Managing triadic supplier relationships in collaborative innovation projects: a relational view perspective

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Abstract
Purpose – Suppliers are essential partners in innovation projects, as they own resources, knowledge assets and capabilities that complement those of buying firms. In today's competitive environment, firms may choose to collaborate with suppliers beyond dyads, forming triadic or three-party relationships. Using the theoretical lens of the relational view (RV), this study aims to explore what type of triad configurations firms use to govern supplier relationships in collaborative innovation projects, how they choose to share resources and implications for project performance.

Design/methodology/approach – The authors use interview data from buyers and suppliers in six case studies of firms involved in ten collaborative innovation projects. The four constructs of the RV are used to observe how firms govern triadic relationships, combine complementary resources, invest in relationship-specific assets and manage information and knowledge exchange with and between suppliers in innovation projects.

Findings – Four archetypes of triadic relationships in innovation projects – labeled Triangle, A-frame, D-Frame and Line – are presented and characterized in terms of their structural and relational features. The authors discuss how each triad archetype is applicable to different innovation projects according to specific project characteristics.

Originality/value – This study is pioneering in its empirical examination of triadic relationships in collaborative innovation projects. It provides a novel typology of four archetypes of triad from the perspective of collaborative relationships with suppliers. Through applying the RV, it advances understanding of how triadic relationships are governed, how they invest in relationship-specific assets, how they combine complementary resources and how they exchange knowledge and information in each type of triad appropriate to different innovation project settings. To date, much of the extant literature has focused on dyads.

Keywords Buyer–supplier relationships, Collaborative innovation, Triad, Relational view

Paper type Research paper

1. Introduction

Open innovation (OI) is a dominant paradigm in innovation management, involving organizations reaching beyond their boundaries for new ideas, knowledge and technologies (Chesbrough, 2003; Bogers *et al.*, 2018). From a supply chain management (SCM) perspective, increasing specialization and outsourcing lead firms to engage with suppliers and/or customers in innovation projects, to exploit a broader set of resources and capabilities that they do not possess (Sjoerdsma and van Weele, 2015). SCM literature recognizes suppliers as primary actors in collaborative innovation projects (Pihlajamaa *et al.*, 2017). Suppliers can increase buying firms' innovation performance by reducing costs, shrinking time-to-market and improving product design (Luzzini *et al.*, 2015; Suurmond *et al.*, 2020).

Supplier innovation creates new business opportunities, especially in technology-intense industries such as the automotive sector (Xiao *et al.*, 2019). For example, the manufacturer Aston Martin collaborated with Flexsys, a US supplier, to develop seamless adjustable wings, improving the aerodynamic

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Supply Chain Management: An International Journal
27/7 (2022) 108–127
Emerald Publishing Limited [ISSN 1359-8546]
[DOI 10.1108/SCM-05-2021-0220]

Received 13 May 2021
Revised 30 September 2021
3 December 2021
Accepted 5 December 2021

performance of luxury models [1]. In China, the original equipment manufacturer Shanghai Automotive Industry Corporation engaged with Alibaba on innovations related to integrated navigation and in-vehicle e-commerce [2]. Michelin, a tire producer, partnered with ProovStation to develop an automatic vehicle inspection solution to provide data on vehicle and tire performance and assess maintenance needs [3].

These practice-based developments have inspired SCM research to focus on supplier involvement in innovation projects, typically adopting a dyadic, or two-party relationship, perspective (Wong and Ngai, 2019). Today, considering the increased complexity of supply networks and the spread of competencies across these networks, relationships between suppliers as well as with suppliers may provide benefits and/or risks for buying organizations (Durach *et al.*, 2020), demanding research to extend beyond dyads to networks. However, there is a dearth of empirical research beyond dyadic relationships (Kataike *et al.*, 2019). This study takes a step in this direction by examining the triad, or three-party relationship, as the unit of analysis and the most elementary building block of networks (Choi and Wu, 2009a, 2009b).

Some SCM studies discuss theoretical and empirical characterization of triads in the context of coopetition strategies (Wu *et al.*, 2010; Wynstra *et al.*, 2015; Ried *et al.*, 2021). However, much less is known about how organizations manage buyer–supplier–supplier relationships in collaborative innovation projects and their consequential intended and unintended innovation outcomes (Potter and Paulraj, 2020). Examining triadic relationships with suppliers in innovation projects is important, for research and practice, for two reasons. First, project success largely depends on inter- and intra-organizational structures and how effectively relationships are managed to combine complementary skills and expertise (Najafi-Tavani *et al.*, 2018). Second, when more than one supplier is involved, inherent tensions between cooperation and competition may occur (Wilhelm, 2011), as buyers request competing suppliers to collaborate in co-design, development and integration of materials and components into product innovations. When coopetition is not appropriately managed, buying firms are exposed to knowledge spillover, opportunistic behaviour, tensions and conflicts (Ried *et al.*, 2021), leading to unexpected risks and losses (Yan and Kull, 2015). To avoid these unintended outcomes, buying firms need to involve the right supplier and carefully manage relationships with, and between, suppliers. Building on this, our study aims to provide new knowledge of buyer–supplier collaboration for innovation by posing the following research question:

RQ1. How do firms govern triadic supplier relationships in collaborative innovation projects?

To answer this question, we adopt a multiple case study approach and use interview data collected from six multinational firms that designed triadic relationships in ten distinctive innovation projects. Information provided by buyers and suppliers was coded and analyzed using the theoretical lens of the relational view (RV) (Dyer and Singh, 1998). RV allows us to study not only different relational design choices but also how and why combinations of these choices are related to performance within individual projects (Patrucco *et al.*, 2021).

This article is organized as follows. Section 2 examines literature on supplier engagement in innovation projects, and the relevance of RV as a theoretical perspective. Section 3 describes the methodology adopted to answer the research question. Section 4 presents the main characteristics of the case studies, while Section 5 discusses cross-case analysis and implications of the findings. Finally, in Section 6, the study's contributions are summarized, and guidance for future research is provided.

2. Theoretical background

2.1 Supplier involvement in innovation projects: beyond the dyadic perspective

Highly competitive and fast-changing markets increasingly demand innovative products and services, causing firms to reach beyond their firm boundary to collaborate more openly with external partners (Bogers *et al.*, 2018). Closed innovation is insufficient in the current competitive scenario, while outside-in OI requires new capabilities for firms to explore beyond their internal resources and use external knowledge and expertise to accelerate innovation projects (Lee *et al.*, 2019). This has generated OI ecosystems that, unlike business ecosystems (primarily focused on competition rather than cooperation), emphasize co-creation and joint research and development efforts between actors in key innovation projects involving collaborating partner organizations (Oh *et al.*, 2016) and individuals (Ter Wal *et al.*, 2020).

From a supply chain perspective, OI ecosystems require reaching out and engaging with several actors, including suppliers, customers, governments, industry associations and even competitors (Solaimani and van der Veen, 2021). This helps create a bigger space to search for and access knowledge (Ardito *et al.*, 2018), supporting formation and development of original ideas that may lead to a successful product or service design, development and launch (Mitrega *et al.*, 2017; Najafi-Tavani *et al.*, 2018; Wang and Hu, 2020). The SCM literature has focused particularly on the value and role of suppliers in focal firms' innovation ecosystems by discussing suitable timing, role and coordination mechanisms of successful involvement of suppliers in buying organizations' innovation projects (Van Echtelt *et al.*, 2008; Johnsen, 2011; Yan *et al.*, 2018). Supplier involvement has often been associated with improvements in innovation project performance (Cousins *et al.*, 2011; Bellamy *et al.*, 2014; Luzzini *et al.*, 2015), but it can also be detrimental for project outcomes when the buying firm is challenged to manage the increased project organizational complexity (Merminod *et al.*, 2021).

The innovation and SCM literatures have largely examined supplier involvement from a dyadic perspective, i.e. establishing collaboration with one, strategic, supplier (Potter and Paulraj, 2020). However, in line with the ideas of OI ecosystems and disruptive innovation, new knowledge may be generated from concurrent interaction with and between various supplier partners (Yan *et al.*, 2017; Najafi-Tavani *et al.*, 2018) rather than only from dyadic relationships with immediate suppliers. For these reasons, over time, collaborative innovation practices with suppliers have become increasingly complex, with simultaneous involvement of more suppliers forming buyer–supplier–supplier relationships, or triads (Potter and Paulraj, 2020). As recent studies highlight, collaborating with more than one supplier in innovation activities is now commonplace in practice, calling for research beyond a dyadic perspective (Ates *et al.*, 2015; Swierczek, 2019).

2.2 Buyer–supplier–supplier relationships in innovation projects

As examination of dyads does not capture the fundamental dynamics of supplier innovation ecosystems, this study considers triads – that Choi and Wu (2009a, 2009b) posit as the basic building block of a network – as the unit of analysis to study how buyer–supplier–supplier relationships are configured in collaborative innovation projects. In a triad, relationships between suppliers, as well as between buyer and suppliers, are part of the same picture, and successful management of these elementary networks depends on the ability of buying organizations to coordinate and align interaction effectively (Dubois and Fredriksson, 2008). The supplier–supplier relationship has been termed "coopetition," where competing suppliers work together to meet buyers' innovation requirements (Wu *et al.*, 2010). Supplier–supplier relationships can take place both between direct and indirect suppliers, so buying firms may have to manage potential coopetition tensions beyond their immediate suppliers (Wilhelm, 2011).

Extant SCM literature provides insights on the management of triadic relationships; however, innovation projects have rarely been the focus of analysis for research and yet these are where business-to-business OI most frequently happens (Markovic *et al.*, 2021). In the context of innovation, we interpret buyer–supplier–supplier triads as a network configuration "consisting of three tightly connected organizations that regularly share knowledge related to the design development and patenting of an innovative new product or process technology" (Potter and Paulraj, 2020, p. 147). In supplier innovation triads, only a careful balance between competition and collaboration, deciding when and how to facilitate sharing of knowledge with and between suppliers and when to prevent this, can ultimately lead to successful innovation project outcomes (Potter and Wilhelm, 2020).

2.3 Supplier innovation triads from the relational view perspective

Originating from strategic management studies of alliances, RV is based on the idea that inter-organizational relationships may provide a superior resource-based competitive advantage than firms working individually (Dyer and Nobeoka, 2000). In their original work on RV, Dyer and Singh (1998) identify four constructs – effective governance, complementary resources, investment in relationship-specific assets and knowledge and information sharing – to explain what is required for effective inter-company relationships. More recently, the authors provide more depth about the interplay of these constructs (Dyer *et al.*, 2018), and our study builds on this. Here, we use RV and its constructs to examine and interpret buyer–supplier–supplier relationships in collaborative innovation projects. The theoretical meaning of each construct is briefly outlined below.

Governance structure

This refers to structures and processes relating to authority, roles and responsibilities within relationships (Shahzad *et al.*, 2018). For triadic relationships, choosing a governance structure means defining the nature of buyer–supplier and supplier–supplier relationships. First, the buying firm needs to identify what type of partners to involve that suit the needs of the innovation project and what type of relationship to establish with them (Patrucco *et al.*, 2021). The buyer may decide, for example, to develop direct relationships with immediate, or first-tier suppliers, and only indirect relationships with second-tier suppliers, or they may choose to have a direct connection with both tiers (Wu *et al.*, 2010; Johnsen, 2011; Wilhelm, 2011). Second, the buyer needs to establish the nature of the interaction between suppliers, as in some cases, suppliers are asked to work together; in others, they are expected to remain distant from each other to limit risks of knowledge leakages and self-interest-driven behaviour (Ried *et al.*, 2021).

Complementary resources

In the context of buyer–supplier relationships, partners may seek to complement each other's resources, such as competencies, knowledge and expertise (Bastl *et al.*, 2013). This means that buying organizations may engage with those suppliers able to participate in joint problem-solving and provide expertise to an integrated project team (Xiao *et al.*, 2019). Triadic relationships allow combining complementary resources of three partners, potentially creating more knowledge and better project outcomes (Mitrega *et al.*, 2017). Buying organizations should identify what suppliers' complementary resources they want to combine with their own and use in collaborative innovation projects, and then evaluate their own and suppliers' abilities to integrate those resources effectively (Charterina *et al.*, 2016).

Investment in relationship-specific assets

When buyer–supplier relationships become institutionalized, the partners may each invest in relationship-specific assets that benefit both parties (Potter and Wilhelm, 2020). These mutual investments may differ and reflect the level of long-term commitment in the relationship between buyer and supplier (Patrucco *et al.*, 2021). For example, buyers and suppliers may commit their organizations' financial and human resources and technologies in different ways (Yan and Dooley, 2014). Prior studies have concluded that, when these specific investments are made, the collaboration is more likely to result in desired innovation outcomes (Wagner and Bode, 2014; Potter and Wilhelm, 2020).

Substantial knowledge and information exchange

Sharing information and knowledge is the "heart" of a collaboration initiative, especially in innovation projects (Ardito *et al.*, 2018). The purpose of supplier involvement is to increase innovation performance through access to their specific competencies and expertise (Jajja *et al.*, 2017), to create new knowledge and a sustained competitive advantage (Jean *et al.*, 2014). However, information sharing can flow in both directions, and the ability to capture shared knowledge between buyers and suppliers depends on appropriate governance mechanisms (Cassiman and Valentini, 2016). Within triadic relationships, designing proper governance for knowledge capture becomes even more complex, as buying organizations may encourage or discourage knowledge and information exchange with and between suppliers depending on the risks of knowledge spillover and opportunistic behaviours (Zeng *et al.*, 2017; Ried *et al.*, 2021).

3. Research methodology

To answer the research question and examine the characteristics of collaborative buyer–supplier–supplier relationships in innovation projects, a qualitative approach enables understanding of the complexity of three-way interactions between buyer and suppliers (Seuring, 2008). Most SCM research focuses on supplier collaboration on innovation activities at the firm level (Jean *et al.*,

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2014; Luzzini *et al.*, 2015; Jajja *et al.*, 2017). For this study, we use case studies of nested innovation projects within firms to capture how OI mechanisms take place in different collaborative project situations (Markovic *et al.*, 2021).

3.1 Case selection

We followed a theoretical sampling approach (Draucker *et al.*, 2007), seeking cases that enabled examination of nuances of different triad-related characteristics and the RV constructs and their theoretical relationships (Randall and Mello, 2012). First, we focused attention on tech-intensive manufacturing industries where innovation represented a significant competitive priority and innovation projects are recurrent. Second, we sought to include multinational organizations that represented focal firms in their global supply chains. These firms govern the supply chain, have direct contact with customers and drive innovation of products and services offered (Seuring and Müller, 2008). In these organizations, collaborative initiatives with suppliers in innovation projects are more likely to take place through the design of structured organizational support mechanisms.

Based on these criteria and using the professional network of contacts of the research team, we were able to connect with almost 100 global European manufacturing companies, who were informed of our need to collect specific information about collaborative innovation projects managed during the past few years. Fifty supply chain professionals agreed to take part in the study. A short questionnaire was sent to these professionals probing the characteristics of their innovation projects, collaboration with suppliers and overall project performance. As a result, we received details for 30 projects managed by 19 companies. To select the final sample of projects and companies, we looked for projects heterogeneously distributed across two dimensions, following a "polar types" approach (Eisenhardt and Graebner, 2007). On the one hand, we included projects with varying extents of innovation (i.e. radical vs incremental) and technological complexity. On the other hand, we sought projects with varying success in terms of general performance, such as cost, time and quality. This "polar-types" approach is common in qualitative innovation studies to ensure theoretical replication (De Massis *et al.*, 2016).

These additional criteria, combined with the need to secure interviewees with representatives from all the triad members, led to the selection of ten collaborative innovation projects undertaken by six different focal firms, all involving established relationships with suppliers. The main company project and interviewee characteristics are provided in Table 1.

The case selection process yielded a heterogeneous sample of projects of product innovations, with a moderate to high level of technological complexity as assessed by the case companies responding to a question on rating how technologically challenging the design, development and integration of components into the final product was. As for performance, we asked to rate if, overall, the project was satisfactory or not, concerning cost, time and quality of project outcomes. A more detailed discussion of both technological complexity and project performance was also part of the interviews. None of the interviewees reported that relationships with the suppliers were terminated following the collaboration, so we assumed our cases represented relationship continuity, before, during and after the innovation project.

3.2 Data collection

Detailed information about the projects was collected during a two-year period (2014–2015) in four stages. First, we organized a short call with senior managers of the companies who completed the preliminary questionnaire. They were briefed about the detailed content of the interview, and the main information to be collected. During this call, we asked these managers to put us in touch with the key informants for the project(s) under investigation.

The first interviews took place with the buying organizations, with multiple informants from different supply chain areas; almost all were senior managers with decision-making authority in the project. Information collected related to characteristics of the innovation projects, nature of the supplier triads, decisions related to the governance of relationships with suppliers, level and methods of supplier engagement, types of knowledge exchanged and project performance. The second series of interviews involved representatives of suppliers that were part of the triad. Here, we interviewed managers and technical people (e.g. engineers) who worked directly on the project activities. We followed a semi-structured interview protocol differentiated between buyer and supplier, designed to explore the main target constructs and any other areas that emerged as relevant. Each interview was conducted face-to-face or through online videoconferencing and lasted between 1.5 and 3 h. All the interviews were transcribed, and follow-up emails and phone calls were made as necessary.

3.3 Coding and analysis method

Although the initial objective was to investigate the relational characteristics of triadic relationships in innovation projects, we did not initially choose an ex ante coding approach based on theory. The data were prepared for analysis following the procedure suggested by Miles and Huberman (1994). Validity and reliability were also considered, consistent with Gibbert *et al.* (2008). Data were first categorized and reorganized through deconstructing and aggregating, to facilitate case comparison. In doing this, we recognized that the RV perspective was clearly emerging from the data; so, data were revisited and coded later according to the RV constructs. Then, they were contextualized in light of the nature of innovation and technological complexity. Two researchers performed coding independently, then cross-checked, and a consensus formed where different codes emerged.

Within-case and cross-case analyses were performed. For within-case analysis, cases were built from interview transcripts, supplementary clarifications from post-interview follow-ups and triangulation with company websites and additional data provided by interviewees (such as relevant project documents mentioned during the interviews). Meta codes were formed to group subsets of data according to RV constructs and innovation project performance. For cross-case analysis, we applied explanation-building procedures to understand the characteristics of triadic relationships, why a connection with project performance existed and how the pattern emergent from the cases helped to formulate a valid explanation to our research question. In the next section, detailed findings are elaborated.

Table 1 Innovation project characteristics

Company name	Company characteristics	Project output description	Interviewees (buyer)	Interviewees (suppliers)	Technological complexity	Project performance
Konsum	*Country*: Germany *Industry*: Consumer goods *Employees*: approx. 4,700	Flexible totem for point-of-sale product display (*Totem*)	Supply Chain Manager (KB1); Procurement team leader (KB2); Category manager (KB3)	Product manager 1 (KS1); Product manager 2 (KS2)	High	Satisfactory for cost, time, and quality
Ideafix	*Country*: Italy *Industry*: Medical devices and equipment *Employees*: approx. 1,500	High-technology car console systems (*Car*) Mobile diabetes management system (*Diabetes*)	Sourcing Director (IB1); Product manager (IB2); Strategic Supply Chain Manager (IB3)	Product engineer (IS1); R&D engineer (IS2); Project manager (IS3)	High High	Satisfactory for quality and time, not for cost Satisfactory for time, not for cost and quality
Quaser	*Country*: Switzerland *Industry*: Medical devices and equipment *Employees*: approx. 500	Micron wavelength surgical laser machine (*Micron*) Surgical laser for prostate surgery (*Prostate*)	Procurement manager (QB1); Regulatory affairs manager (QB2)	Quality managers 1 (QS1); Quality manager 2 (QS2); R&D manager (QS3)	High Moderate	Satisfactory for quality and time, not for cost Satisfactory for cost and quality, not time
BeEnergy	*Country*: Italy *Industry*: Electrical equipment *Employees*: approx. 3,900	Domestic internet of things-based electrical control system (*IoT*)	Strategic sourcing manager (BB1); R&D manager (BB2); Project manager (BB3); Vendor quality manager (BB4)	R&D manager (BS1); Head of Quality (BS2); Software developer (BS3)	Moderate	Satisfactory for cost and quality, not for time
HeartChild	*Country*: Switzerland *Industry*: Healthcare and baby care *Employees*: approx. 2,900	Innovative elastic compression bandage (*Elastic*)	Purchasing manager (HCB1); Head of industrial manufacturing (HCB2)	Head of Quality and Safety (HCS1); Product manager (HCS2); Supply Chain manager (HCS3)	Moderate	Satisfactory for cost and quality, not for time
Heliland	*Country*: Italy *Industry*: Aerospace and defense *Employees*: approx. 5,000	Honeycomb panel for aircrafts (*Panel*) Weapon management system for helicopters (*Weapon*) High resistant windshield for helicopters (*Windshield*)	Head of Procurement (HLB1); Project manager 1 (HLB2); Project manager 2 (HLB3); Project manager 3 (HLB4)	R&D manager 1 (HLS1); R&D manager 2 (HLS2); Production manager 1 (HLS3); Production manager 2 (HLS4)	Moderate Moderate High	Satisfactory for costs, time, and quality Satisfactory for cost, not for time and quality Satisfactory for cost, time, and quality

Notes: In the text, projects will be referred to with reference to the identifier in brackets under the column "project description"; quotes will be reported with reference to the identifier in the brackets under the column "interviewees"

4. Within-case analysis

The within-case analysis illuminated how each case company structured governance, sought to combine complementary resources, invested in relationship-specific assets and shared knowledge and information with suppliers in each project. An overview of each case is reported in the Appendix 1.

5. Cross-case analysis: comparing triad characteristics

The within-case analysis suggests that companies make deliberate choices on the governance of supplier innovation triads, in terms of type of suppliers to partner with and buyer–supplier–supplier interactions. Cross-case analysis reveals that these governance choices generate four different types of triads – *Triangle*, *A-Frame*, *D-Frame*, *Line* – represented in Figure 1.

In line with Dyer *et al.* (2018), the cross-case analysis shows that these four triad governance structures are associated with different configurations of complementary resources, investment in relationship-specific assets and knowledge and information exchange. In the following, we discuss cross-case findings on how buying firms manage relationships with suppliers in innovation projects according to these four triad types.

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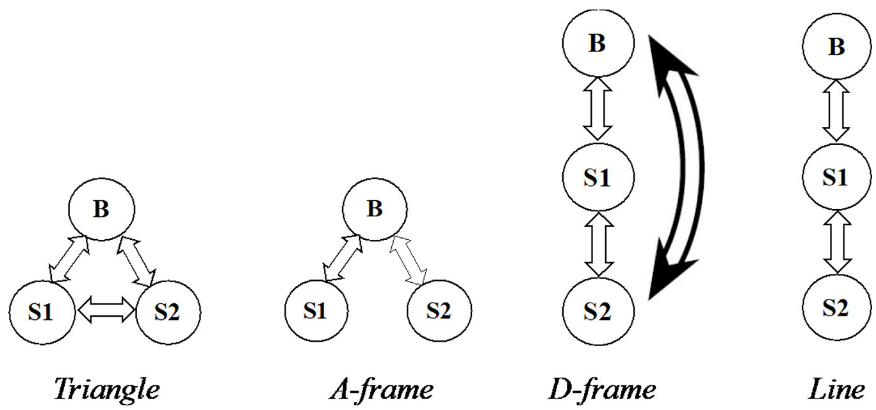
Figure 1 Types of supplier innovation triads



5.1 Triangle triads: involvement of direct suppliers with a three-way interaction

The *Triangle* type of governance is illustrated by the Totem and Car projects, where the buying firms decided to establish collaboration with suppliers of two different strategic product systems. Table 2 summarizes the main characteristics of these cases.

In both projects, the buying firm had deep and direct relationships with each supplier and encouraged connection between the two suppliers, thus forming a formal supplier–supplier relationship.

> Involving the suppliers providing the most strategic components make the project more complex, but also maximize the final result. (IB2)

This option seemed suitable because the product innovations involve several components/parts, and suppliers' design and development activities were highly interconnected. In these cases, it was necessary to involve both suppliers, and there was a need for them to plan and operate collaboratively:

> We didn't have too much choice there [...] we needed both suppliers (to) successfully develop the product, and we needed to be sure they were ready to work side-by-side. (KB1)

The biggest challenge was to establish an efficient connection between the two suppliers, to prevent development constraints, so appropriate mechanisms had to be put in place, and the buying organization needed to act as a facilitator for this interaction.

> Coordination was not easy at the beginning [...] especially at the beginning of the project, they [the buyer] were constantly checking how things were going between the other supplier and us, and try to set joint meetings to discuss potential issues. (IS2)

In both these cases, the combination of resources mostly involved technical capabilities and expertise. For the Car project, a multinational and a medium-sized first-tier supplier with complementary knowledge relating to different strategic components were deliberately selected. Suppliers were involved from an early stage in the innovation project, both being assigned a "black box" responsibility.

> They [the buying firm] wanted to be sure we were developing the new part in line with the concept they had in mind [...] we did it already for other industries, so we were able to provide what they asked for, and show to them the impact on the car system. (IS2)

A similar decision was made in the Totem case, where lack of technical knowledge in Konsum caused the deliberate choice of two complementary suppliers to be integrated into the project team, also with a black-box approach. In these two projects, these technical capabilities seemed to favor dialogue, coordination and success of the buyer–supplier–supplier relationships.

> One supplier was chosen for their technical expertise, the other for their design expertise [...] we don't have these capabilities [...] they complemented and integrated with each other in an excellent way. (KB2)

The nature of investment in relationship-specific assets to support collaboration in Car and Totem was mixed but primarily aimed to give the buying organization greater control of development activities. Ex ante investments (such as collaborative performance design and the definition of costs/benefits sharing mechanisms) were made with the objective to favor control and supervision activities of the buyer. Notably, for both projects, Konsum and Ideafix also invested in creating cross-functional teams, co-designing platforms and sharing assets (e.g. information technology equipment) to control suppliers' progress better.

> We built a dedicated collaboration platform, accessible by both suppliers, to support data exchange and enable information sharing. (KB1)

Given the three-way interaction this type of governance encouraged, intense knowledge exchange with and between suppliers of different components was key for project success. This also explains why higher investments in relationship-specific assets for collaboration were made in both projects. In the Totem case, for example, Konsum organized weekly design meetings with both suppliers to share ideas and project information, but also facilitated supplier–supplier interaction.

> They [Konsum] provided us with an office area equipped with technology [...] they invited the other supplier and us to use that space to work together. (KS1)

Finally, for both Car and Totem projects, direct relationships and robust integration mechanisms with and between suppliers helped achieve an excellent project outcome and speed up innovation; quality and time performance were considered above expectations.

> Engaging two strategic suppliers in product innovation decisions can only benefit the final output [...], and effective communication channels helped us to anticipate possible constraints and recycle. (KB1)

Implementing a robust buyer–supplier–supplier integration can be time-intensive and require additional resources, thereby

Table 2 Triadic relationships in innovation projects – Totem and Car

Relational view construct and project performance		Konsum Totem	Ideafix Car
Governance structure	*Type of suppliers involved*	A direct supplier for technology design and manufacturing, and another direct supplier for the conceiving and manufacturing of totem design	Two direct suppliers of strategic components for the board computer
	Type of buyer–supplier relationship	Formal and direct with both suppliers	Formal and direct with both suppliers
	Type of supplier–supplier relationship	Formal and direct	Formal and direct
Complementary resources		Suppliers involved to provide primarily technical resources and capabilities "They [the buyer] asked to work directly with the other supplier . . . they gave us a blank cheque for the design and development of the technology" (KS1)	Suppliers involved to provide primarily technical resources and capabilities "Suppliers were given full responsibilities on design and development of components" (IB2)
Relationship-specific assets		Buyer's physical asset sharing with suppliers Colocation of suppliers on buyer's facilities Platform for co-development Frequent progress meetings	Dedicated team to support effective suppliers' integration Colocation of suppliers' engineers on buyer's facilities Information systems integration for real-time information sharing Suppliers' training on quality aspects
Knowledge exchange	*Buyer–suppliers*	High "To adjust our project infrastructure to the design and development decisions, updates about suppliers' activities were frequent and intense" (KB2)	High "We needed to discuss with both suppliers how to move forward for each development activity . . . we exchanged so many documents" (IB2)
	Supplier–supplier	High "The dialogue with them [the other supplier] happened daily . . . we needed to avoid any possible constraints on final product development" (KS1)	High "We worked side-by-side with the other supplier . . . there were a lot of choices that were jointly made" (IS2)
Innovation project performance	*Cost*	In line with expectations "We used the planned budget . . . coordinating with the two suppliers was not easy" (KB1)	Below expectations "We used 5% more of the budgeted costs, due to increase in labor cost" (IB3)
	Time	Exceeded expectations "The totem was developed one month in advance . . . this was the result of a good integration between us and the suppliers" (KB1)	Exceeded expectations "We delivered the console two months in advance" (IB2) "We both provided the components at the time that was agreed" (IS1)
	Quality	Exceeded expectations "We developed a product with functionalities that exceeded our customer's requests" (KS1)	Exceeded expectations "Our suppliers realized the components with even better functionalities that we requested, and easy to be integrated . . . we did not experience any problem with the system" (IB2)

increasing costs. This negatively impacted innovation project cost performance in the Car case, where human labor costs increased due to unplanned, greater coordination efforts.

5.2 A-frame triads: involvement of direct suppliers with two-way interaction

The A-frame type of governance is illustrated by the Elastic and Weapon projects. Also, in these cases, the buying firms involved direct suppliers of two different strategic product systems/components/parts. Table 3 summarizes the main characteristics of these cases.

Unlike the *Triangle* archetype, in the Elastic and Weapon projects, the buying organization had relationships with each direct supplier, but it deliberately prevented those suppliers from connecting to form a supplier–supplier relationship. Several reasons for this choice were mentioned, such as

Table 3 Triadic relationships in innovation projects – Elastic and Weapon

Relational view construct and project performance		Heartchild Elastic	Heliland Weapon
Governance structure	***Type of suppliers involved***	Two direct suppliers of high-tech fibers	Two 1st tier suppliers of strategic parts of the weapon system equipment
	Type of buyer–supplier relationship	Formal and direct with both suppliers	Formal and direct with both suppliers
	Type of supplier–supplier relationship	Absent (coordination managed by the buyer)	Absent (coordination managed by the buyer)
Complementary resources		Suppliers involved to provide primarily technical resources and capabilities "Involving suppliers helped us to gain a clearer knowledge about the process development of components and possible integration issues with the final product" (HCB2)	Suppliers involved to provide primarily technical resources and capabilities "Both suppliers were involved early . . . we wanted to gain as much knowledge as possible about parts development and integration in the final product" (HLB3)
Relationship-specific assets		Dedicated team to support effective suppliers' integration **Definition of cost/benefit sharing mechanisms** **Colocation of buyer's engineers on suppliers' facilities** **Information systems integration for real-time information sharing**	Dedicated team to support effective suppliers' integration Definition of cost/benefit sharing mechanisms Suppliers' training on quality and technical aspects Definition of customized non-disclosure agreement documents
Knowledge exchange	***Buyer–suppliers***	Very high "The colocation of our technical people on suppliers' sites helped a lot a constant knowledge exchange about development decisions" (HCB2)	Very high "We learned a lot from both suppliers . . . they were happy to give us more information than needed, and we gave them as much as visibility as possible" (HLB3)
	Supplier–supplier	Absent "We did not even tell suppliers their respective names . . . they both work with other competitors . . . we do not want them to have full visibility on the new product" (HCB1)	Absent "There is a lot of confidentiality in our projects . . . avoiding contacts between suppliers was an obliged choice in this case . . . we must coordinate suppliers' interaction and knowledge exchange for confidentiality reasons" (HLB1)
Innovation project performance	***Cost***	In line with expectations "There was an unexpected higher use of materials that caused an increase of costs, but we were able to counterbalance by saving on other resources" (HCB2)	Exceed expectations "Believe it or not, in the end, we were able to save 5% of the cost that we planned to use" (HLB3)
	Time	Below expectations "The suppliers provided the materials on time . . .; at the end, we had a delay of a couple of weeks because some additional quality tests were required" (HCB1)	Below expectations "We were late one month in delivering the final version of the component" (HLS1) "Suppliers were late, we were late, and Quality took forever to give us the final go" (HLB3)
	Quality	In line with expectations "We develop a very innovative material, even stronger than what requested by them" (HCS2) "We had no quality issue with the final product" (HCB2)	Below expectations "The parts developed by the suppliers were very critical . . . there were some problems at the end that pushed us to review some of the initially planned functionalities" (HLB1)

spillover risks, regulations or simply the need to limit project interfaces, providing suppliers could work effectively, independent of each other.

> Some of our suppliers work with our competitors [...] They are part of the projects, but they don't even know each other names [...] we bridge the connection to avoid constraints. (HLB2)

> We don't want our suppliers becoming too knowledgeable about the manufacturing of the product, but we still need to involve them [...] we avoided any information exchange between them, balancing this with stronger buyer–supplier integration mechanisms [...] both of them were formally part of the project team, participated in concurrent engineering, relying on integrated information systems and structured knowledge sharing procedures. (HCB1)

In these cases, the main issue for the buying firm was to act as a conduit between the suppliers, so that their design and development decisions were aligned, but without the suppliers directly talking with each other.

For both these projects, flexible and adaptable supplier resources and capabilities acted as a form of informal, mutual coordination mechanism, given the absence of a supplier–supplier relationship.

In the Weapon project, suppliers were selected first for their ability to adapt their technical capabilities to the complex technological environment of the buying firm. For Elastic, instead, suppliers were chosen specifically for their technical knowledge of specific materials (fibres). However, substantial project management resources and capabilities were also considered as a qualifying factor, especially considering the absence of a formal supplier–supplier relationship.

> We want our partners to be expert as well in managing complex projects [...] they need to be capable to manage risks and interdependencies without interacting with the other supplier. (HCB2)

> Our projects are very complex to be managed and realize [...] involving external partners must take place only if they are able to provide us with the technical knowledge we don't have, and if they can facilitate project management, not constraining it even more. (HCB2)

This shows that when direct suppliers are involved, but no formal supplier–supplier interaction occurs, the combination of resources involves technical expertise first, but it also requires managerial capabilities on the suppliers' side.

The nature of the specific assets invested in the relationship was similar to those found in the Car and Totem project but, due to the absence of a formal supplier–supplier relationship, several investments were made to assure ex ante, mutual coordination between buyer and suppliers, to prevent constraints in the development of the main project outputs and its strategic components. For example, in the Elastic case, the buying organization invested in building a cross-functional task force specifically to integrate suppliers in the company project team, having all the skills to supervise and coordinate suppliers' design and development activities. In the Weapon project, instead, training initiatives were organized to ensure suppliers' quality performance was in line with industry standards.

> [...] both suppliers were 100% compliant to security rules and industry standards. (HLB1)

Given that, in both projects, suppliers did not have direct contact with each other, the buyers established knowledge-sharing practices to get as much information as possible from suppliers. This was a key aspect in the Elastic case, as HeartChild needed to ensure the two innovative materials from each supplier could be effectively combined into the final product.

> In that situation, we needed to be sure to get as much knowledge as possible from suppliers' development. (HCB2)

In the Weapon project, Heliland chose not to establish any direct relationship between the suppliers, to limit possible knowledge spillover about the final product's technical characteristics. However, some knowledge exchange between suppliers was still imperative to avoid potential development issues. The project manager always moderated meetings between suppliers, so there was no direct contact.

> [...] in this way, we were able to control the project information shared between the suppliers and focusing the discussion, limited on technical characteristics of the two components and their compatibility with the overall design. (HLB2)

When discussing project results, we concluded that cost performance was overall in line with expectations. However, the separation of suppliers slowed down project progress. As suppliers did not talk with each other, the buying organization needed to bridge this connection effectively. This took time, causing delays in project execution.

> Several people in our project team needed to check what both suppliers did, and talk with them to verify complete alignment [...] only if we all agreed everything looked good, we could move to the next critical activity. (HCB2)

In the Weapon project, ineffective execution also caused a deterioration of output quality:

> Sometimes we did not really understand what the counterpart was doing, so we had to ask for clarifications [...] the information we received was not always really clarifying, and this impacted our development decisions. (HLS4)

5.3 D-frame triads: involvement of direct and indirect suppliers with a three-way interaction

The *D-frame* type of governance is illustrated by the Diabetes, Micron and Windshield projects. Here, the nature of the collaboration was different from the previous cases. Instead of collaborating with two different direct suppliers, all these buying firms decided to involve a supplier of a strategic direct component/part supplied to one of their strategic suppliers (i.e. second-tier supplier). Table 4 summarizes the main characteristics of these cases.

In these projects, the buyer had a relationship with the direct supplier and chose to reach around that supplier to form a direct relationship with the second-tier supplier. The first- and second-tier suppliers were also in their own relationship. These companies decided to adopt this governance structure because the design and development of the product (and component) innovation was highly complex, so there was a need to avoid misalignment between actors positioned at different tiers of the supply chain.

> We wanted control over the indirect supplier, as it is where the biggest issues could be generated [...] they were a part of the team as the other supplier, and we wanted full visibility on what they were doing. (QB1)

Regarding complementary resources, the suppliers' expertise, knowledge and capabilities that complemented the buying organizations were still mainly in the technical area, but managerial aspects were also considered. In both the Diabetes and Windshield project, the companies selected first- and second-tier suppliers based on their advanced technological

Table 4 Triadic relationships in innovation projects – Diabetes, Micron, Windshield

Relational view construct and project performance		Ideafix Diabetes	Quaser Micron	Heliland Windshield
Governance structure	*Type of suppliers involved*	A direct supplier for developing the software; an indirect supplier supporting the development of the application layer	A direct supplier for developing the laser beam; and indirect supplier for developing the reflective cylinder	A direct supplier for developing the system; an indirect supplier for developing the innovated material (polycarbonate)
	Type of buyer–supplier relationship	Formal and direct with both suppliers	Formal and direct with both suppliers	Formal and direct with both suppliers
	Type of supplier–supplier relationship	Formal and direct	Formal and direct	Formal and direct
Complementary resources		Suppliers involved to provide both technical and managerial capabilities "We required the supplier to select one of their suppliers for the development of a delicate software aspect . . . they favored our interface with them" (IB1)	Suppliers involved to provide both technical and managerial capabilities "We chose this supplier because they were the best on the market for laser technologies . . . They have a long project experience, and they could have favored the engagement of one of their strategic suppliers" (QB1)	Suppliers involved to provide both technical and managerial capabilities "We were brought into the project early . . . our supplier was involved at a later stage, to avoid risk in the development of an innovative material . . . they [the buyer] managed the interface directly, although we were requested to facilitate the communication" (HLS4)
Relationship-specific assets		Joint performance measurement system design	Dedicated team to support effective suppliers' integration	Joint performance management system design
		Suppliers' training on project management and technical aspects	Suppliers' training on technical aspects	Suppliers' training on technical aspects
		Development of a platform for co-design	Development of a platform for co-design	Frequent progress meetings
		Colocation of buyer's engineers on direct suppliers' facilities	Information systems integration for real-time information sharing	Information systems integration for real-time information sharing
Knowledge exchange	***Buyer–suppliers***	High "A continuous flow of information was established between our team and the software developer . . . several times, we also discussed technical issues with the sub-provider" (IB1)	High "The whole product functionalities depended on suppliers' activities . . . we talked and coordinate with them every day" (QB2)	High "We wanted a complete visibility on the project supply chain . . . we required a detailed report of every critical decision taken, and we tried as much as possible to give them [the suppliers] the data they needed" (HLB4)
	Supplier–supplier	High "We are used to engaging this supplier in projects . . . they select other good partners to be involved, and they favor communication of our requests . . . we require them to work	High "They [the second-tier supplier] are very expert in laser bean technologies, and we are not . . . we have developed a consolidated way of working during the years" (QS3)	High "The discussion and information exchange with the other supplier was required particularly to assure compliance to industry standard and be

(***continued***)

Table 4

Relational view construct and project performance		Ideafix Diabetes	Quaser Micron	Heliland Windshield
		together and frequently updated us on their progress" (IB3)		sure we were both on track with project progress" (HLS4)
Innovation project performance	***Cost***	Below expectations "We used way more labor than planned, so costs were higher . . . the team effort was higher, due to a lot of coordination needed with suppliers" (IB2)	Below expectations "The human labor was way higher than initially planned . . . we ended up using 10–15% more resources" (QB1)	In line with expectations "We stayed within the budget, with no extra-costs" (HLB4)
	Time	In line with expectations "The supplier gave us the final release of the software one week before the planned deadline . . . the machine was launched as planned" (IB2)	In line with expectations "The laser machine was developed in line with the timeline we had in mind . . . this was mostly thanks to an efficient and effective technology development from the suppliers" (QB1)	In line with expectations "The windshield system was finalized on time, and we were able to successfully introduce it in the aircraft model" (HLB4)
	Quality	Below expectations "We had several quality problems, and some of them were software-related . . . we were able to figure them out on time, but the final functionalities do not fully reflect our initial idea" (IB3)	In line with expectations "The machine works as expected, and all the functionalities were there . . . quality control and testing found only minor issues" (QB2)	In line with expectations "The system was integrated easily in the aircraft . . . everything was in line with industry standards and regulation" (HLB1)

capabilities that were lacking in their own organization, but then brought module integration skills and expertise of project management to the relationship, particularly to support effective integration of the second-tier supplier. In all cases, suppliers were involved early, and with "grey box" responsibilities.

Investments in relationship-specific assets were made to enhance coordination between first- and second-tier suppliers. For example, in the Micron project, engineers were loaned to first- and second-tier suppliers. These suppliers invested in a collaborative performance measurement system for the innovation project. In the Diabetes case, co-development platforms and colocation of Ideafix's technical people in supplier offices were implemented. Although this increased the relational investment, it helped prevent possible quality problems.

> The use of platforms for co-development and the location of technical people on supplier offices increased the relational investment, but helped in preventing possible quality problems. (IB3)

In the Windshield project, the design of a specific communication platform for information sharing helped the partners to manage information flow better.

> Investing some time with [. . .] our customer to design information sharing practices helped us [to] better manage the upstream and downstream communication. (HLS2)

In all these projects, knowledge exchange with and between first- and second-tier suppliers was critical due to the impact of both suppliers' design and development decisions on the buyers' activities. However, the intensity of this knowledge exchange within the triad differed. In the Diabetes project, for example, Ideafix set up more robust integration mechanisms with their first-tier supplier (e.g. through colocation and use of a co-design platform) to facilitate the exchange of technical knowledge with the software developer, while limiting the interaction with the second-tier supplier to discrete moments where critical and strategic project decisions were made. In Micron and Windshield, instead, both buying organizations wanted to assure the intensity of knowledge and information exchange was similar with both suppliers.

Diabetes, Micron and Windshield are projects with complex triadic relationships, as the buyer coordinated design and development across first- and second-tier suppliers to ensure their own development activities were not adversely impacted. The main objective was to assure the innovation project proceeded according to plan, which is evident as quality performance aligned with expectations for Micron and Windshield (but less so for Diabetes that involved a very innovative technology).

> We failed the testing of the first prototype because of system component sub-heating [. . .] but we cannot really blame anyone for this, because the technology behind the new system was mostly new to everyone. (IB2)

For these projects, cost performance seemed to rely on the project management abilities of the buyer. In the Diabetes and Micron projects, higher project costs were considered unavoidable, as unforeseen coordination efforts required more resources than were budgeted. Instead, in the Windshield project, the buying firm shared their cost objectives with the supplier, working together to hit these targets.

> We specifically set incentives for both suppliers for helping us lowering the project development cost, to counterbalance the high organizational complexity. (HLB4)

Although more resource consuming, establishing a direct and formal relationship with the second-tier supplier enabled satisfactory time performance, as it avoided circularity in the development cycle and anticipated possible problems with integrating components into first-tier supplier parts.

5.4 Line triads: involvement of direct and indirect suppliers with two-way interaction

Finally, the *Line* type of governance is illustrated by the Panel, Internet of Things (IoT) and Windshield projects. In these cases, the nature of the collaboration involved a supplier of a strategic direct component/part and one of their strategic suppliers. Table 5 summarizes the main characteristics of these cases.

Compared to the Diabetes, Micron and Windshield cases, in these projects, the buying organizations did not establish any formal relationship with the sub-suppliers in the second tier, due to the low impact of design and development activities of indirect suppliers on buyers' project planning and execution. So, they were part of the triad, but their management was delegated to the direct supplier. Thus, in these cases, the relationship established between the buyer and the direct supplier seemed even stronger than in the Diabetes, Micron and Windshield projects and the first-tier partner was given full responsibility for coordinating with the indirect supplier.

> We decided what our supplier to bring in, and they [the buyer] gave us freedom on how to manage the relationship [. . .] but we needed to report compulsively how things were going. (BS1)

We also noted that this configuration took place every time the decisions and activities of the second-tier suppliers were not immediately impacting the buying organization project's progress but were mediated by the first-tier supplier.

In these three cases of supplier innovation triads, the buying firms delegated responsibility for combining second-tier suppliers' technical resources to first-tier suppliers. They focused more on ensuring that managerial resources, particularly relating to project management, were combined. The managerial competencies and resources of first-tier suppliers seemed to be the main driver for their involvement, though they also had the desired level of technical capabilities to contribute to the product innovation. For example, in the Prostate case:

> We had 3-4 suppliers that could have potentially provided us with the laser beam [. . .] we selected the one who seemed more capable to bring in also one of their most strategic suppliers. (QB2)

In the Panel project, instead, one of the primary responsibilities of the first-tier supplier was to coordinate the indirect supplier's involvement and commitment to the project effectively; BeEnergy adopted a similar strategy for the IoT project:

> When this happens, we can fully delegate to the two suppliers the design and development of the application, thus reducing the number of technical activities directly executed by the project team. (BB2)

This delegation usually took place as a "black-box" interaction.

Project-specific investments were made to assure implicit alignment between the three actors involved. The definition and agreement of joint goals and the design of a performance management system were commonly found in all the projects. Also, cost/benefit-sharing mechanisms (especially with direct suppliers, as in the IoT and Panel projects) were created, along with the creation of dedicated technologies to support real-time information sharing and progress-checking. For example, in the Prostate case, the buying organization shared testing laboratories with the first-tier supplier.

> We made the first-tier supplier direct part of the core project team. (QB1)

Since a formal buyer–supplier relationship with the indirect supplier was not in place, the buyers' knowledge exchange efforts were directed only toward the first-tier supplier.

> We had periodic meetings and an intense exchange of opinions with several technical people from the customer [. . .] the information we provided included both our perspective and that of our supplier. (QS2)

However, the buyers need to be sure that effective and timely knowledge exchange is in place between suppliers, especially in those industries, such as aerospace and defence, where all the supply chain actors must meet quality standards:

> We did not have too much direct interaction with the other partner [. . .] but we provided them recommendations about the key design and development aspects they needed to agree and be aligned on. (HLB2)

Finally, the triad members in the IoT, Panel and Prostate projects were very attentive to cost reduction. The buyer empowered the first-tier supplier to manage the relationship with the indirect supplier, thereby saving coordination and organizational costs. This focus on efficiency did not seem to penalize quality performance, which was reported to be in line with expectations for all the projects. However, if the first-tier supplier failed to coordinate the involvement of the indirect supplier effectively, project time performance could be affected, as happened in the IoT and Prostate projects:

> [. . .] we honestly fail[ed] to synchronize the two relationships inbound and outbound, and we needed to delay some activities. (BS2)

6. Discussion: archetypes of triadic relationships in innovation projects

The cross-case analysis shows that, according to different types of triadic governance structures (*Triangle*, *A-frame*, *D-frame*, *Line*), the knowledge and complementary resources buying firms seek in the triads are different, and that a wide range of investment in relationship-specific assets was found. The combination of these factors also has a different impact on project performance. In line with RV and existing literature about innovation network models and triadic relationships (Choi and Wu, 2009a; Holma, 2012), the four configurations can be differentiated according to their structural and relational characteristics. The results are reported in Figure 2.

Regarding governance structure, we can differentiate between cases where the triad involves only direct suppliers or direct and indirect suppliers and if the triad operates through a three-way interaction (unitary triad) or a serial interaction (serial triad). On the relational side, we can differentiate:

- the extent to which triad actors are directly linked and the strength of ties between them (where a triad has a low degree of cohesiveness if the triad is open and/or the ties are weak); and
- the extent to which the triad acts as an entity (which depends on the extent to which the actors are likely to agree upon how to deal with the environment, and so establish coalitions).

Table 5 Triadic relationships in innovation projects – Prostate, IoT, Panel

Relational view construct and project performance		Quaser Prostate	BeEnergy IoT	Heliland Panel
Governance structure	***Type of suppliers involved***	A direct supplier for developing the laser beam; an indirect supplier for developing the reflective cylinder	A direct supplier for developing the software for the central control system; an indirect supplier for supporting the development of some code aspects	A direct supplier for developing the panel; an indirect supplier for developing the main material (phenolic resin)
	Type of buyer–supplier relationship	Formal and direct only with the direct supplier	Formal and direct only with the direct supplier	Formal and direct only with the direct supplier
	Type of supplier–supplier relationship	Formal and direct	Formal and direct	Formal and direct
Complementary resources		Suppliers involved to provide primarily managerial resources and capabilities "The supplier was a leader in the market, and definitely reliable to manage the interface with the indirect supplier . . . They have as much project management experience as we do" (QB1)	Suppliers involved to provide primarily managerial resources and capabilities ". . .we were asked to develop the main software . . . but we were first responsible for favoring integration of one of our suppliers as well" (BS1)	Suppliers involved to provide primarily managerial resources and capabilities "We trusted the supplier and their capabilities to select and involve the right strategic partner without the need for us to be involved" (HLB1)
Relationship-specific assets		Joint goals definition and PMS design Development of a platform for co-design Information systems integration for real-time information sharing Buyer's physical asset sharing with suppliers	Joint goals definition and PMS design Definition of cost/benefit sharing mechanisms Development of a platform for co-design Continuous communication channel through frequent meetings	Joint goals definition Definition of cost/benefit sharing mechanisms Information systems integration for real-time information sharing Continuous communication channel through regular meetings
Knowledge exchange	***Buyer–suppliers***	Very high "Information exchange was intense, especially at the beginning . . . we were fully informed and aligned about the involvement process for the second-tier supplier" (QB2)	Very high "Our engineers had an executive meeting with the supplier every week . . . updates about the application and system development were provided to each other" (BB2)	Very high "This [direct] supplier was the only actor having a full understanding of project progress . . . we discussed technical and managerial issues every other day" (HLB2)
	Supplier–supplier	High "We learned a lot from this project, from both the customer and our supplier" (QB1)	High "The two suppliers worked basically side-by-side for the whole duration of their activities, given the existing interconnection" (BB1)	High "We were chasing them [the other supplier] every 2–3 days, to update them, receive information and assure we were on track with industry standards" (HLS1)
Innovation project performance	***Cost***	Exceed expectations "There were some delays, but overall, it was a very efficient project . . . we used resources wisely" (QB2)	Exceed expectations "The project was able to save 10% of the budget costs . . . we thought supplier involvement would have been more complicated" (BB3)	Exceed expectations "We did not use all the resources, especially labor costs . . . the fact we did not directly manage the interface with one supplier definitely helped" (HLB1)

(***continued***)

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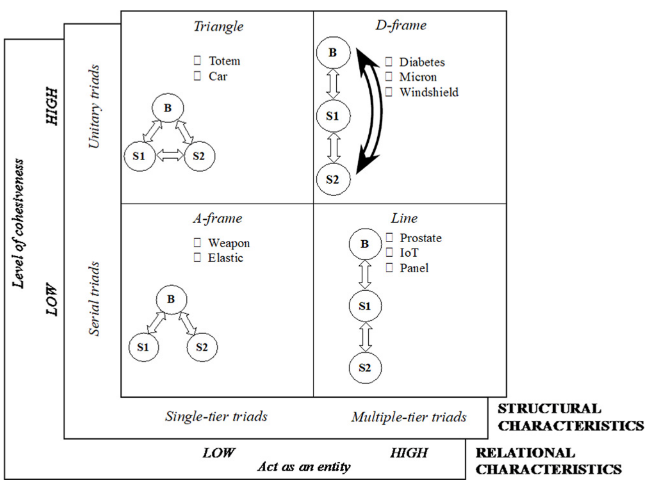
Volume 27 · Number 7 · 2022 · 108–127

Table 5

Relational view construct and project performance	Quaser Prostate	BeEnergy IoT	Heliland Panel
Time	Below expectations "The laser system was delivered on time, but quality control and testing took a very long time . . . we finished 1.5 months later than expected" (QB2)	Below expectations "Some project activities were really slow; we ended up with more than two months of delay" (BB3)	In line with expectations "We worked to deliver the panel parts on time and ready to be installed . . . it seems that everything was good" (HLS3)
Quality	In line with expectations "Overall, the machine was good . . . we initially include features that were not really feasible" (QB2)	In line with expectations "The final result was satisfactory . . . there will be space in the future to include more functionalities" (BB3)	In line with expectations "Materials unavailability required some design changes . . . at the end, the innovation was nicely introduced" (HLB2)

Figure 2 Classification of supplier innovation triads: structural and relational characteristics



Our findings show that, in some cases (i.e. Totem, Car, Elastic and Weapon), buying organizations decide to form single-tier triads by involving suppliers at the same tier in the supply chain, i.e. they are both direct suppliers to the buying organization. In this situation, the extent to which the triad acts as an entity is low, as the buying organization and the suppliers usually face different environments (sometimes they can even be competitors), and so they are less likely to form coalitions. However, when the buying firm intends to collaborate with two direct suppliers, they choose whether to facilitate engagement of immediate suppliers directly with each other, forming a *Triangle* triad (with a high level of cohesiveness), or to keep them apart, filtering and choosing what flows in the triad to whom, forming an *A-frame* triad (with a low level of cohesiveness).

In projects where the buying firm wants to collaborate with a direct supplier and its supplier (i.e. Diabetes, Micron, Windshield, Prostate, IoT and Panel), we have multiple-tier triads. In these configurations, the triad acts as an entity, as buyers and suppliers are more likely to agree on how to deal with the environment and are therefore more likely to form an aligned coalition. The choice for the buying firm is whether to reach around the immediate supplier to an indirect supplier to engage them in innovation, forming a *D-frame* triad (with a high level of cohesiveness) or whether to liaise on innovation with them via the first-tier supplier forming a *Line* triad (with a low level of cohesiveness).

Table 6 presents an integrated view of the four conceptualized archetypes of triads and their characteristics. It provides the opportunity to discuss the conditions for the applicability of each governance archetype, thereby answering our research question.

Where buying firms lack technical knowledge, and there is a need for high technical interdependence between component parts, a *Triangle* triad ensures tight control and substantial knowledge exchange between suppliers in designing and developing new components. *Triangle* triads also leverage complementary resources as what the buying firm lacks technically is provided by suppliers. In addition, investment in relation-specific assets will be made to ensure deep and frequent knowledge exchange. In our cases, all the *Triangle* innovation projects were characterized by high technological complexity.

An *A-frame* triad is instead more appropriate when the buyer has good technical knowledge and can control first-tier suppliers providing different, less interdependent components. For these projects, technological complexity was assessed as moderate. *A-frame* triads are also appropriate for competition rather than cooperation between first-tier suppliers to avoid the risk of knowledge spillover. This feature is not an issue in the other archetypes.

Triangle and *A-frame* triads focus on the development of many, interdependent components. However, with a single critical component, innovation projects focus intensely on getting that component right, using either a *Line* or *D-frame* triad. Buying firms choose to reach around the first-tier supplier to form a direct relationship with the second-tier supplier (*D-frame*) when they have good technical knowledge and capability themselves and want tight control over the innovation. A closer look at project characteristics reveals that *D-frame* triads (as with *Triangle*) were

Table 6 Supplier innovation triad archetypes and conditions for their applicability

Project, relational view construct and project performance		*Triangle*	*A-frame*	*D-frame*	*Line*
Project characteristics	**Technological complexity**	High	Moderate	High	Moderate
	Interdependence between activities	High	Low	High	Low
	Risk of spillover	Low	High	Low	Low
Governance structure		Direct suppliers involved; three-way interaction	Direct suppliers involved; two-way interaction	Direct and indirect suppliers involved; three-way interaction	Direct and indirect suppliers involved; two-way interaction
Complementary resources		Technical capabilities; gray box involvement	Technical capabilities; black box involvement	Technical and managerial capabilities; gray box involvement	Managerial capabilities; black box involvement
Knowledge exchange	***Buyer–suppliers***	High	Very high	High	Very high
	Supplier–supplier	High	Absent	High	High
Relation-specific assets		Investments to maintain alignment in project activities' execution	Investments to maintain alignment in project activities' execution	Investments to mutually coordinate project activities' execution	Investments to mutually coordinate project activities' execution
Benefits on innovation project performance		Time and quality	Cost	Time	Cost

used with high technological complexity; this gave rise to deep knowledge exchange, higher investment in relationship-specific assets and strong leveraging of complementary resources. The finding that firms decide how to collaborate with suppliers on a project-by-project basis and, according to specific project features, introduces a contingency perspective (Hong and Hartley, 2011). Here, it is found that decisions on structuring and managing supplier relationships in innovation depend particularly on the project's technological complexity and technical capabilities in the firm and each supplier.

When second-tier suppliers' development activities affect first-tier development but not the buying firm so directly, and the buying firm does not have technical resources and capabilities, it is more likely to devolve responsibility to the first-tier supplier in a *Line* triad. Early supplier involvement is also a feature of *Line* triad innovation projects.

We can conclude that firms choose different types of triads (or governance mechanisms), according to where complementary resources reside in direct or indirect suppliers, to achieve their project objectives, depending on whether they are innovating high or moderate technological complexity products. These findings echo some of the results previously included in conceptual contributions about the governance of triadic relationships with suppliers (Choi and Wu, 2009a, 2009b; Potter and Paulraj, 2020), but in our study, the findings specifically relate to collaborative innovation projects. Further, they contribute to understanding of the interplay of RV constructs posited by Dyer *et al.* (2018).

We can also conclude that firms seek to keep certain suppliers close to them and, sometimes, with each other, according to how much technological capability they have themselves and how they manage the risks of spillover through collaborating too closely, i.e. they apply caution to "let the right one in." This conclusion supports and extends the empirical SCM literature focused on the management of coopetition in supplier–supplier relationships (Choi *et al.*, 2002; Wu *et al.*, 2010; Ried *et al.*, 2021; Potter and Wilhelm, 2020).

Finally, although establishing a causal relationship between types of triads and performance is beyond the scope of our case study methodology, our results do enrich the discussion about how dyadic and triadic supplier collaborations impact innovation project performance (Bellamy *et al.*, 2014; Ates *et al.*, 2015; Swierczek, 2019). In this study, we provide detailed evidence that, across all observed performance variables, *Triangle* triads showed good performance, particularly on time and quality. Most *D-frame* projects achieved expected time performance, but cost and quality aspects were not always satisfactory. *A-frame* performance was quite mixed, with projects achieving or exceeding cost performance expectations, but not meeting time and quality targets. For *Line* projects, cost and quality performance were always satisfactory, but some project delays were found.

7. Conclusions and future developments

This research uses the theoretical lens of the resource view to examine triadic collaborative relationships with suppliers at the innovation project level, providing a novel perspective beyond the more traditional dyadic level of analysis. Through analysis of ten collaborative innovation projects within six case organizations, the RV lens enables the theoretical identification of four archetypes of buyer–supplier–supplier relationships. These archetypes are discussed according to the RV constructs, their suitability to be used in different project types and how and why they contribute to performance outcomes in terms of cost, time and quality. These findings have several theoretical and managerial contributions, outlined in the following sections.

7.1 Theoretical contributions

This study complements prior SCM research focused on the conceptualization of inter-organizational triadic relationships (Choi and Wu 2009a; Potter and Paulraj, 2020), by providing four triad archetypes (*Triangle, A-frame, D-frame, Line*). These archetypes are shown to differ in terms of configurations of their governance structures, combination of complementary resources, investment in relationship specific assets and exchange of knowledge and information.

The research advances understanding of OI ecosystems in supply chains (Oh *et al.*, 2016), supplier collaboration (Koufteros *et al.*, 2007; Patrucco *et al.*, 2021) and the governance of tensions in supplier–supplier relationships (Wu *et al.*, 2010; Ates *et al.*, 2015; Zacharia *et al.*, 2019). Particularly, this research contributes with an empirical triadic study. In contrast, most prior studies of innovation projects have been either conceptual (Wu *et al.*, 2010) or within dyadic relationships (Patrucco *et al.*, 2021). Also, the findings and contributions are focused on the innovation project within triadic relationships and how project decisions impact performance (Markovic *et al.*, 2021), while most prior studies have been focused on firm-level findings (Van Echtelt *et al.*, 2008; Holma, 2012; Luzzini *et al.*, 2015).

Finally, the application of RV to researching OI with suppliers has previously only been marginally explored in SCM literature (Castaldi *et al.*, 2011). In particular, we ultimately posit that governance mechanisms, the combination of complementary resources, investment in relationship-specific assets and knowledge and information exchange can be deliberately designed and managed in OI triadic relationships.

7.2 Managerial implications

In the cases examined, managers chose which type of triadic configuration was appropriate in different innovation projects; however, these decisions were made based on experience and judgement, rather than managerial guidance or evidence. Identification of four archetypes of triad configuration in innovation projects, and in which circumstances each is appropriate, provides an evidence base for future managerial decisions.

In particular, the case analysis outlines the following relevant decisions for managers: which suppliers need to be involved in the project and under what circumstances; and how to engage suppliers and combine their resources into the projects, that implies choosing the appropriate governance structure, designing mechanisms to combine buyer and supplier resources, investing in the relationship and adopting formal knowledge sharing approaches.

One distinction between the triad archetypes is knowing when and how to let the right supplier in and, through the dimensions presented in Table 6, this research guides managers on when it is appropriate to invite suppliers to collaborate in innovation, when it is unwise, and how to deploy this collaboration. The relation between forming and managing different types of triads and why they give rise to different innovation project performance, in terms of cost, time and delivery, contributes to managerial decision-making.

7.3 Limitations and future research directions

The case study methodology may limit the possibility to generalize the findings to other types of innovation projects in other sectors presenting different characteristics and dynamics. Moreover, the qualitative nature of the research does not allow us to draw any conclusions about any possible causal relationships between variables – particularly how types of triads relate to specific innovation project performance. Further confirmatory research could use appropriate empirical methodologies to test the relationships emerging from the results of this study, including a longitudinal view of the RV constructs evolution over time. The choice of RV as a theoretical lens did not steer us to examine other relevant aspects of buyer–supplier relationships in innovation projects, such as the role of trust and power, or the facilitating role of the buying department and how this varies in different triad archetypes. These can all be the subject of future studies. Finally, we recognize that the innovation ecosystem literature describes innovation networks as comprising multiple actors and complex relationships. Future research might focus on more complex networks (i.e. four actors or more) and analyze how the characteristics of RV constructs might vary in different network configurations.

Notes

1 See www.flxsys.com/news/2019/3/6/flexsys-press-release-aston-martin-incorporates-flexsys-technology

2 See www.techgenyz.com/2021/01/13/saic-alibaba-collaborate-launch-new-electric-car/

3 See www.tiretechnologyinternational.com/news/testing-analysis/proovstation-partners-with-michelin-to-provide-automated-tire-and-vehicle-inspection.html

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Further reading

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Appendix 1. Within-case analysis

This section summarizes the main characteristics of the cases analyzed through the interviews.

Konsum

Konsum presented us with a project to realize a flexible totem for a dynamic exposure of products at the point of sales. Konsum viewed this project as high technologically complex, which is why they chose to encourage collaboration between a supplier responsible for the design of the technology and an engineering supplier responsible for its development. Both suppliers were formally engaged in the innovation projects as team members from early in the project, and Konsum facilitated a combination of their complementary resources from the outset. Several resources were shared between the buyer and the supplier, which facilitated knowledge and information exchange between the buyer and the suppliers and between suppliers. The project was closed one month in advance and used the planned budget. The totem was successfully introduced in 40 points of sales.

Ideafix

Ideafix viewed all two of its innovation projects as high technological complexity and sought to maximize the combination of complementary resources through as much supplier collaboration as possible but choosing different governance structures. In the Car project, the company chose to engage with two first-level suppliers of strategic components, encouraging substantial information and knowledge exchange among all the members during the whole duration of the project. Suppliers were chosen because of their technical capabilities and resources, and Ideafix put in place several investments (including intensive supplier training on quality management and continuous improvement) to facilitate communication, collaboration and effective joint decision-making. As a result, the project was considered successful, although the development of the technology was more expensive than planned. In the Diabetes project, Ideafix decided to select a direct and an indirect supplier for the development of the software also, in this case, most of the emphasis on combining complementary resources focused on combining technical resources, although managerial resources were requested to the direct supplier to favor the involvement of the second level one. Like the Car case, three-way communication and information sharing were put in place to favor knowledge exchange. However, the relationships with the suppliers and between the suppliers were complicated to be managed for Ideafix, and the project ended up having quality problems that required additional costs.

Quaser

Quaser provided two cases of projects characterized by moderate technological complexity; in both cases, a direct and an indirect supplier were involved but, although the projects shared similar technological requirements for new systems development, Quaser appeared to operate on a project-by-project basis, and a different approach in setting up the supplier innovation triad was used. While, in the Micron case, Quaser decided to keep high integration with both first- and second-level suppliers, for the Prostate project, the company delegated to the first-level supplier to combine the second-level resources indirectly in the project. This choice increased the level of information and knowledge exchange between Quaser and the first-level supplier and the number of specific assets needed to ensure triad's members were operating in an aligned way. Although the laser was successfully developed, project delays occurred (because of the delegated integration responsibility to the direct supplier). In the Micron project, instead, Quaser sought suppliers' collaboration primarily for their technical resources, although several specific investments were made here as well to favor the real-time flow of knowledge and information between the parts. Even for this case, the laser machine was successfully developed, on time, but with a good amount of extra costs.

BeEnergy

BeEnergy selected a project related to the realization of an IoT-based electrical control system for houses. In this project, characterized by moderate technological complexity, the company involved a direct and an indirect supplier for software development, trusting the first-level supplier to combine the second-level supplier's technical resources with its own. In this project, BeEnergy was relatively hands-off on the technical side of the project and only sought to integrate managerial resources with the first-level supplier. For this reason, they had a strong coordination and knowledge exchange with the direct supplier and the definition of *ad hoc* investments for the project (particularly, the definition of costs and benefits sharing mechanisms and key performance metrics at contract level to alignment between assure all the parts). As a result, the system was developed with the expected functionalities but, on both the buyer and suppliers' sides, recycles of many activities occurred, which caused a delay in the project end.

HearthChild

HeartChild described a project concerning the development of a new type of elastic bandage, classified as moderate complex from a technological perspective. The company set up the triad by involving two strategic suppliers of raw materials (fiber), from which to sought mostly technical skills and resources, but avoiding direct interaction between suppliers, to avoid knowledge spillover and strategic information leakage to other competitors. This required HeartChild to double the coordination efforts and the relationship-specific investments. Nevertheless, the product was developed successfully, and in the end, the buying company was able not to exceed the initial projected costs.

Heliland

Three innovation projects were examined in the Heliland case, and Heliland seemed to take a project-by-project approach to its choice of governance structure. In the Weapon project, two direct suppliers of strategic parts were involved, but engagement between first-level suppliers was discouraged because of spillover risks. Although knowledge exchange was intense with both partners and several specific investments were made (including a separated supplier training to favor tacit mutual coordination), the project was delayed, and the weapon system was not developed with all the planned functionalities – which limited its use in all the helicopter and aircraft models. In the Panel project, instead, Heliland chose a direct and an indirect supplier for panel development, sought to integrate the first-level supplier in project management and procurement, delegating to the direct supplier to combine required technical resources with the second-level supplier. In the Windshield project, Heliland still chose a direct and an indirect supplier for system development; still, they decided to establish a direct and formal relationship with both of them, as the overall project relied heavily on the development of an innovative material by a second-level supplier. For this case, Heliland wanted their technical capabilities to be combined with theirs and both the first- and second-level suppliers, thus working with both levels to ensure this. This case required several specific assets to assure the triad was working correctly, which favour strong knowledge creation and exchange both between buyer and suppliers and between suppliers. The windshield system was developed with performance in line with what was expected. The same situation happened in the Panel project; however, thanks to the combined use of an innovative platform for real-time innovation sharing and synchronous meetings, both the buyer and the supplier could anticipate (and avoid) several activity constraints and save costs.

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