.41**	0.51**	–			
4. Desorptive Capacity	0.41**	0.60**	0.65**	–		
5. Supply Chain Competence	0.14*	0.22**	0.39**	0.34**	–	
6. Marker variable (coopetition)	0.34**	0.12	0.128*	0.12	0.09	–

Notes. $N = 271$. *SD.* = standard deviation; $^{**}p < 0.01$; $^{*}p < 0.05$; two-tailed test.

Appendix 3. Non-response Bias (Harman's one-factor test).

Variables	First/early respondents	Last/late respondents	Significance values
Average Business Ecosystem Embeddedness	4.57	4.74	0.421
Average Connective Capacity	4.25	4.38	0.667
Average Absorptive Capacity	5.01	4.85	0.514
Average Desorptive Capacity	4.54	4.80	0.323
Average Supply Chain Competence	5.89	5.89	0.963
Average Ln Age	2.22	2.56	0.177
Average Ln Size	2.79	3.50	0.060
Average Scope	2.57	2.63	0.639
Average Sector	9.41	10.02	0.492

Note. t-Tests results to analyse the differences between the first and last 20% of respondents according to demographic and model variables. The results show no significant differences between early and late respondents, and thus non-response bias is not considered to be a major concern in this study.

Appendix 4. Measurement scales.

Business Ecosystem Embeddedness (newly developed scale based on the literature review of section 3.2.1 Business Ecosystem Embeddedness.)	Please indicate the degree to which each of the following situations is present in the environment where your firm conducts its business (1: Very low degree; 7: Very high degree):
Code	Items
*ECO01	We find a large number of loosely interconnected entities.
ECO02	We find a large number of entities that depend on each other for their mutual effectiveness and survival.
ECO03	We find a large number of entities that depend on each other even if they do not directly interact.
ECO04	We are part of a complex larger community that is structured as several networks of entities (e.g. networks of partners and other organisations).
ECO05	We find different networks, each of them valuable for different purposes (such as access to knowledge, resource exchanges, or for obtaining relevant information).
ECO06	We find critical and potential partners that are valuable for our business success (e.g. suppliers, distributors, outsourcing firms, technology providers, competitors, and a host of other organisations).
*ECO07	We maintain formal or informal relationships with other organisations that fall outside the traditional chain of suppliers, distributors, and customers (e.g. relationships with financing institutions, business associations, universities, research institutes, stakeholders, government agencies, incubators, or even competitors and customers when their actions and feedback affect the development of our products/services).
ECO08	We find room for potential opportunities to create new markets, technologies, or products/services that may not exist today.
ECO09	Our firm and other organisations conduct their business on a larger infrastructure or platform (i.e. clusters, services, tools, or core technologies).
ECO10	We share a similar vision with many of the organisations in our networks about the future of our business environment.
*ECO11	Our goals must sometimes be sacrificed for the greater good of our business environment.
Items ECO01 to ECO05 refer to *interdependencies*; items ECO06 to ECO08 refer to *value potential*; and items ECO09 to ECO11refer to *shared components*.	
Connective capacity (newly developed scale)	Please indicate the degree to which your firm demonstrates each of the following abilities (1: Very low degree; 7: Very high degree). Ability to:
Code	Items
CC01	Gain privileged access to external knowledge without directly acquiring or owning it (e.g. through a portfolio of alliances where knowledge is accessible).
CC02	Retain knowledge in inter-firm networks, outside organisational boundaries (i.e. through a portfolio of alliances where knowledge is available).
CC03	Acquire external knowledge retained in inter-firm networks, outside organisational boundaries (i.e., knowledge from previous alliances or portfolios of alliances that the firm can integrate at any time).
CC04	Exploit external knowledge retained in inter-firm networks, outside organisational boundaries (i.e. knowledge from previous alliances or portfolios of alliances that the firm can utilise in its business).
Absorptive Capacity (adapted from Ettlie and Pavlou 2006)	Please indicate the degree to which your firm demonstrates each of the following abilities (1: Very low degree; 7: Very high degree). Ability to:
Code	Items
AC01	Identify, value, and import external knowledge from other entities in the networks.
AC02	Adopt adequate internal routines to analyse the external knowledge from other entities in the networks.
AC03	Successfully integrate new knowledge acquired from other entities in the networks with existing knowledge.
AC04	Successfully exploit newly integrated knowledge in concrete applications (e.g. developing a product using external knowledge).
Desorptive Capacity (adapted and extended to the business ecosystem from Roldán Bravo, Ruiz Moreno, and Llorens-Montes 2016)	Please indicate the degree to which your firm demonstrates each of the following abilities (1: Very low degree; 7: Very high degree). Ability to:
Code	Items
DC01	Identify opportunities to transfer knowledge externally.
DC02	Identify own knowledge from the firm that is relevant to other entities in the networks.
DC03	Identify and select critical partners willing to acquire and exploit the firm's knowledge.
DC04	Codify and share knowledge effectively with different members in the networks.
DC05	Organise effectively the transfer of knowledge to different members in the networks.
DC06	Support the process of knowledge transfer to the different members in the networks.
DC07	Exploit knowledge externally to appropriate returns from innovation (i.e. through patents or licences).
Supply Chain Competence (adapted from Chow et al. 2008)	Please indicate the degree to which your firm is able to perform the following actions in response to unforeseen circumstances and/or unpredicted and changing market conditions in a timely manner (1: Disagree completely; 7: Agree completely):
Code	Items
SCC01	Respond to requests in a timely manner.
*SCC02	Forecast/predict sales with greater accuracy and increasing precision each time.
SCC03	Fill orders with improved accuracy.
SCC04	Make/(provide) high-quality products/(services).
SCC05	Respond to the needs of key customers effectively.
SCC06	Work with key suppliers effectively.
*SCC07	Issue advanced notice on shipping delays effectively.

Note. *Removed items.