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Managing open innovation within supply networks in mature industries

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Abstract

Purpose – The purpose of this paper is to investigate how focal firms in supply networks manage weak and strong ties for exploration and exploitation innovation in mature industries. In doing so, the paper extends the understanding of how focal firms manage open innovation (OI).

Design/methodology/approach – The empirical base is a multiple case study conducted on three companies operating in mature industries in Europe.

Findings – Findings of this study reveal, analyze and explain a diverse set of OI practices in the supply networks of mature industries in which the focal firms integrate strong and weak supply ties to enhance innovation outcomes. This study provides a fine-grained view of the benefits of the additive and interactive effects of strong and weak ties in OI. More specifically, the analysis reveals an enhancing role of strong supply ties in exploration, which previously was associated solely with weak ties. Moreover, this study sheds light on the dominant and orchestrating roles of focal firms.

Practical implications – The findings provide insights to enhance OI practices beyond the limited role of the weak ties of the supply network and highlight the essential role of the strong supply ties in mature industries.

Originality/value – While previous studies have associated exploration with weak ties, findings of this study reveal that exploration-oriented activities in mature industries also extend to strong ties. In the strong ties of mature industries, this study finds there is not only the exploitation of existing knowledge but also the reconfiguration and innovation of products.

Keywords Open innovation, Supply network, Strong ties, Weak ties, Mature industries, Exploration
Paper type Research paper

1. Introduction

In recent decades, to deal with the pressures of a highly competitive environment and short life cycle, companies have been opening up their innovation process by involving external

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partners and searching for new ideas and knowledge (Chesbrough and Crowther, 2006; Emden *et al.*, 2006). In this process, suppliers are recognized as a cornerstone of the open innovation (OI) approach (Pittaway *et al.*, 2004). Supplier involvement in developing new products often includes long-term buyer–supplier relationships, which enhance quality, lower costs and shorten the time to enter the market (Dyer and Nobeoka, 2000). In addition, supply networks provide access to ideas, knowledge and other resources that the focal firm can leverage (Wilhelm and Dolfsma, 2018). Within the supply network, focal firms establish varied inter-organizational supply relationships depending on the duration of interaction and the frequency and intensity of collaboration. According to social capital theory, these types of relationships can be coded as strong or weak ties (Granovetter, 1973). Since the resources and capabilities of strong and weak ties are different, focal firms set up networks of strong and weak supply ties to explore and exploit a wide range of innovation opportunities (Dittrich and Duysters, 2007).

Supply networks are complex systems with a number of direct supply ties and several tier levels, i.e. suppliers of suppliers (Lu and Shang, 2017; Sharma *et al.*, 2020). Several scholars advocate an analysis of entire supply networks (Kim and Narasimhan, 2019). In other words, considering only specific suppliers limits our understanding of innovation practices and management. In a similar vein, previous studies have reported the benefits of direct and relational embeddedness mainly for exploitation and incremental innovation (Kim *et al.*, 2020), such as process innovation (Freel and Harrison, 2006; Tomlinson and Fai, 2016). However, few studies explore in-depth the pivotal role of strong supply ties in OI; and the interactive effects of strong supply ties in absorbing and integrating new knowledge and resources in inbound OI (Zhu *et al.*, 2017). While existing studies provide significant insights, they are limited in managing supply networks for exploration and exploitation and, most importantly, the role of strong ties in OI in mature industries.

Whereas the value of supply networks is widely recognized in enhancing innovation, in previous literature, the strong ties are restricted to exploitation and closed innovation and weak ties to exploration and OI (Gobbo and Olsson, 2010). For instance, as noted by Michelfelder and Kratzer (2013): "*A 'semi-open organization' provides the benefits of weak ties and opportunities for open innovation, but at the same time it provides the benefits of strong ties, trust, and IP regulation, imitating elements of traditional closed organizations*" (Michelfelder and Kratzer, 2013, p. 1173). Therefore, we aim to contribute to previous literature by showing that exploration and OI also extend to the strong ties of the supply network.

The literature on knowledge management highlights the challenges in simultaneously cooperating with different inter-organizational relationships (Agostini *et al.*, 2020) and can provide effective and innovative solutions (Michelfelder and Kratzer, 2013). However, this is especially limiting for mature industries that are mainly based on strong supply ties, as these companies show less flexibility in changing their innovation approach (Chiaroni *et al.*, 2011). Along these lines, we aim to provide an answer to the following research question: "*How do focal firms in mature industries manage OI practices within the entire spectrum of inter-organizational supply networks (i.e. strong and weak ties)?*"

This is a relevant question, especially for firms in mature industries managing complex and multi-tier structures. These firms are increasingly relying on their supply networks to innovate and address changes in customer demands and technology. Moreover, mature industries and their strong ties are the largest contributors to the manufacturing sector in terms of revenues and employment, so exploring the role of OI in those ties is critical.

A multiple case study of three large companies in mature industries was employed to answer the research question. The structure of this paper is as follows. In Section 2, we present the extant literature on OI and network theory. Sections 3 and 4, we describe the research methodology and findings of the case studies. In Section 5, the paper ends with a discussion that positions our paper's unique niche in the literature and draws conclusions.

2. Theoretical background

2.1 Open innovation and suppliers: exploration and exploitation

In a rapidly changing environment and with the increasing cost of innovation, recent literature has highlighted the importance of knowledge exchange and collaboration with external actors (Galati and Bigliardi, 2017) to access new knowledge and technology (Bigliardi and Galati, 2013). Companies with a tendency to search for external sources and knowledge seem to sustain their competitiveness over time (Chesbrough *et al.*, 2006). As an innovation management model, OI allows firms to access external knowledge sources by establishing relationships with external actors (Chesbrough, 2003). This concept was coined by Chesbrough (2003, p. xxiv) as "*a paradigm that assumes that companies can and should use external ideas as well as internal ideas, and internal and external paths to market, as companies look to advance their technology*." On the inbound side of OI, the focus is mainly on the inflow and exploration from external actors, while on the outbound side, the focus is mainly on the outflow and exploitation. Exploration is the search for new knowledge, use of unfamiliar technologies and the creation of products with as yet unquantified demand, while exploitation is the use and refinement of existing knowledge, technologies and products and has more certain and proximate benefits (Greve, 2007; March, 1991).

The adoption of OI and its outcomes depend on a broad range of factors, such as the type and characteristics of actors, and the industrial context (see, for example, Zacharias *et al.*, 2020). Open approaches to innovation can involve diverse external actors along the value chain, including suppliers (Emden *et al.*, 2006). Although suppliers' involvement in the innovation process is not a new phenomenon, the focus has mainly been on long-term buyer–supplier relationships (Dyer and Nobeoka, 2000). Because more companies have opened up their innovation process and involved suppliers (Emden *et al.*, 2006; Dittrich and Duysters, 2007; Di Minin *et al.*, 2010; Agostini and Caviggioli, 2015), firms now establish different inter-organizational relationships with external actors. These firms are involved in the innovation process to access and acquire knowledge through innovation networks (Pullen *et al.*, 2012; Kim and Choi, 2018). These inter-organizational relationships can be long- or short-term (Galati and Bigliardi, 2019). Dittrich and Duysters (2007) show the proactive role of suppliers in innovation collaboration at Nokia, where the buyer–supplier relationship is much more complex than merely outsourcing or subcontracting. A review of OI practices in Europe revealed the proclivity of firms to engage suppliers in OI strategy, which suggests there is a positive role played by suppliers in innovation performance (Greco *et al.*, 2015). While the OI concept is widely explored and validated in high-tech industries (Parida *et al.*, 2012), previous studies provide evidence that the concept is also adopted in traditional and mature industries (Chesbrough and Crowther, 2006; Chiaroni *et al.*, 2011). However, the focus has mainly been on the automotive industry as an example of a mature industry (Ciravegna and Maielli, 2011; Lazzarotti *et al.*, 2013; Agostini and Caviggioli, 2015; Aversa *et al.*, 2015; Wilhelm and Dolfsma, 2018). Di Minin *et al.* (2010) provide evidence that Fiat – an Italian automaker – adopted an OI strategy during economic difficulties in order to sustain its technological base and continue to function as a value-added enterprise.

2.2 Network theory and open innovation: strong and weak ties

Previous studies have adopted the social network theory as a framework to explain the relevance of inter-organizational relationships in enhancing knowledge generation. For example, Granovetter (1973) analyzes the diverse dynamics characterizing strong and weak ties, in which the strength of a tie is defined based on the duration of interaction and the frequency and intensity of collaboration. Strong ties are characterized by trusting relationships and repetitive, intensive and frequent inter-organizational interactions. Weak ties are characterized by low commitment levels and infrequent interactions. Different inter-organizational relationships impact the social capital the network can use for innovation, where social capital is "the sum of the actual and potential resources embedded within, available through, and derived from the

network of relationships possessed by an individual or social unit" (Nahapiet and Ghoshal, 1998, p. 243). In the literature, there are two main streams analyzing how networks can enhance knowledge generation: relational embeddedness and structural embeddedness.

Relational embeddedness focuses on the quality of relationships and highlights that trust and developing knowledge routines make actors more willing to share knowledge (Coleman, 1988). In Coleman's (1988) view, close interactions among strong ties generate reciprocal exchanges in which partners are willing to cooperate and share knowledge. Those with strong ties trust each other and are more willing to share knowledge (Nahapiet and Ghoshal, 1998). Frequent and close interactions encourage and develop mutual trust and openness and create knowledge routines for knowledge transfer (Powell *et al.*, 1996; Lee and Cavusgil, 2006; McEvily and Zaheer, 2006). Developed knowledge routines in strong ties facilitate the exchange of fine-grained knowledge (Uzzi, 1997) and accelerate new product development. Zhao and Lavin (2012) emphasize that complex knowledge needs strong ties to be exchanged. Strong ties allow firms to understand their partners' competencies (Rindfleisch and Moorman, 2001). Some scholars point out the effectiveness of strong ties in exploiting existing technological capabilities (Rowley *et al.*, 2000; Dittrich and Duysters, 2007) and enhancing the innovation performance of the focal company (Fritsch and Kauffeld-Monz, 2010). The positive impact of long-lasting, repeated and intimate relationships facilitates joint problem-solving arrangements (Uzzi, 1997) and interactive learning processes among participating companies (Powell *et al.*, 1996; Inkpen and Tsang, 2005).

Structural embeddedness emphasizes the underlying architecture of relationships and focuses on external ties to access new knowledge (Burt, 1992). The structure of relationships and their quality affect the knowledge exchange among actors (Inkpen and Tsang, 2005) and a firm's performance. Aligned with Burt's (1992) view, the traditional approach is that the negative outcome of strong ties manifests itself over time in not being able to produce new knowledge (Lowik *et al.*, 2012). Moreover, strong ties may blind companies to new opportunities by creating redundant information and resources (Gilsing and Duysters, 2008) and reducing the exploratory capability of the focal company (Lew *et al.*, 2013). In Burt's (1992) view, weak ties provide great social capital benefits and allow firms to access non-redundant knowledge. In his approach, the structure of relationships plays an important role, and new opportunities can be created through accessing external ties. However, Bengtsson *et al.* (2015) demonstrate that connectivity with too many weak ties has a negative effect on innovation. Moreover, weak ties' lack of mutual trust may inhibit firms from sharing and exchanging knowledge (Inkpen and Tsang, 2005). This is especially significant in mature industries where a great deal of innovation is generated in supply networks outside of a leading firm and therefore qualifies as OI (Gurca *et al.*, 2021). In fact, in those mature industries (e.g. the automobile industry), some of the suppliers are world leaders in their fields, are suppliers for other high performing global companies and have themselves an extended international supply network of strong and weak ties that is a fertile ground for innovation (Aversa *et al.*, 2015). In those industries, strong ties with the leading innovation capabilities become its enabler driver, far from being an obstacle to OI (Obradović *et al.*, 2021).

2.3 Focal firms integrating strong and weak ties: additive effects and interactive effects

Both relational and structural embeddedness suggest that, in order to support innovation, companies should build diverse network structures and follow different – often opposite – practices. Hence, a third research stream has emerged, offering a lens to address this contrast. Building on the relational and structural embeddedness views, this research stream highlights the importance of both strong and weak ties in creating innovation. In particular, Michelfelder and Kratzer (2013) identified two effects associated with the integration of strong and weak ties: (1) additive effect, referring to the distinctive

but complementary benefits of both strong and weak ties, and (2) interactive effect, referring to synergies between strong and weak ties.

Regarding the additive effect, previous studies suggest that strong and weak ties provide different advantages. For example, Rowley *et al.* (2000) studied the influence of strong and weak ties on focal firms' performance across varied business environments. They found that strong ties support exploitation when uncertainty is low, while weak ties positively influence exploration when uncertainty is high. Capaldo (2007) attributes this distinct but complementary effect to a dual network structure. Similarly, given that resources and capabilities of strong and weak ties are different (Granovetter, 1973), Dittrich and Duysters (2007) emphasize that focal firms set up strong supply ties for the implementation and exploitation phases and weak supply ties for exploration. In other words, different types of partner can be beneficial for different knowledge content, i.e. exploration or exploitation (Bengtsson *et al.*, 2015; Arranz *et al.*, 2020), and different innovation, i.e. incremental or radical (Hemphälä and Magnusson, 2012; Terhorst *et al.*, 2018; Jugend *et al.*, 2018).

As for the interactive effect, scholars suggest possible synergies generated from combining strong and weak ties. Numerous studies posit that focal firms rely on strong ties to realize and exploit the knowledge acquired from weak ties (Tiwana, 2008). Thus, the influence of strong ties on innovation performance can be leveraged when integrated with weak ties (Rost, 2011) because strong ties facilitate a tacit exchange of knowledge. Weak ties might also influence the innovation activities of strong ties as the knowledge provided by weak ties might refine the outcomes of R&D projects of strong ties (Michelfelder and Kratzer, 2013). Thus, the integration of weak and strong ties provides different benefits and could also generate synergies between those ties.

Although the extant literature explains how focal firms use their strong and weak ties to access knowledge, establishing and managing those ties is still challenging (Lokshin *et al.*, 2011). One challenge for the innovation network is related to the risks of "redundancy" and "overload" of strong and weak ties, respectively (Mariotti and Delbridge, 2012). This challenge can be exacerbated when focal firms need to interact simultaneously and cooperate with different inter-organizational relationships (Sarala *et al.*, 2019), implying the need to shift the research focus from one type of inter-organizational relationship to multi inter-organizational relationships (Agostini *et al.*, 2020). In line with previous literature (Randhawa *et al.*, 2016), we aim to shed light on OI practices of inter-organizational supply relationships (i.e. strong vs weak ties). The most recent literature provides evidence of OI with strong ties in mature industries (Aversa *et al.*, 2015; Gurca *et al.*, 2021; Obradović *et al.*, 2021). However, the overall dynamics of how focal firms integrate strong and weak ties are still missing. Therefore, this paper has a twofold aim: first, to investigate how focal firms cooperate and involve both strong and weak supply ties to enhance OI (Granovetter, 1973; Burt, 1992; Gilsing and Duysters, 2008); second, to explore the benefits from the additive and interactive effects of strong and weak supply ties in OI.

3. Research methodology

3.1 Research design

To answer the research question, we employed a multiple case study methodology. The case study approach provides a tool to study a contemporary phenomenon in depth (Yin, 2014) and pursues a replication logic by collecting fine-grained data (Eisenhardt and Graebner, 2007).

We adopted purposive sampling (Eisenhardt, 1989) considering two criteria: (1) each case was required to adopt an OI approach; (2) each case had to develop at least one OI practice involving strong and weak supply ties. The sampling criteria allowed us to identify replicable cases (Stake, 2013). Because the research question is about supply networks in mature

industries, we selected three European firms from different mature industrial sectors that rely heavily on their established suppliers. Although the business growth rate is slower than in high-tech industries, the three firms have adopted an OI approach since 2014–2015 to enhance their innovation capabilities. Given that the OI approach between large companies and small- and medium-sized enterprises is different (Usman *et al.*, 2018), we focused solely on large companies in the research design. Moreover, all three cases have their headquarters and R&D departments in Europe, which enabled us to investigate related strategies and approaches to OI by interviewing involved managers directly.

The three selected companies are reported in Table 1, where real names have been anonymized for confidentiality reasons. More details on the data collection can be found in Table A1.

3.2 Data collection and analysis

Given that organizations are socially embedded, the semi-structured interview was used as the main source of data collection to obtain information from those informants experiencing the OI phenomenon (Gioia *et al.*, 2013, p. 16) and explain and discuss OI practices. However, to ensure construct validity in the current case study, a clear case study protocol was designed.

The research protocol and interview guidelines include the definitions of weak and strong ties, and the interviews have been structured within two sections containing questions about both strong and weak ties. During the interviews, we asked informants to determine their tie strength. This allowed us to distinguish OI practices within strong and weak ties. We then cross-checked the identified tie strength following Granovetter (1973), Capaldo (2007) and Lowik *et al.* (2012). In particular, we asked informants to provide more precise information on suppliers in terms of the relationship's overall duration (less than five years, more than five years), the frequency of collaboration (total number of contacts within a year) and the intensity of collaboration (total number of agreements per year).

Having access to documentation and extensive archives enabled us to triangulate data, increase the reliability of those data (Jick, 1979) and validate the information from various sources. To avoid bias, interviews were conducted with individuals who had responsibility for the OI approach of the companies (Eisenhardt and Graebner, 2007) and were from different functional areas and geographical locations and at different hierarchical levels. The interviews were carried out with practitioners in senior positions who provided a managerial perspective to study the phenomena in a specific context (Gibbert *et al.*, 2008). The interviews, which two researchers undertook, took place between June 2015 and February 2016 (nine

Company	Industry	Background*	Open innovation adoption
Home-APLNC	Consumer Product Manufacturing	>50,000 employees >12 billion revenue in euros	Established a separate OI department, which collaborates closely with R&D and Purchasing departments
Offshore Comp	Transportation	>20,000 employees >4 billion revenue in euros	Not a separate department, works under Research and Innovation department
Energy Comp	Energy and Environmental	>60,000 employees >75 billion revenue in euros	Not a separate department, works under Research and Sustainability department

Note(s): *Collected from "Selected consolidated financial data 2016"

Table 1.
Firms' profiles

months). Any additional data, along with the interviews, was documented as a source of evidence and then analyzed. The duration of each interview ranged from 40 to 90 min and was openly recorded, then transcribed – in total, 185 pages. We followed an iterative process of cycling among theoretical constructs, data and literature to refine our propositions, relate them to existing theories and clarify our contributions. We stopped collecting data when we reached the analytical generalization we provided and when additional data did not add to our theoretical framework.

In our inductive multiple case study, we first developed a narrative description of each case separately. Table A2 presents a brief description of each case. Then, we conducted cross-case comparisons by comparing OI approaches, supply networks, innovation goals and output across the cases. In the second stage of analysis, we coded OI practices into two overarching themes based on the type of supplier relationships: strong and weak ties. By comparing similarities and differences among OI practices, we identified two main patterns involving strong and weak ties: (1) additive effects and (2) interactive effects. Next, OI practices were coded based on innovation orientation, i.e. exploration and exploitation, and the role of the focal firms in coordination interactions. Constant comparison between the emerging codes and themes from the current literature allowed us to identify emerging patterns in the data (Glaser, 2005, p. 105). Then the codes were grouped and discussed by the authors before undertaking further analysis and development. Evidence on OI practices and codes can be found in quotations from the interviews, as reported in Table 2.

Analysis of the cross-case study will be described in detail in Section 4.

4. Results

We identify different OI practices across the cases (Table 3). From the analysis of OI practices, two patterns have been identified in which focal firms have leveraged their strong and weak ties to enhance innovation capabilities: (1) additive effects and (2) interactive effects. Although informants across all cases highlighted the importance of strong and weak supply ties, there are some differences among the three cases. Table A3 presents innovation goals and outputs, innovation context, OI approaches, supply networks and the role of the focal firm in supply networks across the cases.

4.1 OI practices with additive effects

First, we discuss the additive effects and explain how focal firms leverage supply networks to gain access to distinct capability and knowledge from both types of ties (i.e. strong and weak).

4.1.1 Strong supply ties. 4.1.1.1 Adding strong ties for exploitation. It quickly became evident that the firms tend to establish new strategic partnerships with suppliers. Establishing partnerships along the supply chain enables the focal firms to access knowledge embedded within the existing supply networks. Such knowledge is useful to improve the quality of products, reduce time to market and enhance efficiency in production processes. Having an OI mindset, the firms have realized the value of knowledge gained through first-tier suppliers, i.e. direct suppliers, and the value of knowledge embedded within the entire supply network. By establishing relationships with second- and lower-tier suppliers (e.g. sub-suppliers), the firms can gain access to tacit and embedded knowledge in a shorter time. For instance, Offshore Comp involves its first supply tier as well as other supplier tiers directly in innovation processes:

> We identify the suppliers of our suppliers, or suppliers operating in other industrial sectors that can be potential partners to implement their solutions in our industry – as stated by the R&D Analyst.

In this way, the boundaries between the focal firms and their suppliers and the boundaries between the focal firms and the suppliers of their suppliers have blurred. This allows the focal

OI practices	Concepts and sample quotes
Additive effects	
Strong supply ties Adding strong ties for exploitation	• Searching and evaluating potential strategic suppliers "*Non-established suppliers, they can be new strategic suppliers or new suppliers, because our purchasing organization used to be in touch with some companies that today are not our suppliers but anyway we are already working together in some technology challenges*." – a manager of Home-APLNC • Involving sub-suppliers (tier 2, tier 3, etc.) "*. . . mainly we discover that many large suppliers are sub suppliers of our suppliers and now we are trying to involve them directly with us*." – Head of Research and Innovation of Offshore Comp
Collaborating with strong ties for exploration	• Innovation collaboration with the existing suppliers "*We ask them actively to come up with new ideas and we suggest that if the idea has consumer benefits maybe we can create a partnership and launch that new idea first*." – a director of Home-APLNC • Joint development projects with existing suppliers *"Mainly our suppliers are big multinational companies with reliable and technological solutions in their portfolio. Thus, the opportunity to start a new project any time is so high . . . the mutual trust can help in interaction on a daily basis." – a manager of Home-APLNC* *"Supplier plays a strategic and decisive role in creating and maximizing value, and we want [them] involved from the moment of need, listening to [their] proposals and developing innovative approaches together."* – Website of Energy Comp
Weak supply ties Adding weak ties for exploration	• Outsourcing problem solving across globe and industries *"Through platforms, we identify new business opportunities . . . we request for ideas responding to a specific need for the current business . . . Each idea is evaluated with reference to the opportunities for consumers, business opportunities and potential partnership model"*. – a manager of Home-APLNC "*We also invite a certain number of suppliers even if they are not directly related to the domain issue being addressed and they help us to solve the problem. For example, we have a power plant and we have some issues in some parts, and we call on suppliers that are not necessarily from the power plant field, but they have some technology or services which can be connected to that, such as chemicals. And we ask them to come up with some solutions regarding those topics*." – a manager of Energy Comp • Co-develop solutions "We *have an OI team that is established. It helps a lot to get fresh ideas from new potential suppliers, a lot of workshops on new areas and also for suppliers. We did more, and we are now more open*." – a director of Home-APLNC "*We are looking for [suppliers] eager to work with [us] . . . to co-develop solutions . . .. The [suppliers] collaborate with us to develop a minimum viable product [suppliers] work closely with our . . . experts."* – Website of Home-APLNC • Technology scouting to innovate business models "*Experts with a diverse knowledge and business background may be invited for a round table meeting and are asked for new solutions. The aim of this approach is mainly for new business*." – a manager of Energy Comp "[we] request for ideas to respond to the opening of [our company] to new businesses" – a manager of Home-APLNC • Collaboration with (new) smaller suppliers "*. . . small suppliers or potential suppliers, they come with completely new ideas . . . what suppliers offer you which is new, maybe from other industries, then it is much easier to talk with small suppliers and new ones*." – a manager of Home-APLNC

(*continued*)

Table 2.
Codes and sample quotes

OI practices	Concepts and sample quotes
Interactive effects of strong and weak ties	
Promoting OI for exploration	• Spreading OI culture within the supply network "*Diversity is in open innovation, in term of typologies and DNAs and day to day activities, technology, culture. So, the opportunity we have is to expose suppliers to diversity. To really make them touch and feel open innovation opportunities. This workshop is one of the methodologies, not the only one. And we are having important results.*" – a manager of Home-APLNC • Supporting suppliers to implement OI "*we used to support other companies to implement open innovation, we usually do it for free. Then we start we do the same with our suppliers. If we are supporting other companies, we first should support our suppliers.*" – a manager of Home-APLNC
Collaborating with strong ties for exploitation	• A general OI attitude in both strong and weak ties "*We cannot have a closed door, we should have our doors open to bring the new idea in, the question is how we are using that knowledge, and whether we are able to see that opportunity.*" – a director of Home-APLNC • Developing new ideas based on knowledge from strong ties *"[Our aim is] to accompany [small suppliers] operating in key sectors, with dedicated services offered by our [strategic suppliers]"* – Website of Energy Comp- General Manager "*Involving [strong ties] suppliers in our innovation strategy results in increasing our innovation performance and creating values for the whole innovation project.*" – a manager from Offshore Comp
Connecting ties for exploitation	• Acting as an intermediary between suppliers "*We take them [suppliers] to a technology road day to make them be recognized for what they are offering. Technology road day is willing to offer products and technology to other stakeholders.*" – a manager of Home-APLNC • Supporting industry-wide technologies "*So, in two examples of innovations, in one the supplier has a capability and we work to adopt technology in our products, and the other is to encourage suppliers to develop something that is not just for them to benefit from it but also others, industry. Because the investment costs a lot for them, if we do not do that they cannot benefit from economies of scale in the long-term.*" – a director of Home-APLNC *"We work with suppliers to develop a particular part of the component, not just purely for us but also industry-wide." – a manager of Home-APLNC*
Connecting ties for exploration	• Sponsoring joint R&D projects within the network *"The company involves different suppliers in order to co-create knowledge, even with competitors.*" – a manager from Offshore Comp • Sponsoring an open supply network "We facilitate knowledge flow and interaction." – a manager of Home-APLNC

Table 2.

firms to adopt existing technological innovation quickly. In other words, when a firm needs specific knowledge, it can access this through its supply network without spending time developing it internally. Thus adding strong ties for exploitation with suppliers speeds up the innovation cycle.

In this OI practice, the focal firms initiated the innovation projects through strong ties. Often, the focal firms determine the scope of projects (e.g. formulate the problem in the production process), then potential suppliers present their solutions to the focal firms. At this stage, the focal firms scan, evaluate and select the best potential supplier, along the supply tiers, which will be in charge of developing innovative solutions/components addressing issues and challenges related to the supply chain. In this way, the firms can reuse the suppliers' current knowledge to improve the effectiveness of processes and activities along the supply chain. Therefore, the OI practices extend to the strong ties of the supply network by adding new strong ties in the supply network as needed.

4.1.1.2 Collaborating with strong ties for exploration. Our findings show that the focal firms leverage strong ties through collaborative innovation with strong supply ties. Therefore, we labelled this OI practice as "*Collaborating with strong ties for exploration*."

Table 3. OI practices across the cases

OI practices	Description of OI practices	Supplier tie	Micro-practices	Innovation orientation	Role of the focal firm	Evidence from cases*
Additive effects						
• Adding strong ties for exploitation	Establishing partnerships along the supply chain to exploit existing knowledge embedded within supply networks	Strong	Searching and evaluating potential strategic suppliers and involving sub-suppliers	Exploitation	Dominant role	O, H and E
• Collaborating with strong ties for exploration	Promoting and being open to new ideas coming from strategic partners	Strong	Innovation collaboration and joint development projects (by designing incentives programs)	Exploration	Dominant role	O and H
• Adding weak ties for exploration	Connecting to weak supply ties to access diverse sets of technology solutions and knowledge	Weak	Outsourcing problem solving, co-develop solutions, technology scouting, collaboration with (new) smaller suppliers (through workshops, round table meetings, incentives or rewarding programs for suppliers)	Exploration	Dominant role	O, H, and E
Interactive effects						
• Promoting OI for exploration	Encouraging and supporting strong supply ties to practice the OI model	Both	increasing awareness (by OI seminars and events)	Exploration	Orchestrating role	H and E

(*continued*)

Table 3.

OI practices	Description of OI practices	Supplier tie	Micro-practices	Innovation orientation	Role of the focal firm	Evidence from cases*
• Collaborating with strong ties for exploitation	Involving both strong ties and weak ties in innovation	Both	Having an open doors attitude evaluate new ideas coming from all sides	Exploitation	Dominant role	O and H
• Connecting ties for exploitation	Facilitating knowledge exchange between strong and weak ties to enhance exploitation	Both	Acting as an intermediary between suppliers and supporting industry-wide technologies	Exploitation	Orchestrating role	H
• Connecting ties for exploration	Facilitating knowledge exchange between strong and weak ties to enhance exploration	Both	Sponsoring joint R&D projects within the network and sponsoring an open supply network	Exploration	Orchestrating role	O, H and E

Note(s): *O: Offshore Comp, H: Home-APLNC, E: Energy Comp

Furthermore, as the innovation capability of the focal firms heavily relies on their strong supply ties, the collaboration with strong ties allows firms to develop new products or reconfigure business processes.

As a manager of Home-APLNC stated:

> We have from our purchasing department an innovation day: one day with face-to-face discussions with suppliers. We usually sit down with one single supplier and we touch on strategy and gaps, and what we can do to address them. When we see an opportunity for a project or innovation, we invite some suppliers and introduce them to new business opportunities and show them what the next projects are and define how we are working on them on an operational basis.

This quote demonstrates that frequency of communication and cooperation with strong ties increase the opportunity to create innovation and expand the scope of R&D projects (e.g. from component development to adopting new technological solutions). As respondents repeatedly underscored, one reason is that some strong supply ties continuously develop their resources and capabilities and OI practices extend to the existing strong ties of the supply network.

By adopting OI, the focal firms seek innovation initiatives proposed by the strong supply ties. Unlike the previous practice, the scope of projects (e.g. formulating the problem) is not well defined by the focal firms; indeed, the suppliers themselves, to some extent, were autonomous in initiating innovation projects. At the same time, the focal firms direct and lead innovation efforts. Supplier programs with incentives were designed to encourage strong suppliers to take the initiative; such innovation initiatives range from improving existing products and services to implementing technological solutions.

4.1.2 Weak supply ties. 4.1.2.1 Adding weak ties for exploration. Respondents emphasized that establishing relationships with weak ties enables firms to tap into new knowledge and technologies across industrial sectors and/or geographical zones (*Adding weak ties for exploration*). For instance, Energy Comp has initiated collaborative innovation with its Chinese suppliers. Energy Comp's Head of OI Culture further stated:

> In the past, if we were working on topic X, we involved suppliers in topic X. But now we are involving suppliers from Y and Z areas also.

To broaden the pooled knowledge, the firms have arranged a series of meetings, round tables and workshops to interact with and identify potential suppliers. For example, Home-APLNC and Energy Comp have mainly developed digital platforms to outsource problem-solving where suppliers can register and post their solutions to problems defined by the focal firms; moreover, both companies have invested in Innovation Hubs where suppliers can experiment, test and iteratively develop and refine their ideas.

Weak ties allow the focal firms to share innovation costs and risks, and access to diverse ideas and knowledge can lead to new opportunities. Accessing such knowledge sources can enable the focal firms to develop new products, services and manufacturing processes. For instance, Home-APLNC described a project to apply touch technology in home appliances. The idea was generated and proposed by a supplier from the Information Technology sector. Home-APLNC then decided to co-develop the innovation project with the supplier to simplify and improve the interaction between the end-user and the appliances.

Similarly, Offshore Comp systematically seeks to identify and collaborate with suppliers from other industries and looks for "novel" knowledge, i.e. not previously used in the marine industry. An example of Energy Comp's successful projects is the implementation of wireless technology to reduce costs in building energy plants. When a potential supplier introduced its technology, Energy Comp offered the supplier a contract to co-develop and share risks related to the innovation activities and thus incentivize collaboration.

Beyond developing new products and/or processes, firms also seek to innovate and streamline their business models through technology scouting. The informants revealed that collaboration and knowledge exchange with weak ties enable them to realize new business opportunities and potential business models. Illustrating this approach, one manager from Energy Comp explained: "*. . . we are experimenting with a new business model, and there is nobody out there to work on that business model. But we found a small supplier . . ., and they are doing something that we are interested in. They are not established suppliers as they are just a start-up. So, with them we are developing a new business model. It is a particular way of scouting for new technology*." The respondents emphasized that developing new business models enables them to sustain their competitiveness.

What became evident from the findings was that the respondents had experienced the ease of collaboration with small suppliers in co-creation, as small suppliers were found to be more flexible. For this reason, all cases connect with small suppliers in supply networks to tap into heterogeneous pools of knowledge. As one of Home-APLNC's managers points out: "*. . . small suppliers come to us with completely new ideas*." Conversely, large suppliers are often powerful actors seeking to possess and leverage intellectual property (IP), consequently influencing knowledge flow by imposing their conditions and terms on the IP. The three firms aim to build a win-win situation and provide their suppliers with the opportunity to experiment with new solutions and share the risks.

All three cases reported using incentives or reward programs such as competitions for suppliers, which allow suppliers, especially the small ones, to participate and share their business ideas and technology not only for product and service innovation but also related to business model innovation. In this OI practice, the focal firms play the main decision-making role in formulating problems, setting priorities, evaluating and selecting business ideas and technological solutions and leading joint innovation projects.

4.2 OI practices with interactive effects

Four interactive effects and synergies between strong and weak ties were found:

4.2.1 Collaborating with strong ties for exploitation. The firms pointed out that although weak ties bring new knowledge and technology, they need the support of strong ties to create innovative strategies. We have labelled this "*Collaborating with strong ties for exploitation*," as the focal firms combine the tacit knowledge of strong ties with new knowledge acquired from weak ties to realize innovation. The existence of knowledge routines and mutual understanding with strong ties paves the way for knowledge integration within existing product design. Such knowledge routines allow the focal firms to realize the opportunities derived from newly acquired knowledge from weak ties. The firms rely on the resources and skills of strong supply ties to transfer innovative ideas into tangible products or services. In other words, the focal firms aim to exploit newly acquired knowledge from weak ties with the support of their strong ties. When considering suppliers in OI, a manager of Home-APLNC said:

> If I get in touch with a start-up, I will need the support of my suppliers in order to support and implement this innovative solution. We need the synergy. So suppliers are part of the open innovation journey in the everyday challenges of innovation.

In such OI practice, the focal firms determine when and how to involve strong ties in the projects; moreover, they manage the interactions between strong and weak ties and play the gatekeeper role. In other words, they supervise the innovation projects and control knowledge exchange between strong and weak ties.

4.2.2 Promoting OI for exploration. The findings underscore that the focal firms have implemented OI and lead and support their strong supply ties to exploit the OI model. For example, by holding innovation seminars and events, the firms aim to raise awareness of OI within their supply networks. These seminars provide opportunities for strong supply ties to

recognize external knowledge sources (e.g. new technologies and digital solutions). We have labelled this "*Promoting OI for exploration*," as a focal firm enhances its innovation capability by encouraging strong ties to add weak ties to their networks. By adopting OI, strong ties can also search for and benefit from external knowledge resources and experimental (sometimes risky) ideas. This, in turn, enhances the innovation capability of the focal firms. According to the managers, the more innovative suppliers are, the more beneficial it is for the cases regarding the availability of more innovative solutions.

> We hold webinars and show them models and practical ways to implement open innovation. More than 100 suppliers have been trained .... of course, we expect that they also utilize the open innovation process in their company. Suppliers can deploy an open innovation approach like ours to improve processed, production and achieve cost reductions. There are clear advantages for them, and consequently for us as their customers – a manager of Home-APLNC.

By promoting OI for exploration, for instance, Energy Comp reduces the time to market and thus places itself in a strategic position which ensures reaping the benefits from being first into the market. In this OI practice, strong ties add weak ties to their portfolio, and the focal firms indirectly benefit from knowledge provided by the weak ties. Here, the focal firms' role is merely to create an environment where strong supply ties could implement and realize the benefits of OI by specifying the benefits and challenges of OI and introducing best practices of OI across different industries. In other words, the focal firms do not control knowledge exchange among actors or direct innovation projects.

4.2.3 Connecting ties for exploitation. A pattern emerged from the data showing that the integration of strong and weak ties also provides advantages for suppliers (both strong and weak ties) embedded in such networks. This pattern was labelled "*Connecting ties for exploitation*" as an emerging role of the focal firm in facilitating knowledge exchange between strong and weak ties to generate common knowledge around new technological trends and adopting new innovative solutions. In this way, the innovative capability of suppliers (both strong and weak ties) is enhanced through exploiting a diverse set of (existing) technological solutions, especially digital-enabled solutions.

> We work with suppliers to develop a particular part of the component, not purely for us but also industry-wide – a manager of Home-APLNC.

This quote describes a situation in which the focal firm, given its position in the network, mediates the interactions within its supply network to foster innovation. By introducing innovative ideas and technologies, for example, through a "technology road day," suppliers were able to establish strong relationships with the solution provider; this fosters the adoption and exploitation of the existing technological solutions. This also illustrates that the role of the focal firm has been shifted from controlling buyer–supplier relationships (traditional role) to facilitating knowledge exchange within the supply networks and shaping the industry.

4.2.4 Connecting ties for exploration. The findings also suggest that integrating strong and weak ties can support exploration activities by providing novel knowledge at the network level. This pattern was labelled "*Connecting ties for exploration*," as knowledge exchange at the network level enables suppliers to collaborate and share costs and risks. The combination of weak and strong ties may lead to knowledge creation derived from new interactions. The knowledge exchange at the network level allows suppliers to access complementary knowledge and capabilities, which support their exploration activities. By coordinating the interactions between weak and strong ties, the focal firm enhances the exploration capabilities of suppliers in the network.

> [in an R&D project] all suppliers through the value chain are considered ... to co-create knowledge, even with competitors. The uncertainty of some projects is high. The ultimate result of the project is unknown to all players. There is no guarantee that the project will be successful.

> In many cases, we not only need complementary knowledge from suppliers, but also co-creation of new knowledge – a manager of Energy Comp.

This quote describes how creating an environment for knowledge exchange between strong and weak ties provides innovation opportunities. We observed an example in Offshore Comp where the interaction between weak ties and strong supply ties led to joint R&D projects and experimenting with simulation tools to design and support maintenance.

In this OI practice, the focal firms act mainly as facilitators by fostering collaboration and co-creation by reducing interaction barriers among suppliers. The aim was to create an environment where each supplier could meet, interact and collaborate across the network.

5. Discussion and conclusions

5.1 The positioning in the literature

By adopting a multiple case study, this paper illustrates how focal firms manage strong and weak ties in the supply network of mature industries to pursue OI. The findings identify additive and interactive effects and classify a set of OI practices focal firms adopt in their orchestrating or dominant role.

We summarize the findings in Figure 1. The focal firms appear to choose different OI practices depending on whether they are looking for exploration or exploitation and whether

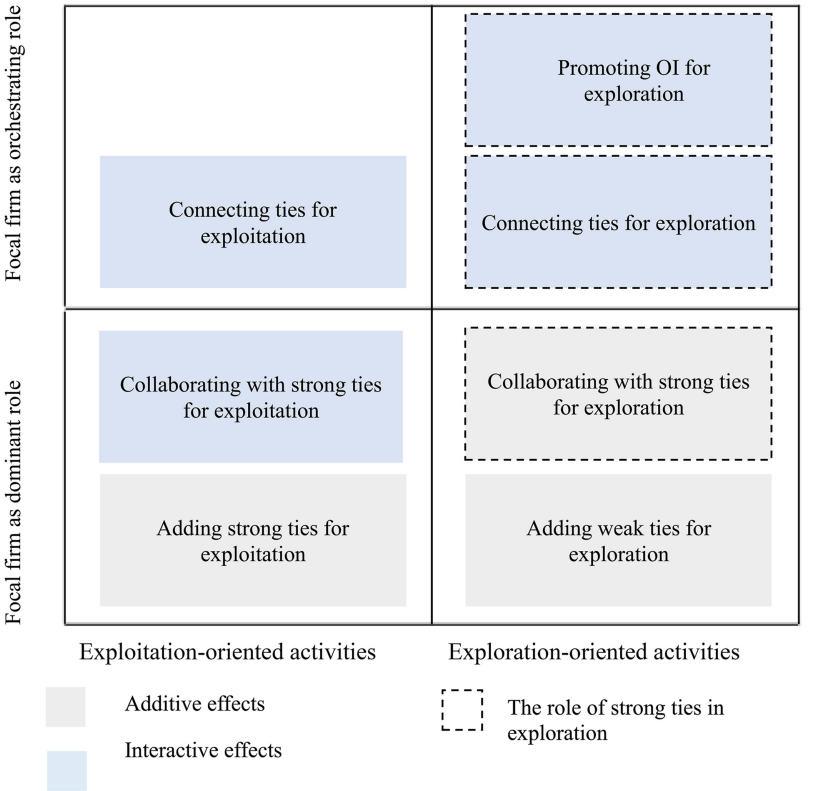

Figure 1.
OI practices to enhance innovation capability

they play a dominant or an orchestrating role. In what follows, we discuss OI practices with suppliers in two sections: the additive and interactive effects.

5.1.1 Additive effect. The findings show that forming strong and weak ties with suppliers brings new opportunities for innovation.

For strong ties, one OI practice that helps the focal firms add strong ties was related to effort given to expanding inter-organizational interactions with second- and lower-tier suppliers. Adding strong ties for exploitation along the supply chain enables the focal firms to gain access to complementary knowledge and resources and, in that way, pursue exploitative innovation. This occurs because the first-tier supplier may not be willing to share its knowledge and technology with focal firms, diluting its competitive advantage (Grant, 1996) embedded in the supplier's network (Kazemargi *et al.*, 2016). Although previous studies suggest that strong ties positively influence exploitation activities and associate weak ties with the exploration of new ideas (Dittrich and Duysters, 2007; Bengtsson *et al.*, 2015), our findings show that collaboration with some (if not all) strong ties increases the opportunity for the creation of innovation and exploration. Thus our study extends exploration to strong ties as well. Instead of considering an inverted U-shaped relationship between tie strength and the acquisition of new knowledge and technology (Uzzi, 1996; Hagedoorn and Frankort, 2008), we view suppliers as continuously seeking to develop their resources and capabilities (Lorenzoni *et al.*, 2001).

For weak ties, adding them is highly relevant for access to diverse knowledge (Bergenholtz, 2011) and technologies (Eisingerich and Bell, 2008; Cantarello *et al.*, 2011). First, it was shown that the firms directly add weak ties to their supply network by forming relationships, particularly with small suppliers. This greater flexibility increases the ability of small suppliers to develop and implement technology innovations (e.g. digital solutions) compared to large suppliers. However, unlike large suppliers, small suppliers have few (if any) formal procedures and contractual frameworks for innovation collaboration.

5.1.2 Interactive effect. Previous studies highlight the complementarity between strong and weak ties in the innovation process (Rowley *et al.*, 2000; Dittrich and Duysters, 2007) and suggest benefits in integrating strong and weak ties. Tiwana (2008) suggests that while firms are increasingly seeking to access diverse knowledge and resources through weak ties, the creation value of the acquired knowledge relies heavily on strong ties. Strong supply ties provide complementary skills and resources (Emden *et al.*, 2006). Michelfelder and Kratzer (2013), as evidenced by how weak ties not only enable firms to access novel knowledge but also refine the outcomes of the R&D projects of strong ties. This study provides evidence supporting the interactive effects between strong and weak ties in both exploitation and exploration oriented activities. For the former, our findings emphasize the role of strong ties in realizing value. This is consistent with previous studies highlighting the dependence of focal firms on their strong supply ties in exploiting new knowledge (Emden *et al.*, 2006) and the creative value of acquired knowledge (Dyer and Nobeoka, 2000; Gilsing and Duysters, 2008; Rost, 2011). Moreover, we identified how focal firms facilitate interaction between strong and weak ties to exploit existing technologies. As for exploration oriented activities, our findings add two novel interactive effects of strong ties with weak ties under the orchestrating role of firms: (1) promoting OI for exploration; and (2) connecting ties for exploration.

By promoting OI for exploration, the focal firms indirectly add weak ties. This enabled the focal firms to increase innovation opportunities and the pace of innovation and is consistent with prior studies, which demonstrate that connectivity with too many weak ties has a negative effect on novelty (Zhou *et al.*, 2009; Bengtsson *et al.*, 2015). By promoting OI for exploration, the focal firms can benefit from weak ties indirectly.

Concerning exploitation-oriented vs exploration-oriented activities, from the cases, we induced that firms increasingly depended on both strong and weak supply ties within networks for exploration and exploitation. While much prior research on mature industries has focused on incremental innovations (Freel, 2003; Laursen and Salter, 2006) and low frequency of breakthrough innovations (Bartos, 2007), this study's findings reveal that OI activities in mature industries are not necessarily limited only to incremental innovations and exploitation of existing knowledge but also encompass the reconfiguration and innovation of products, services or even business models through the exploration of new knowledge and emerging technologies (Chesbrough and Appleyard, 2007; Chesbrough *et al.*, 2013).

Finally, the findings demonstrate how the focal firms play an orchestrating role in OI (Schepis *et al.*, 2021) beyond the traditionally dominant role. In particular, these findings emphasize the orchestrating role within the supply networks of mature industries, as innovation increasingly relies on the interactions among organizations (Dhanaraj and Parkhe, 2006; Hurmelinna-Laukkanen and Nätti, 2018). In this way, orchestrating such interactions in the network will lead to OI.

Drawing on the in-depth case studies, our study sheds light on how firms cooperate in different inter-organizational supply relationships (i.e. strong and weak ties) to enhance innovation capability. Our findings illustrate that firms benefit from both additive and interactive effects by integrating strong and weak ties in OI practices by analyzing different OI practices.

5.2 Theoretical implications

This study has several theoretical implications. First, we contribute to the OI literature by demonstrating how focal firms in mature industries manage OI practices within the entire spectrum of inter-organizational supply networks (i.e. strong and weak ties). Our study provides a more fine-grained understanding of OI practices within strong and weak supply ties. While it is widely accepted that cooperation with strong supply ties enables firms to exploit their existing knowledge, our research reveals that in mature industries, exploration-oriented activities are not restricted to cooperation with weak supply ties. Indeed they are enabled by the additive effects of strong supply ties and the interactive effects generated by integrating them with weak ties. Our study also shows that in mature industries, where the networks of suppliers already exist, the focal firms can benefit from exploration oriented activities with strong supply ties and weak supply ties. Both ties and their dynamic interplay enable firms to explore new knowledge and technologies. For instance, strong supply ties can support exploitation-oriented activities (e.g. by providing complementary knowledge for new ideas from weak ties) and at the same time exploration oriented activities (e.g. collaborative innovation). This could enable firms to sustain their competitive advantages in the short- and long term (Andriopoulos and Lewis, 2009).

Second, this study contributes to social network theory by explaining the benefits of combining new (additive effects) and old ties (interactive effects) and leveraging their different characteristics (strong and weak) for alternative purposes (exploitation and exploration) and roles for the focal firm (dominant and orchestrating). We find that the integration of strong and weak ties results not only in the benefits of each separately (Rowley *et al.*, 2000; Dittrich and Duysters, 2007) but also in a higher innovation capability due to the interactive effects between them (Tiwana, 2008; Rost, 2011; Michelfelder and Kratzer, 2013). Whereas previous studies have suggested the existence of additive and interactive effects of strong and weak ties in high technology firms (Michelfelder and Kratzer, 2013), our study illustrates how firms in mature industries enhance exploration-oriented activities through the creation of synergies between strong and weak ties.

Last and most importantly, by focusing on multiple rather than single inter-organizational relationships (Agostini *et al.*, 2020), our findings show that the focal firms not only retain their traditionally dominant role in the network but could play an orchestrating role in supply networks (Dhanaraj and Parkhe, 2006; Hurmelinna-Laukkanen and Nätti, 2018).

5.3 Practical implications

This study presents several implications for practitioners. First, it provides insights for firms in mature industries in their journey to OI adoption. Whereas collaboration with external actors such as users, customers, universities and competitors allows firms to access new knowledge and technology, our study suggests that managers in mature industries should note the important role of established suppliers (both small and large) and strong ties for OI practices. By introducing OI practices with consolidated suppliers, firms could enhance their innovation capability in a rapidly changing business environment.

Second, this study shows that focal firms' managers need to cooperate with both strong and weak ties for exploration and exploitation oriented activities. Our findings help managers answer questions such as: Why should we cooperate with suppliers? What are the benefits of the integration of strong and weak ties? Who should control and make decisions in collaborative innovation projects? By answering such questions, firms could harness the synergies of strong and weak supply ties. In other words, through the integration of strong and weak supply ties, firms could benefit from each supply tie and their interactions to create a more inclusive OI approach.

This study also reminds firms of their dual role in supply networks to enhance innovation capability. On the one hand, as the main decision-makers, focal firms can pursue their own innovation interest and strategy by exercising a dominant role. However, on the other hand, focal firms can serve as orchestrators who influence and facilitate collaboration and interactions to benefit the entire supply network. Thereby the focus is on sharing knowledge and innovative solutions, allowing all actors embedded in supply networks to enhance their innovation capability.

5.4 Limitations and future research

This study focuses on companies in mature industries to provide an analytical generalization (Gibbert *et al.*, 2008) expressed by an analytic framework. The three cases were representative of leading-edge firms from different mature industrial sectors, all three leaders in OI practices. The investigated companies operate in different sectors, which allowed us to provide a broader view of mature industries. Therefore, findings are restricted to mature industries.

The point of view is consistently one of the focal firms managing the supply network. Future studies might take the underresearched point of view of numerous suppliers managing ties with focal firms in mature industries.

The integration of strong and weak ties, simultaneously pursuing exploration and exploitation activities and playing a dual role, may introduce tensions in managing opposing needs. This presents a future research opportunity to explore the tensions among focal firms managing simultaneously new and old ties and strong and weak ties. There are also research opportunities in balancing exploration vs exploitation and the competitive oriented vs collaborative oriented activities.

One promising theoretical lens would be to build upon the ambidexterity literature to explore and investigate mechanisms to balance the tensions in managing networks in OI (Smith and Lewis, 2011; Arora *et al.*, 2016).

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Appendix

Company	Interviewees' job titles	Interview methods
Home-APLNC	- Open Innovation Manager - Advanced Development Director - Global Purchasing Director	- Phone calls: 4 calls for a total of 130 min - Web conferences: 3 calls for a total of 225 min
Offshore Comp	- Head of the Research Promotion Department - Research and Innovation Analyst - E-procurement and suppliers integration - Head of Research and Innovation – Division X	- Phone calls: 3 calls for a total of 145 min - Emails
Energy Comp	- Head of Open Innovation Culture - Head of Project Portfolio	- One face-to-face interview for a total of 50 min - Web conferences: 2 calls for a total of 140 min

Table A1. Interviewees' demographics and interviews' characteristics

Company	Case description
Offshore Comp	Offshore Comp is based in Europe and one of the leaders in ship manufacturing. During the last years, Offshore Comp has started new collaborations with suppliers around the world. Offshore Comp realized the need to involve both strong and weak ties to remain competitive in the market. For strong ties, Offshore Comp works closely with strong ties that are willing to explore new ideas and innovation. For weak ties, Offshore Comp has launched a technology program to scout for cutting-edge technology which has not yet been implemented in the offshore industry
Home-APLNC	Home-APLNC is a global leading company in home appliances. To sustain competitive advantage, Home-APLNC developed OI programmes and involved suppliers to develop new innovation solutions. Home-APLNC, has dedicated a group responsible for OI which collaborates closely with the R&D and Purchasing departments. The OI team developed an OI programs including one-day webinars, workshops and roundtables to facilitate knowledge exchange and collaboration. Moreover, Home-APLNC developed a platform to interact with suppliers and crowdsourcing. The company has developed its supply network with the aim of enhancing innovation performance
Energy Comp	Energy Comp is a European-based power company and a global leader. The company provides and distributes energy globally, but does not produce any products, so in order to innovate, Energy Comp relies heavily on its suppliers. To explore new technologies, the company collaborates with suppliers in different ways: scouting for innovative solutions, problem-solving collaboration, and new technology development collaboration. Apart from strong ties, the company has increased the number of collaborations with weak ties, especially with small suppliers. Energy Comp developed a platform to scout for ideas and collaborate with weak ties faster

Table A2. Brief case descriptions

	Offshore Comp	Home-APLNC	Energy Comp
OI goals	To develop the products and application of technologies	To develop the existing products (by focusing on customers) and exploring it enabled future scenarios (e.g. IoT)	To develop new service development (e.g. sustainable energy)
Innovation constraints (such as specific regulations and industry standards)	High	Low to medium	Low to medium
OI approach with suppliers	Close collaboration with a few suppliers in different areas (e.g. modularization, new materials etc.)	Inviting external suppliers to participate in OI events (webinars, seminars, workshops etc.) and in oi challenges	Inviting external suppliers to participate in OI challenges
Standardizing scouting	Defining innovation projects and scout new technology with specific suppliers	Defining innovation projects in a digital platform where suppliers participate and post their ideas and solutions	Defining innovation challenges (by energy comp or other companies) in a digital platform where suppliers participate and post their ideas and solutions
OI hub	–	A central innovation hub to boost knowledge sharing and collaboration	A network of innovation hubs across the globe to experiment with new technologies and business models
Innovation output	More exploitation than exploration	Exploitation and exploration	More exploration than exploitation
Role of firm in supply network	Governing innovation projects within supply network	Governing innovation projects and facilitate knowledge exchange and collaboration within supply network	Governing innovation projects and facilitate knowledge exchange and collaboration within supply network
Supply network structure	More presence of strong ties than weak ties	Balanced presence of both strong and weak ties	More presence weak ties than strong ties

Table A3.
Cross case analysis

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