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The Dynamics of Coordination in Innovation Networks

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Despite abundant literature dedicated to networks and coordination, few empirical studies address the internal operations of inter-organizational networks. This research therefore aims to characterize coordination mechanisms of various forms and analyse their evolution through an empirical analysis of six innovation networks. A comparative case study approach examines how three main dimensions (dependency, prior business relations, and type of conflict) influence the type of coordination adopted by a hub firm, as well as its evolution. Each case serves as a distinct experiment that stands on its own as an analytic unit. The six cases thus are discrete experiments that serve as replications and contrasts. The study reveals a negative effect of a singular reliance on trust. Indirect guarantees need to combine with direct guarantees to facilitate hub firm dependence. Moreover, the coordination modes and the use of hard conflict resolution mechanisms vary with the type of conflict (i.e., project or behavioural). These findings have key implications for research and practice.

Keywords: coordination mechanisms; dependence; hub firm; innovation network

Introduction

Empirical studies of the internal operations of innovation networks are scarce (Ahuja, 2000; Dhanaraj and Parkhe, 2006), most research focusing instead on the creation, structure or collapse of innovation networks. Yet, beyond these factors, networks comprise various elements, such as their ability to facilitate information exchange and expertise transfer while also encouraging opportunistic behaviours (Goerzen, 2007). For this study, we investigate coordination mechanisms in innovation networks, because firms must interact with others and manage these relationships to develop innovation projects. Innovation is key to competitive success (Dhanaraj and Parkhe, 2006), but innovation projects entail great transactional uncertainty and exchanges of tacit knowledge, requiring strategic efforts to maintain the network and extract value from it (Powell *et al.*, 1996; Ahuja, 2000).

Hub firms expressly function to orchestrate innovation networks. Prior research on innovation network orchestration (e.g., Dhanaraj and Parkhe 2006; Batterink *et al.*, 2010) typically has assumed that a commercial firm is the focal knowledge acquirer (e.g., Doz *et al.*,

2000), but has not clarified the unique role of the ‘network orchestrator’ that exerts influence without any hierarchical authority (Dhanaraj and Parkhe, 2006). As Winch and Courtney (2007) warn, the question of how innovation hub firms operate and the conditions in which they are most effective remains unanswered (Batterink *et al.*, 2010). Literature on coordination mechanisms highlights factors such as dependence (Gao *et al.*, 2005; Grandori and Soda, 1995; Jiang *et al.*, 2008), prior business relations (Reuer and Arino, 2007; Jiang *et al.*, 2008), or the type of conflict (Das and Teng, 2002), though only individually (Das and Teng, 1998), and without analysing their detailed implementations. To remedy this situation, we investigate coordination mechanisms within innovation networks and their development throughout the process, thus answering our research question: How do dependence, prior business relations and the type of conflict affect coordination mechanisms, their forms and their development?

In the next section, we offer a brief review of research into coordination mechanisms in innovation networks and discuss dependency according to resource dependency theory (Pfeffer and Salancik, 1978). We also address two dimensions that might influence coordination mechanisms: prior relations and type of conflict. By examining six innovation networks, we compare the coordination forms used by the hub firms over the course of their innovation projects and derive an answer to our

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research question. This comparative case study approach also enables us to examine the influence of the dimensions on coordination modes. By tracing the evolution of six innovation networks, we identify changes in the modes over time. In this respect, comparative case studies are particularly appropriate for studying organizational changes (Van de Ven and Poole, 1990). Finally, we conclude with some current limitations and avenues for further research.

Theory

Innovation networks – which consist of sets of vertical and horizontal relations established among various organizations that are orchestrated by a hub firm so it can take advantage of invention(s) – offer a fertile ground for understanding the evolving ways firms implement coordination mechanisms. A hub firm is one ‘that possesses prominence and power gained through individual attributes and a central position in the network structure, and that uses its prominence and power to perform a leadership role in pulling together the dispersed resources and capabilities of network members’ (Dhanaraj and Parkhe, 2006: 659). Having filed a patent application the hub firm calls on network partners to transform its invention into an innovation, though in this process, it must regulate the transactions (Powell *et al.*, 1996). The hub firm is central to innovation networks and has authority over other members, derived from its property rights; unlike R&D consortia, filed patents belong only to the hub firm. Moreover, by establishing the network, the hub firm has the most links with all other members (Drewello *et al.*, 2002): It holds a central position and is in charge of most coordination mechanisms.

Coordination mechanisms and innovation networks

Coordination mechanisms are arrangements among economic entities that govern how they cooperate to develop an innovation project (Grandori and Soda, 1995). This definition centres on strategic interactions rather than operational ones (e.g., task distribution, communication). Similarly, prior research has proposed that coordination in inter-organizational relations can be achieved through strategic mechanisms such as reputation, trust, collective sanctions, working groups, procedures, costs and revenue-sharing rules (Grandori and Soda, 1995; Das and Teng, 1998; Gilsing and Nooteboom, 2006). In various typologies of coordination mechanisms, authors distinguish formal versus informal mechanisms, exchange regulation versus incentive or sanction schemes, or transactional versus relational modes. We avoid these simple classifications, which seem insufficient to analyse the different forms of each

mechanism.¹ Yet the vast number of coordination mechanisms means we cannot be exhaustive. Instead, we focus on five representative, well-studied mechanisms: type of exchange and degree of formalization; trust; shared benefits; guarantees and conflict resolution² (see Appendix 1).

Type of exchange and degree of formalization. Formal exchange mechanisms include standardized procedures, technical reports, analytical accounting, budgeting and planning, as well as confidentiality agreements and contracts (Martinez and Jarillo, 1989; Gulati, 1995a; Das and Teng, 1998). Informal exchanges, which are implicit and verbal, instead include the creation of joint teams (Grandori and Soda, 1995), seminars, meetings or staff transfers (Martinez and Jarillo, 1989), as well as decision making methods. Informal modes are less costly (Gulati, 1995a), increase strategic flexibility and reduce the risk of conflict (Nooteboom *et al.*, 1997), but they also require more time to implement (Das and Teng, 1998), which can mean product obsolescence in an innovation network. Finally, existing contractual theories (e.g., transaction costs, positive agency, incomplete contracts) mainly suggest two measures of the degree of formalization in exchanges: the existence of a contract and the number of clauses, as well as the forms of the exchanges (e.g., written and explicit or not).

Inter-organizational trust. Trust is an underlying psychological condition that may be the cause or result of a specific behaviour (cooperation) or choice (risk) (Woolthuis *et al.*, 2005), though it also has been portrayed as an informal arrangement (Dyer and Singh, 1998; Martinez and Jarillo, 1989), or complement to contracts (Dyer and Singh, 1998; Poppo and Zenger, 2002). Variations in risk and interdependence can affect the degree of trust (Cullen *et al.*, 2000), which in turn has a direct influence on partnership success (Morgan and Hunt, 1994), especially in uncertain environments. For example, in an innovation project setting, trust can induce predictions of network members’ behaviour (Ring and Van de Ven, 1994). Because unforeseen events are inherent to innovation networks, it is impossible for contracts to be comprehensive, so some trust must exist. We consider three possible states: trust; mistrust; and no trust.

¹For example, conflict resolution arrangements include joint resolution (informal), persuasion (informal), coercion (informal), sanctions or recourse to a third party (both can be formal or informal, but generally formal and contracted). Moreover, some seemingly informal arrangements are written into contracts.

²We acknowledge freely that many other mechanisms (or governance modes) could be studied, especially those of a relational nature, such as common culture, reputation or inclusion in social networks.

Shared results. An essential element of cooperation is the determination of how outcomes get shared among members. An equitable division (i.e., each member's payoffs are a function of its contribution) can give project members an incentive to work harder, which should improve the overall performance of the innovation project (Kabanoff, 1991). An equal share instead implies that the parties (hub firm and members) each receive the same share of the outcomes, regardless of their investment. Whether planned *ex ante* or not (an important distinction in positive agency theory), the distribution can be either fair or equal (cf. theory of incomplete contracts).

Guarantees. These mechanisms attempt to prevent opportunistic behaviour (Min-Ping *et al.*, 2009), by making it expensive for opportunist members to exit. We distinguish immediate or direct guarantees, which pertain to specific assets, from deferred or indirect guarantees, which instead affect reputations or future business opportunities. Accordingly, this tool can take multiple modes: no guarantees; direct; indirect; or a mixture. The direct modes imply immediate reactions to members' behaviours, whereas indirect modes strike a later blow to the opportunist's reputation (Rubin, 1990) or exclude the member from further business opportunities. This latter consequence appears very useful as a guarantee, because firms usually join networks specifically to gain business opportunities (Brunetto and Farr-Wharton, 2007).

Conflict resolution. An innovation network contains multiple possible interactions: two-to-two; one-to-several; and several-to-several (Gomes-Casseres, 1994). If a conflict arises between technical partners, another member (e.g., hub firm) can intercede to resolve the issue – a notion not previously addressed in network literature. Conflict resolution mechanisms are highly complex in innovation networks and must reflect the heterogeneous levels of network members' commitment. Thus it is difficult to give an *ex ante* description of a conflict resolution mechanism, and we followed Mohr and Spekman (1994) to select five mechanisms³ that likely describe multilateral relations in innovation networks: (1) joint resolution of a problem, such that the parties agree to work together to find a mutual solution; (2) persuasion, which occurs when one party tries to persuade the others that a particular solution is the best outcome; (3) coercion, such that one partner forces others to accept its preferred solution; (4) sanction, in

which case a network member is expelled; and (5) introduction of a third party to obtain recourse to arbitration.

In Appendix 1 we summarize these coordination mechanisms and forms, as well as the main theories on which they are based. These coordination mechanisms help reveal the inner workings of inter-organizational relations, especially innovation networks. Prior research has identified the overall potential impact of network dimensions such as hub firm dependence, prior relations and type of conflict, but to the best of our knowledge, no studies address their separate impacts on each mechanism and its implementation.

The influence of dependence, prior relations and conflict type

Three inter-partner relation dimensions are critical determinants of which coordination mechanisms are used: dependence (Ambos and Schlegelmilch, 2007); prior relations (Jiang *et al.*, 2008); and conflict type (Das and Teng, 2002).⁴

Dependence. In an innovation network, partners share scarce resources which creates dependence. A classic definition notes that the 'dependence of an actor A, on another actor B, as directly proportional to A's motivational investment in goals mediated by B, and inversely proportional to the availability of those goals to A outside of the A-B relation' (Emerson, 1962: 32). Ambos and Schlegelmilch (2007) show that increasing levels of dependence lead to more socialization and formalization; other studies (Baliga and Jaeger, 1984; Gupta and Govindarajan, 1984; Gencturk and Aulakh, 1995), report positive relationships between dependence and control. Dependence also influences parties' perception of the benefits they receive (Doz, 1988), and the use of guarantee systems and conflict resolution mechanisms. In dependency situations, partners often resort to coercive and punitive actions (Kumar *et al.*, 1998; Lui *et al.*, 2006), because asymmetric dependency influences inter-firm trust, which is critical to the development of long-term relationships (Kumar *et al.*, 1995). That is, dependency relationships are more dysfunctional and less stable than symmetric relationships, so they make it more difficult to develop trust. A high level of dependence leads to less trust (Kumar *et al.*, 1995), more control (Ambos and Schlegelmilch, 2007), less relationship continuity and less cooperative behaviours.

³Mohr and Spekman (1994) added domination as a sixth mechanism for bilateral relations. In the multi-lateral relations we study, domination is largely indistinguishable from coercion.

⁴Inter-organizational relations also are affected by other dimensions (e.g. past alliance history, partnership experience, cognitive interpersonal connivance, communication, commitment, type of opportunism). Our purpose is not to develop an exhaustive list (Jiang *et al.*, 2008) but rather to focus on those that appear the most determinant.

Prior exchange relations. Innovation networks can include unfamiliar partners or repeated ties with the same partners. With unfamiliar partners, contractual agreements and formal mechanisms serve to deter opportunistic behaviour. The lack of mutual understanding and trust causes partners to feel uncertain about the future (Ring and Van de Ven, 1994; Doz, 1996; Jiang *et al.*, 2008). Prior relations thus can be a valuable asset that enables partners to develop relational capability and capital (Dyer and Singh, 1998). Partners invest in relationship building and bear relationship-specific set-up costs (Reuer and Arino, 2007). Familiar partners also develop a good understanding of their partners' procedures, management systems and cultures, which can mitigate *ex post* coordination, conflict resolution or information-gathering issues that formal contractual provisions otherwise attempt to address (Reuer and Arino, 2007). Relationship-specific knowledge also develops from frequent and intense partner interactions, which can enhance cooperation efficiency (Dyer and Singh, 1998). Regular relations increase mutual trust and reduce the need for contractual safeguards (Gulati, 1995a), so the partners avoid the costs of more complex collaborative agreements (Reuer and Arino, 2007). Gulati (1995b) also shows that more prior alliances lower the likelihood of subsequent equity-based alliances. However, Goerzen (2007) finds that the propensity to repeat equity-based partnerships has a negative influence on economic performance, particularly in environments marked by technical uncertainty (e.g., innovation networks). Thus, prior relations likely lead to commitment and the development of relationship-specific assets, such as mutual knowledge of partners' procedures and values. Repetition over time also creates opportunities for mutual learning that encourage the development of trust (Inkpen and Currall, 2004).

Conflict type. In innovation networks, partners have individual interests that are not necessarily congruent with their partners' (Das and Teng, 2001). Conflicts, which refer to the degree of divergence in partners' preferences, interests and practices (Hardy and Phillips, 1998), arise because of the inherent uncertainty and interdependencies between parties (Mohr and Spekman, 1994). Das and Teng (2002) strongly recommend taking this dimension into account in analyses of cooperation agreements; because conflicts arise for various reasons, their sources affect cooperation in different ways. We consider two main types (Mooney *et al.*, 2007):

1. Cognitive conflicts appear when partners disagree about a task. In innovation networks, partners might have different views about the best technical solutions, and to resolve the cognitive conflict, they might exchange ideas during meetings (informal coordination) (Amason, 1996). Cognitive conflicts generally

improve decision making by fostering more mutual understanding (Mooney *et al.*, 2007);

2. Affective conflicts involve personal disagreements, such as power struggles or personal incompatibilities over private interests and opportunistic behaviour. Partners' incompatible goals could lead them to try to maximize their private benefits without furthering common benefits, such as by adopting opportunistic behaviours to appropriate others' tacit knowledge (Das and Teng, 2002). Even with an explicit contract, firms rarely seek legal penalties in response to affective conflicts (Lee and Cavusgil, 2006). Moreover, inter-organizational trust decreases when one partner displays dysfunctional behaviours (Morgan and Hunt, 1994; Lusch and Brown, 1996).

With Appendix 2 we summarize literature pertaining to these dimensions and their effects on the coordination mechanism(s). Accordingly, we derive the theoretical model in Figure 1.

Methods

Despite research into each coordination mechanism, no studies address the dynamic processes in innovation networks that may affect their implementation or use; therefore, we adopt a qualitative approach to explore these phenomena.

Case selection

We opted for a qualitative case study methodology to gain a comprehensive, in-depth understanding of which coordination mechanism is best suited to each situation, as defined by hub firm dependence, prior relations and type of conflict, as well as over time. The six case studies constitute a theoretical sample (Glaser and Strauss, 1967); we took great care to select innovation networks of different sizes and in different sectors⁵ (see Table 1) that also share common characteristics (Miles and Huberman, 1994). All the chosen networks focused on technological innovation, contained at least three members, were structured around a small hub firm and included members of different sizes, including very large firms (see Appendix 3).

We focus on the hub firms for several reasons. Small and medium-sized enterprises (SMEs) often form links to obtain access to required assets, and learn new skills (Powell *et al.*, 1996). By taking a central role, the hub firm gains power and influence in the network (Wasserman and Faust, 1994), so the study of its dependence

⁵Most prior innovation network studies feature biotechnology or information technologies (Gilsing and Nooteboom, 2006). We selected cases from other sectors as well.

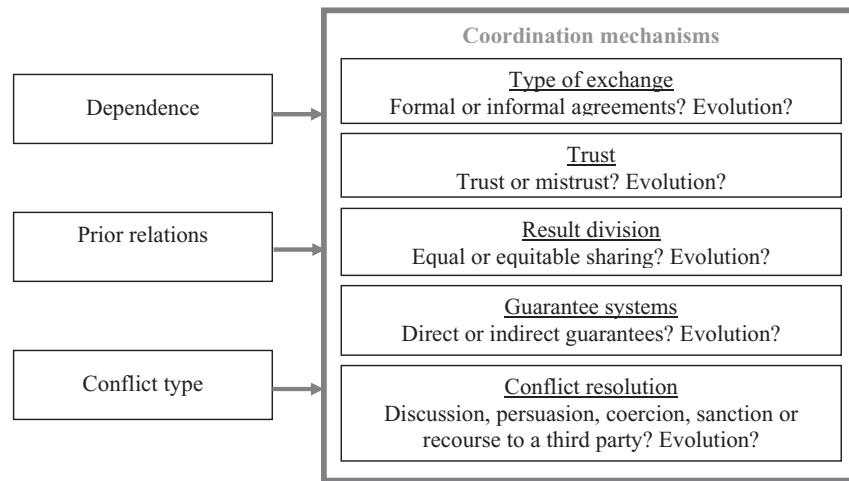


Figure 1 Theoretical model of coordination mechanisms

Table 1 Six innovation networks studied

Project	Hub firm	Number of members	Subject	Business sector	Characteristics
Project A Motorization	SME (12 people)	65	Essential component for automobile manufacturers	Automotive	Highly ambitious: very high investment and highly technical
Project B Pinc&Pile	SME (2 people)	8	Product for beauticians (business-to-business)	Large-scale retail	Significant conflict; the commercial and industrial partners claimed property rights on patents already filed
Project C Telescopic	Independent (1 person)	11	Product for everyday use	Large-scale retail	Stagnant project; oligopolist target market leading to distribution problems
Project D Transparts	SME (3 people)	9	Machine improving the processing of small parts	Industry	Opportunistic behaviour by commercial partner, with complementary patent filed without notification
Project E Protect	SME (6 people)	24	Protection for sports	Sports and leisure	Project running successfully without too many problems
Project F Jump	Independent (1 person)	6	Sports material	Sports and leisure	Hub firm benefited from the experience of another project sponsor

relationships becomes particularly interesting, especially for SMEs. Moreover, innovation networks typically involve high levels of transactional uncertainty and exchanges of tacit knowledge, such that coordination among actors is necessary and difficult. Finally, size asymmetry (e.g., small hub firm and large partners) tends to affect the management of alliance relations and the coordination mechanisms implemented (Oliver, 1990).

Data collection and coding

Fifty-three interviews (see Table 2), conducted between March 2006 and February 2008, included the members of six innovation networks, including project bearers and financial, technical, industrial, commercial and legal members.⁶ They averaged 90 minutes in length. The

⁶For confidentiality, we cannot provide the names of the inno-

semi-structured interviews were designed to identify coordination mechanisms implemented by the hub firms, so we first asked informants to describe their project and how they coordinate with others. Next we focused on coordination modes and prepared a map of each network, which informed further interviews.⁷ The maps helped interviewees describe the coordination modes they used with different members. To complement these data, we gathered internal e-mail exchanges between project members; notes made by the hub firm in progress reports, business plans and contracts; and external sources such as Internet and press articles, which offered triangulation in most cases. For each case, we examined a range of relations (approximately 100 in

vation projects. The members – a term that refers to an organization, not an individual – are combined to indicate the mean number per year of observation.

⁷The maps are available on request.

Table 2 Data collected in six innovation networks

<i>Information sources</i>	<i>Interviews</i>	<i>Frequency and total duration of passive observations</i>	<i>Internal data</i>	<i>External data</i>
Motorization (A)	13 5 hub firms 5 technical members 2 financial members 1 industrial member	Very frequent 7 days	Contracts (7) Funding request files (2)	Internet site 54 press articles
Pinc&pile (B)	9 3 hub firms 2 legal members 1 technical member 1 financial member 2 industrial members	Frequent 3 days	Contracts (3) File for innovating project contests (1)	20 press articles
Telescopic(C)	6 2 hub firms 1 legal member 2 technical members 1 financial member	Not frequent 1 day	Meeting reports (8) Email exchanges (50)	Internet site 28 press articles
Transparts (D)	7 2 hub firms 2 legal members 2 financial members 1 commercial member	Not frequent 1 day	Email exchanges (25) Legal mails from lawyers (13)	Internet site 12 press articles
Protect (E)	10 4 hub firms 1 legal member 3 technical members 1 industrial member 1 commercial member	Very frequent 5 days	Contracts (16) Email exchanges (10)	Internet site 35 press articles
Jump (F)	8 2 hub firms 1 financial member 2 technical members 1 industrial member 2 commercial members	Not frequent 2 day	Contracts (3) Email exchanges (20)	Internet site 8 press articles

total⁸) between hub firms and network members. For example, in project A, the hub firm contacted 29 technical members: 11 partners and 18 service providers.

To code the data from different sources, we used content analysis procedures (Strauss, 1987). First, we coded all data into categories, according to our theoretical model (Yin, 1989), that reflect the five coordination mechanisms and three dimensions. Second, we created subcategories for each mechanism. For example, the conflict resolution subcategories were its five modes: joint resolution, persuasion, coercion, sanction and third-party arbitration. Third, a second researcher recoded a random selection of 15% of the data (eight interviews). This double coding check ensured consistency in the classification of the verbatim comments.

⁸The lack of precision in the number of relations studied reflects the complexity of the topic. Most interviewees referred to a group of members (i.e., technical members) rather than individual firms.

Results

In discussing our results regarding the influence of the three dimensions on the five coordination mechanisms, we detail each one and link the findings to theoretical literature.

Degree of formalization

As we show in Figure 2, none of our innovation networks was composed exclusively of members with which the hub firm had had previous relations. Instead, they relied on formal exchanges, such as confidentiality agreements at a minimum, to protect their inventions. The level of dependence influenced the degree of formalization; informal exchanges arose when the level of dependence was low, because that situation lowered the risk for the hub firm, and informal arrangements reduced any contractual costs. This solution also facilitated exchange flexibility and adaptability for the future development of the innovation project:

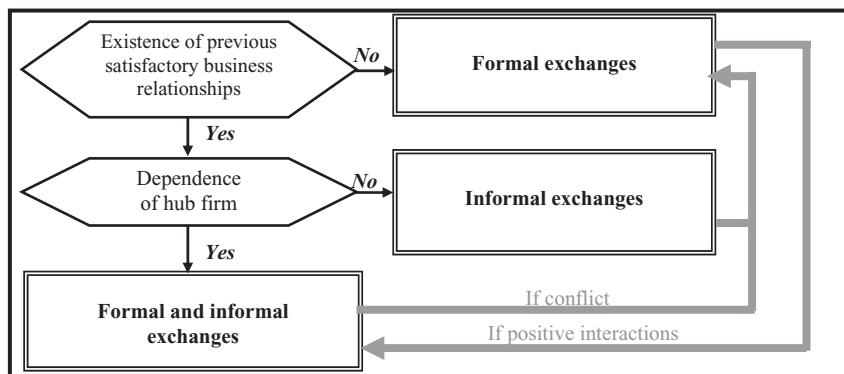


Figure 2 (Re)defining the degree of formalization

If the company with which you work can easily be replaced by another, it is not necessary to sign a partnership agreement. A confidentiality agreement is sufficient. It is long and costly to draw up a partnership contract, especially if you do not possess the required legal competence (Managing director, Transparts).

With greater dependence, the hub firm found informal arrangements insufficient and supplemented them with formalized relations. Formal contracting represented its attempts to reduce the risks of opportunistic or defective behaviour:

You can never know for sure how your partner will behave. Signing a contract doesn't mean that you will be fully protected but it will limit the risks. We've been involved in partnerships in the past and I know that partners' objectives can change over the course of the cooperation. The contract will serve as a reminder of their original commitment. This is very important, especially when this partner plays an important role for the project (Managing director, Protect).

The degree of exchange formalization also changed as interactions developed. A partner that is loyal to the hub firm and shares a common vision of the project encourages the emergence of informal relations; if conflict arises, the degree of formalization instead increases. Unlike informal discussions, formal exchanges (e.g., contracts, letters, e-mails, written reports) offer tangible evidence of how cooperation evolves, and in a dispute, they provide concrete evidence for a court or arbitrator. However, we did not observe any development from formal to exclusively informal arrangements.

Trust

Hub firms tend to be cautious when they are dependent and have had no previous relations with another member. A member with an essential role may be tempted to pursue selfish goals and take advantage of its position to impose its vision to the hub firm. If the hub firm has a less than positive perception of the member's

intentions, it needs high expectations of that member's expertise and efficiency (i.e., competence-based trust; Zucker, 1986):

We are well aware that there are significant risks involved when cooperating with such a company, but we don't have much of a choice. I chose these partners because they could really help us for this project. They are highly recognized in their sector (Managing director, Jump).

Without prior relations but also without dependency, other coordination mechanisms arise, such as guarantees, conflict resolution arrangements or exchange formalization. In this situation, hub firms often tested how members behave. If the member reaches the objectives set by the hub firm and demonstrates high commitment to the project, trust can develop. For example, a provider in the Motorization network agreed to execute additional tasks requested by the hub firm, leading to enhanced trust between them:

This is a very nice project and I think it will be a big success. It is interesting for me to be associated with this project because I can learn a lot and it also highlights our knowledge. Currently, we are just providers; but by showing the hub firm how we can contribute to the project, we hope to become a partner. We must therefore adopt an exemplary behaviour (Engineer, Motorization).

As Figure 3 indicates, when all runs smoothly in the project, trust develops; if not, mistrust emerges. In an exchange, it is possible for trust and mistrust to alternate. For example, unfulfilled commitments in the Transparts network turned trust into mistrust. If the conflicts related to cooperation are not resolved, the hub firm may even consider the member an enemy to confront (i.e., win-lose game).⁹

⁹Our configurations only include arrangements by the hub firm that favoured progress for the innovative project.

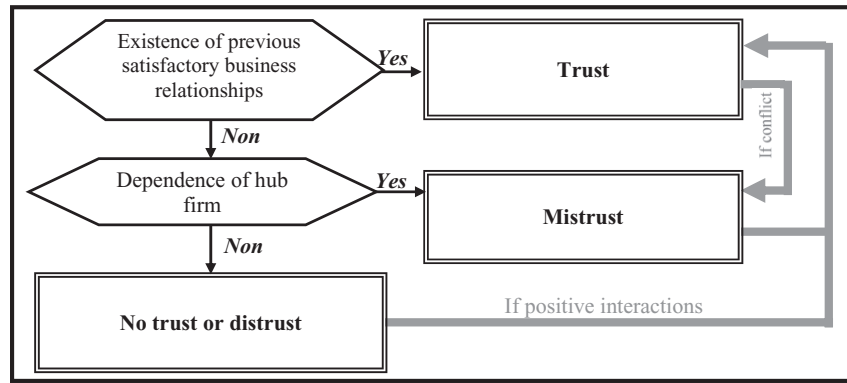


Figure 3 (Re)defining trust

Shared results

The distribution of outcomes, generally agreed on *ex ante*, was equitable in most cases, as we show in Figure 4. This division existed even when the hub firm was dependent or had no previous relation with the member. The consensus objective was to encourage members' involvement:

If you want to work with a company like PSA Peugeot Citroen, it is necessary for its percentage of retribution to be equivalent to its input, otherwise you can just dream that they'll work with you (Managing director, Motorization).

Yet the intangibility of certain resources prevents precise assessments of members' contributions, so other allocation methods are difficult to implement. Distribution rules are not static but instead get renegotiated with changes in the hub firm's level of dependence and trust, particularly as cooperative experience with another member increases. For example, with its industrial provider, the hub firm in the Pinc&pile network shared outcomes proportional to financial commitments. As trust increased, the division grew more balanced, though without ever becoming equal. Transitions from an equal to an equitable division also occurred when the partner's level of commitment was less important than initially anticipated (e.g., Telescopic network). A lack of involvement may relate to free-riding behaviour (e.g., Transparts) or changes in the resources and skills required for the project. However, when equal distribution did not appear at the start, it was never introduced later, usually to avoid potential conflicts stemming from perceptions of injustice by members who had been involved from the beginning:

You cannot treat a partner who's been with the project since its beginning in the same way as a partner who came on board later on. It would be unfair because the risks taken by a partner decrease with the progress of

the project. Consequently, recent partners cannot receive the same part of the results (Managing director, Telescopic).

Nor was there any evolution toward an egalitarian distribution, for similar reasons; initial members would not have understood this privilege, increasing the risk of conflict.

Guarantees

Cooperative contracts are inherently incomplete and cannot anticipate all risks associated with an innovation project, so hub firms rely on different types of guarantees. For example, in the Protect case, the hub firm formalized its exchanges with members but also used guarantees based on reputations or the purchase of specific machines to protect itself from potential opportunistic behaviours. The more dependent the hub firm, the more it protected itself by combining direct and indirect guarantees, as Figure 5 shows. The hub firms used safeguards to prevent opportunistic behaviours or exit by members that were critical to the project:

In the contract we specified that the company was to invest in specialized machinery and that we would pay them three months after delivery. So if any problems arose we would have time to identify them and to react. There were also penalties for late deliveries (Managing director, Jump).

Without prior knowledge of the member, the hub firm turned to direct guarantees. For example, in the Motorization network, a technical partner was required to purchase a highly specialized machine to test certain parts; the machine could not test other types of parts and thus represented a direct guarantee for the hub firm. Indirect guarantees, mostly based on potential reputation damage, also were available, though only when the hub firm was dependent and had cooperated successfully in

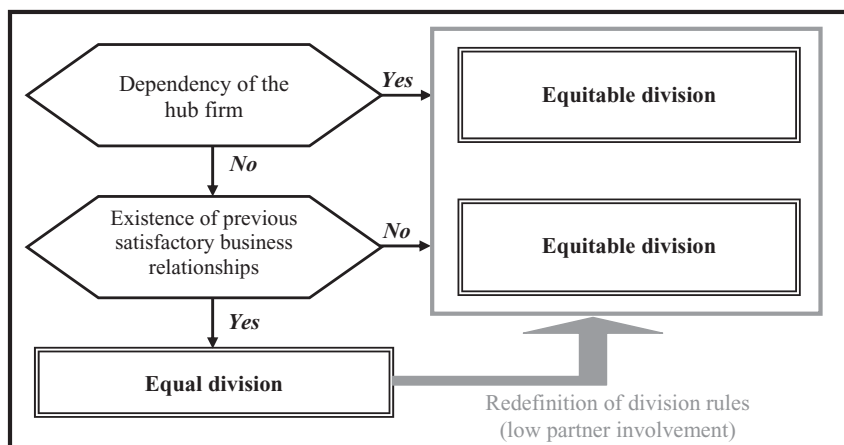


Figure 4 (Re)defining outcome divisions

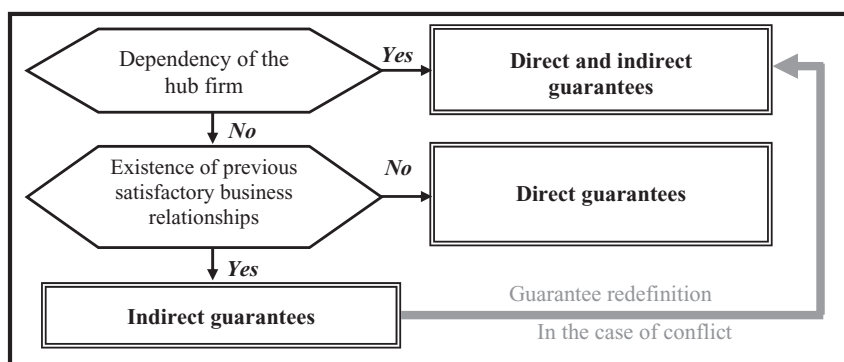


Figure 5 (Re)defining guarantees

the past with the member. The hub firm in the Telescopic case was dependent on its commercial partner and protected itself only through indirect guarantees. It was not in a position to act when the member was bought by another firm and left the project:

This partner did not provide sufficient guarantees. It is a large firm and I was not in a position to negotiate. However, I will not proceed like that next time because it is too much of a risk: without this type of firm it is not possible to continue with my innovation project (Managing director, Telescopic).

In the Jump project, the hub firm could affect the reputation of members with which it had close ties; thus, it used only indirect guarantees with one technical partner that offered commonly available, easily substitutable competencies and with which it had previous positive relations.

The types of guarantee change in the case of conflict or when hub firms reduce their dependence (e.g., Jump and the purchase of specialized machinery). If conflict resulted from opportunistic behaviour by a partner, indirect guarantees were backed by direct guarantees:

At the start I did not require many guarantees from this technical member because they were not essential to the project. But we had some trouble with them, so we decided to add a clause to the contract to include a penalty for late delivery (Managing director, Motorization).

In the Transports case, the hub firm noted its past relation with its commercial partner and its low degree of dependency and therefore opted for relations based on trust, informal exchanges and indirect guarantees. When that partner filed a complementary patent though (for powders, whereas the hub firm’s patent covered solids and liquids), it implemented new guarantee procedures and grant back clauses,¹⁰ stipulating that the firm had the right to use any innovation introduced by members during the project. Conversely, despite any emergence of

¹⁰A grant back clause is a ‘provision in a licensing agreement under which the licensee is required to disclose and transfer all improvements made (including related know-how acquired) in the licensed technology during the licensing period’ (<http://www.businessdictionary.com/definition/grant-back-clause.html>).

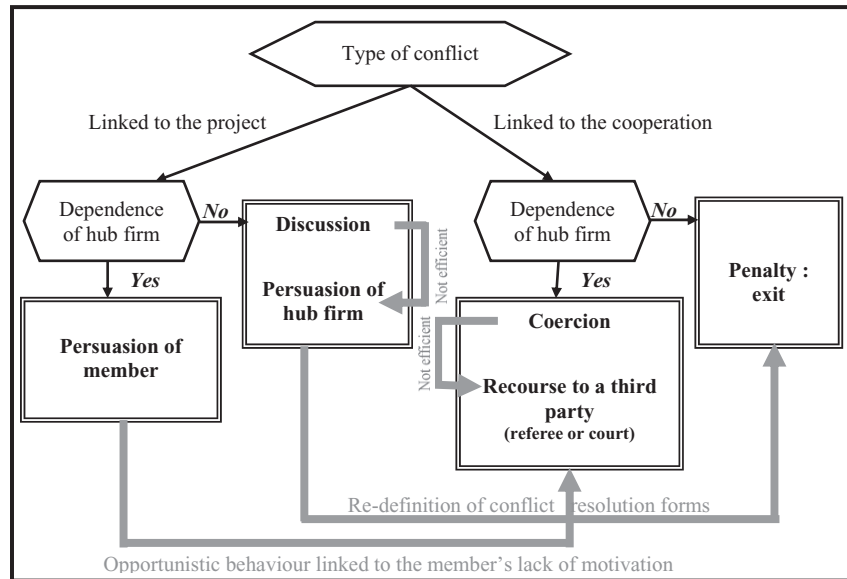


Figure 6 (Re)defining conflict resolution forms

trust, direct guarantees generally were included in the original contract and could not be replaced completely by indirect guarantees.

Conflict resolution

When a conflict situation arose, as can occur at any time in an innovation project, the hub firm took resolution measures that reflected its degree of dependence and the type of conflict, whether cognitive or affective (see Figure 6).

First, if the conflict related to the project and the hub firm was not dependent, the hub firms all communicated with their partners to resolve conflicts, that is, to ‘calmly solve them through dialogue’. If any issues remained unresolved through discussion, the hub firms attempted to persuade other members to adopt their own choices. Only if this solution failed to satisfy all members would it lead to a loss of motivation and thus the risk of opportunistic behaviour.

Second, when conflict related to the project but the hub firm was dependent, its patents could not guarantee that the hub firm had bargaining power, so the persuasion flows reversed, from member to hub firm. The influential member would convince the hub firm to adopt a solution favourable to its own interests. For example, in the Jump project, the technical partner chose the materials that best served its interest.

Third, for cooperation conflict with a non-dependent hub firm, such that the partner displays minimal commitment and acts opportunistically, the hub firm generally prefers exit by the member, because it can select another partner. This sanction is faster than engaging in lengthy discussions, which could affect the project’s

progress. Replacing a member also is no more expensive than rebuilding a relation destroyed by treachery.

Fourth, when the hub firm was dependent and faced conflict linked to cooperation, it used coercion or a third party to resolve the conflict. Its dependence means the hub firm must rely on still other members; together, they all force the defaulting member to surrender. In addition, it may also appeal to an arbitrator, if this route has been specified in the contract. Otherwise, it would appeal to the courts and allow a third-party judge to settle the dispute. Such arrangements leave little hope of reviving cooperation, as both the Pinc&pile and Transparts cases showed. In both cases, the defaulting member exited, but the procedure entailed two challenges: It is long – legal proceedings can even exceed the duration of the project – and it is costly, especially for small firms. However in some cases, the hub firm must turn to this method because the contract did not contain an arbitration clause or the conflict involved betrayal.

Discussion

Whereas previous work on innovation networks has focused on one or two coordination modes and used a static approach, we adopt a more integrative and dynamic perspective to analyse how hub firms coordinate their networks.

Risk of low formalization

Trust as a complement to formal mechanisms. By accounting for the role of dependence and the potentially negative influence of prior relations, this study

adds nuance to the debate about the relationship between contracts and trust (Poppo and Zenger, 2002). A widespread assumption holds that trust correlates positively with successful cooperation and, though it may fluctuate (Ring and Van de Ven, 1994), generally increases the level of partner satisfaction (Lei and Slocum, 1992). However, this study shows that it also can turn into mistrust, such that trust and mistrust are endpoints on a continuum (Lewicki *et al.*, 1998). The level of trust needed between members is difficult to determine (Hamel, 1991) and maintain: Either too much or too little trust leads to poor resource and skill transfers (De Wever *et al.*, 2005), which have significant consequences for both the project and the hub firm. Some authors (Kumar *et al.* 1995; Gao *et al.*, 2005), consider this question as a function of the degree of dependence between members. Although trust strengthens the level of commitment (Cullen *et al.*, 2000), which might intensify the degree of dependence (Das and Teng, 2001), our case studies reveal that the degree of dependence is secondary. Instead, previous business relations play a more important role for promoting trust (Gulati, 1995b; Goerzen, 2007). As do Dyer and Singh (1998), we have observed that prior successful relations facilitate trust. In all six cases, trust and formalization are not systematically linked.

In this sense, we consider two streams of literature. First, challenges to the excessive use of transactional modes lead to calls to use socio-cognitive modes such as trust instead (Nooteboom *et al.*, 1997; Woolthuis *et al.*, 2005). In this case, trust represents an informal arrangement, though some authors also maintain its complementary nature with contractual arrangements (Martinez and Jarillo, 1989; Dyer and Singh, 1998; Poppo and Zenger, 2002). Second, trust appears as a coordination mode, complementary to exchange formalization (Langfield-Smith and Smith, 2003). Thus it could be a specific mode of control (Inkpen and Currall, 2004), or a contextual variable that influences the level of formalization (Ring and Van de Ven, 1994; Das and Teng, 1998).

Our study reveals trust as complementary to and not substitutable with formal coordination modes. Establishing an exchange relationship based solely on trust could prove dangerous (e.g., Pinc&pile, Transparts), leading to wasted time and weak motivation. Furthermore, a detailed contract does not appear detrimental to cordial behaviour or trust (Lee and Cavusgil, 2006), contrary to the idea that high formalization destroys trust or exacerbates conflicts (Nooteboom *et al.*, 1997; Woolthuis *et al.*, 2005). In the six innovation networks we studied, contracts instead facilitate trust, because drawing up the contract required frequent exchanges. This lengthy negotiation phase offered members an opportunity to communicate, get to know one another, and express their motivations and objectives.

Perhaps our results reflect the relatively small size of all six hub firms. Research with a relational perspective (e.g., Gulati, 1995a; Dyer and Singh, 1998), suggests a de-emphasis on contracts, such that partners switch from contractual to relational coordination, when there is a high level of goodwill trust and mutual expectations of reciprocity (Zucker, 1986). Our results offer a different perspective: We found no evidence that positive goodwill trust dynamics reduce the importance of contracts. Rather, trust clearly is a complement to formal modes. Thus:

Proposition 1a: In an innovation network with a small hub firm, a sole reliance on trust, even if prior relationships have been successful, has negative consequences.

Our results challenge the role of trust as the social glue that keeps members together (Faems *et al.*, 2008). Unlike previous research that suggests that poor goodwill trust contributes to partnership dissolution (Doz, 1996; Arino and de la Torre, 1998), we observe no such effects. In the Jump and Protect projects for example, regardless of their negative goodwill trust dynamics, the partners negotiated new contracts involving the same members. Hub firms explained their decision by describing their technological dependence on a competent partner that could ensure project success (Faems *et al.*, 2008). These findings suggest that competence trust (Nooteboom 2007; Zucker, 1986), or a belief in the partner's ability to meet expectations, might be more important than goodwill trust. Thus, we propose:

Proposition 1b: In an innovation network, relying on competence trust benefits the project more than relying on goodwill trust.

Insufficient indirect guarantees. The guarantees we found were not limited to financial guarantees but also extended to specialized assets and brand image. In uncertain environments, such assets modify the degree of interdependence (Thomke and Kuemmerle, 2002). By forcing a member to invest in specific assets, the hub firm can increase the member's dependency while decreasing its own (Dyer and Singh, 1998). Using its central position within the network, the hub firm also can influence members' reputations and future business opportunities. The more dependent the hub firm, the more it tended to protect itself using a combination of direct and indirect guarantees. If the partner brought key resources to the project, guarantees tended to include both investments in specific machines or financial delay penalties and threats of reduced future business opportunities; the hub firm's main objective was to minimize the risk of partner exit. We thus confirm the need for multiple guarantees in non-recurrent transactions:

Proposition 1c: In an innovation network with a highly dependent hub firm, a combination of direct and indirect guarantees can advance the project.

Sense of justice in equitable distribution. The equitable distribution of outcomes is more effective for curbing opportunistic behaviour (Gulati, 1995b; Das and Teng, 1998), because it binds members to the hub firm and network. A member probably will not risk jeopardizing its relationship by exploiting the hub firm's specific investments if it has an equal stake in the project (Das and Rahman, 2010). Before launching the project, the members agree on the returns they will receive, and an equitable distribution appears to be the preferred solution (Jap, 2001), especially in innovation networks characterized by high uncertainty. Equity also offers a means to legitimize the resource allocation, because the issue of fairness persists throughout the project's lifecycle, particularly because the sense of distributive justice is critical in innovation networks. Equitable distribution as an incentive can promote project performance (Kabanoff, 1991; Jap, 2001). An opportunistic member cannot expect cooperation from the hub firm in its withdrawal process and will find it difficult to recover its equity stake. That is, 'The value of the tied-up equity that an opportunistic partner risks losing would raise the required threshold of economic gains from opportunism' (Das and Rahman, 2010: 64). Thus:

Proposition 2: In innovation networks, equity distribution decreases the risk of partner opportunism and advances the project.

Compromise in conflict resolution. Conflict resolution modes vary with the degree of dependence and type of conflict. For Kozan *et al.* (2006), the way to manage conflict depends on the level of investment made by the parties to the exchange, which can be linked to the level of dependence, regardless of the type of conflict. However, the type of conflict also has a major impact. For example, in our case studies, if the conflict related to the project, the conflict resolution mechanism proceeded along the five mechanisms, as theorized in prior research: Members started by negotiating before turning to harsher techniques (Mohr and Spekman, 1994) such as coercion or sanction. However, this prediction was not supported when the conflict related to the cooperation itself (e.g., Pinc&pile), in which case the hub firm used the most drastic solutions available and took the partner to court. Thus:

Proposition 3a: In innovation networks, hard conflict resolution mechanisms are better suited to conflicts related to cooperative dimensions.

Tuten and Urban (2001) also extend Mohr and Spekman's (1994) model to include the previous relations as

a potential moderating variable; they posit that resolution methods are softer when partners previously have been in a long-term relationship. In our innovation networks, previous relationships did not have a significant effect on conflict resolution mechanisms though. In both cases that featured hard conflict resolutions, the hub firm had an existing, long-term partnership with the members. The type of conflict and degree of dependency seemed to have more influence on the resolution mechanism used:

Proposition 3b: In innovation networks, hard conflict resolution mechanisms are better suited to conflicts including a hub firm with a low level of dependency.

Finally, conflicts erode trust and reduce employee satisfaction, which tends to delay the project and undermine the level of commitment to the relationship (Cullen *et al.*, 1995). The complexity of these emotionally charged phenomena is difficult to grasp just with contractual theories, which offer only two conflict resolutions: revocation (exit) or court. In reality, our case studies show that other mechanisms, such as joint resolution, are common, provided that each party accepts the dialogue or persuasion techniques. If a conflict arises between a hub firm and a technical partner, the hub firm may call on another technical member to lead the focal partner in the desired direction (Motorization). Such a situation has not been considered in prior literature, which instead usually focuses on bilateral relations (Mohr and Spekman, 1994). We offer:

Proposition 3c: In innovation networks, the use of another network member as an arbitrator can facilitate conflict resolution.

Conclusion

This in-depth study reveals several aspects of innovation networks that previously have remained unstudied. We investigate the impact of three dimensions (hub firm dependence, previous business relations, type of conflict) on five coordination mechanisms. The degree of formalization and trust vary depending on the existence of previous positive relationships; the distribution of outcomes and guarantees instead vary with the hub firm's level of dependence. Our results offer additional knowledge about not only these five coordination mechanisms but also their different forms and how they develop during the course of the innovation project. We suggest several generalizations of these results.

1. Exchange formalization. Contracts are inherently incomplete in innovation networks. Extending incomplete contract theory (Grossman and Hart, 1986), we find that it is not always beneficial to draw up a more exhaustive contract; beyond a certain

point, the marginal cost of adding clauses increases beyond the benefits. Instead, informal exchanges are appropriate when the level of dependence was low, because the level of risk for the hub firm is limited.

2. Trust and formalization. In our case studies, trust and contractual arrangements are complementary, not substitutes for each other.
3. Guarantees. Reputation provides a common tool, perhaps due to the small size of the hub firms in our sample, to threaten damage to a defaulting or opportunistic member.
4. Conflict resolution. Literature on inter-organizational cooperation suggests that discussion leads to cooperation. In innovation networks, this solution works only if all members are satisfied; otherwise, it can harm the project by creating delays and frustration. Conflict literature also identifies neglect as a possible solution (Turnley and Feldman, 1999). In innovation networks, especially during development phases that face major time constraints, this practice did not emerge, despite its apparent frequency in other settings (e.g., franchise relations).

Research implications also emerge from these theoretical discussions. Unlike other forms of cooperation (e.g., R&D consortia, exploration partnerships), innovation networks resort almost exclusively equitable distribution, though the distribution varied somewhat according to the nature of the innovation being undertaken. In our cases, patents already had been filed; in more fundamental research projects, the resources and contributions of each member would be more difficult to define precisely (Gilsing and Nooteboom, 2006). It would be interesting to analyse whether guarantee mechanisms differ in innovation networks that include competitors (i.e., cooptation). Reputation threats or cultural integration could play much more important roles, because competitors operate in the same economic environment and are often culturally close. Finally, testing our propositions in a sample that includes both small and large hub firms could reveal the coordination mechanisms that are unique to SMEs.

Our results have managerial implications as well, especially in terms of how hub firms select coordination mechanisms. Their degree of dependency and experience in previous positive relationships with the network members should lead hub firms to pursue a strategic combination of the coordination mechanisms. They also should allow for evolution in their tactics as conflicts arise and the project progresses. Our study offers a practical way to manage such innovation networks. Hub firms, especially small ones, should be very careful when implementing coordination modes to stabilize their network and promote project success.

Finally, our study suffers from several limitations. First, we analysed a specific context in which the hub

firm had registered the patent(s). These hub firms were all European, and it may not be possible to generalize the results to other hub firms, especially in other countries with different intellectual property laws and cooperation mechanisms. Second, we did not address the intensity of the innovation. The degree of uncertainty in the network increases with the degree of novelty, so coordination mechanisms likely vary according to the type of innovation. Third, we analysed only the hub firm's degree of dependence, without studying the degree of dependence of other members. Further research should note dependence throughout the network to shed further light on these aspects. Quantitative studies also could use more refined Likert scales to measure coordination mechanisms and the degree of dependence.

Along with these extensions, further research should recognize that coordination mechanisms appear in other types of networks too (e.g., clusters, R&D consortia), so a comparison of the different forms of cooperation could provide additional insights into the coordination mechanisms that underlie each form. Such investigation could verify the relevance of the mechanisms in heterogeneous contexts. Some forms might develop in less uncertain environments or settings with low strategic stakes; they also might vary according to the type of financing. We call for research that studies whether the mechanisms shift with the presence of multiple hub firms (e.g., architect, lead operator and caretaker). Other dimensions that may influence the coordination mechanisms include the hub firm leader's personality and/or personal networks, which support the maintenance of a reasonably varied, large pool of potential members eligible for more tightly coupled, action-oriented networks (Grandori and Soda, 1995). Finally, research could note the structural properties of innovation networks and thus add to understanding of density or connectivity in innovation networks – properties that likely affect the development of trust and conflict levels.¹¹ We thus hope research continues to explicate the way innovation networks can be coordinated.

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Appendix 1

Table A1 Coordination mechanisms and forms in an innovation network

<i>Coordination mechanism</i>	<i>Mode</i>	<i>Underlying theory</i>	<i>Definition</i>
Exchange formalization (Lee and Cavusgil, 2006)	Formal	Contractual and trust approach	The use of a formalized, legally binding agreement or a contract to govern the inter-firm partnership.
	Informal		The role of discussion, commitment, and relational capital in the governance process.
Trust (Mesquita, 2007)	Trust	Relational and contractual	The confident positive willingness of one to be vulnerable to the conduct of another in conditions of interdependence and risk, 'Confident positive' means that one will purposefully act on the basis of another's conduct, 'interdependence' means that one cannot realize the expected economic outcomes without cooperation with the other, 'risk' refers to the probability of loss as perceived by the decision maker. The decision to be vulnerable occurs when the trustor believes in the trustee's abilities, benevolence, and integrity.
	Distrust		Confident negative willingness to be vulnerable to the conduct of another under conditions of risk and interdependence.
Result division (Jap, 2001)	Equal Equitable	Agency and incomplete contractual	Each party receives an equal share of the payoffs – a 50/50 split. Each member's payoffs are a function of resources provided (tangible and intangible contributions, costs incurred) to the collaboration. Derived from equity theory, which states that people judge an outcome as fair when the ratio of their own resources and output equals the ratio of resources and output of others.
Guarantees against opportunistic behaviour (Brousseau, 2000)	Direct	Contractual	Immediate effect to control the behaviour of members.
	Indirect	Contractual	Impact at later time, based on the ability to harm the reputation of a member or limit future business opportunities.
Conflict resolution (Mohr and Spekman, 1994)	Discussion	Relational	Joint problem solving. Different groups come together to find a mutual solution for a problem.
	Persuasion	Relational	Partners attempt to persuade each other to adopt particular solutions.
	Coercion	Relational and contractual	One or many partner(s) restrain others from choosing the conflict resolution solution.
	Sanction Third-party arbitration	Contractual Contractual	Excluding the partner from the innovation network. A third party (arbitrator or court) provides the solution.

Appendix 2

Table A2 Dependence, prior relations and conflict type

<i>Sources</i>	<i>Dimension</i>	<i>Coordination mechanisms</i>
Gencturk and Aulakh (1995); Baliga and Jaeger (1984); Ambos and Schlegelmilch (2007); Gupta and Govindarajan (1984)	Dependence	Formalization/control level
Kumar <i>et al.</i> (1995)	Dependence	Trust and confidence
Doz (1988); Sriram <i>et al.</i> (1992)	Dependence	Sharing of benefits
Lui <i>et al.</i> (2006)	Dependence	Guarantee systems
Kumar <i>et al.</i> (1998); Lui <i>et al.</i> (2006)	Dependence	Conflict resolution mechanisms
Ring and Van de Ven (1994); Inkpen and Currall (2004)	Prior relations	Trust
Doz (1996); Lui <i>et al.</i> (2006)	Prior relations	Formalization
Gulati (1995b)	Prior relations	Trust/contractual safeguards
Klein (1980)	Prior relations	Safeguards
Reuer and Arino (2007)	Prior relations	Conflict resolution mechanisms
Amason (1996)	Conflict type	Conflict resolution/formalization
Lee and Cavusgil (2006)	Conflict type	Formalization
Morgan and Hunt (1994); Lusch and Brown (1996)	Conflict type	Trust

Appendix 3 Descriptions of six case studies

Motorization

The project emerged as a result of two situational factors: the evolution of regulation and the difficult introduction of hybrid vehicles. Greater political awareness prompted new regulations for energy savings and environmental responsibility for vehicles. The difficulty of mass producing hybrid vehicles created high production costs relative to performance; opportunities to reduce these costs remained limited by the use of old technologies (electric motors, batteries). The hub firm selected partners and sub-contractors on the basis of their technological capabilities. The technical complexity of the project required a lot of R&D, and the total cost (estimated at 5500K€) required many financial and technical partners.

Pinc&pile

Regardless of disinfection efforts, the hygiene of conventional tweezers is sub-optimal, so Pinc&pile attempted to address a previously unsolvable problem, from both technical (creation of the mould) and financial (high production costs, 2€ per clip) perspectives. The project involves the creation of disposable tweezers in recyclable plastic. To build the network, the hub firm paid a particular attention to: (1) prior relationships and chose cooperation with members with which it had already worked, even if they lacked a strong reputation; (2) degree of motivation and involvement; and (3) skills.

Telescopic

Recognizing the lack of hygiene in warehouses in emerging countries, the hub firm thought about a more healthy system and filed patents to improve the uses of certain types of packaging. Its innovation consists of releasing a straw from the can at the end of the manufacturing process to improve the cleanliness of canned beverages. The hub firm chose members according to their area of expertise. Telescopic comprised many members, including financial supporters; the investment is estimated at more than 800 K€.

Transparts

The hub firm, after two decades of experience in the development of special machines (conveyor systems for basic parts to be assembled), moved to realize standard industrial solutions to solve or simplify problems related to components on assembly machines. It devised a system of rotating cams, driven by a motor, which represented a technical feat. With its great versatility, the invention has given the hub firm success in various markets such as automobiles, explosives (with a flameproof motor) and cosmetics.

Protect

The hub firm specialized in helping create consumer products, mainly for suppliers of sports equipment. The design of the headphone product at the centre of this project included a deformable structure that easily adapted to the user's morphology. The hub firm surrounded itself with partners and sub-contractors that provided access to a broad range of resources and skills. Each member assumed a specific role according to the allocation of tasks. The potential innovation could be partially modular, such that its independent parts could be developed separately and in parallel, according to standard design rules and interfaces. The hub firm and partners focused on core activities, such as design and manufacture, and thus retained non-substitutable strategic resources; sub-contractors took charge of the lower value-added components.

Jump

A ski and snowboarding coach was frustrated by the lack of progress by students in the summer season, so he developed a small-scale board to enable training on trampolines. Skiers adopted it quickly; they learned to orient themselves in space through repeated jumps and to safely perform compulsory figures. The encouraging results of this test phase led the innovator to start a company to develop and commercialize Jump as not only a teaching tool for advanced training but also a fun object to help master jumps in the air. Member selection mainly proceeded through word of mouth and Internet connections. Both ways provided quick solutions, added skills or supported the purchase of equipment through central purchasing routes.