The influence of hub firm size and degree of dependence on the coordination mechanisms applied to innovation networks

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RÉSUMÉ :

La compréhension du fonctionnement interne des réseaux interorganisationnels prend depuis quelques années une place croissante dans la littérature. Pourtant, rares sont les études empiriques, surtout dans le domaine de l'innovation - notamment des réseaux d'innovation. Le vide est encore plus flagrant lorsqu'il s'agit d'étudier les réseaux pilotés par des entreprises de petite taille. Cet article comble partiellement ce vide grâce à une exploration de six réseaux d'innovation où les PME jouent un rôle central. Ces cas seront comparés à un cas « pilote », où le pivot est une grande entreprise. L'objectif est d'identifier les spécificités des modes de coordination mis en place par les PME en situation d'asymétrie de taille au sein des réseaux d'innovation créés pour mettre leur invention sur le marché. L'analyse empirique qualitative met en lumière que la taille du pivot et son degré de dépendance influent de manière considérable sur les modes de coordination mis en œuvre par le pivot. Les résultats de cette recherche qualitative menée sur sept projets d'innovation montrent que (1) la répartition des résultats et les garanties varient en fonction du degré de dépendance du pivot, (2) la confiance et le degré de formalisme sont corrélés à la taille du pivot PME et (3) les modes de résolution de conflits sont influencés tant par la taille que le degré de dépendance.

Mots-clés : modes de coordination, dépendance, PME, pivot, réseau d'innovation, taille

ABSTRACT

Investigations into the internal functioning of inter-organizational networks have become increasingly common in the literature over the last few years. Nevertheless, empirical studies remain relatively rare, particularly in the field of innovation networks. The void is even more striking in the case of networks orchestrated by small firms. The present article partially fills this void through an exploration of six innovation networks in which SMEs play a central role. These cases are compared with a "reference" case, in which the hub firm is a large company.
The objective of the present research was to identify and characterize the coordination mechanisms used by hub firms that are in a situation of dependence with respect to other members of the network. We also analyzed the influence of hub firm size on the coordination mechanisms chosen, and we investigated the links between firm size and degree of dependence.

Our qualitative empirical analysis shows that hub firm size and degree of dependence have a considerable influence on the coordination mechanisms used. The qualitative analysis of seven innovation projects indicates that (1) the division of results and the guarantees that are put in place vary as a function of the hub firm's degree of dependence, (2) trust and recourse to formal agreements are correlated with hub firm size, and (3) conflict resolution mechanisms are influenced by both hub firm size and degree of dependence.

Keywords: coordination mechanisms, dependence, SME, hub firm, innovation network, size

INTRODUCTION

Empirical studies of the internal functioning of innovation networks are rare (Ahuja, 2000; Dhanaraj & Parkhe, 2006), as most research has concentrated on the formation or the structure of innovation networks, or on the factors leading to their collapse. Networks facilitate the exchange of information and the transfer of expertise; however, this can also favor the development of opportunistic behaviors (Goerzen, 2007). The risk of such opportunistic behaviors is greater when the hub firm of an innovation network is an SME (Fonrouge, 2007).

However, to the best of our knowledge, the link between a hub firm's degree of dependence (particularly when the hub firm is a small company) and the coordination mechanisms adopted by the hub firm has never been analyzed. Furthermore, recent research into coordination mechanisms has treated mechanisms individually (Fréry, 1997; Das & Teng, 1998). Our exploratory study was designed to remedy this situation by analyzing the ensemble of coordination mechanisms used within innovation networks and by investigating the specific characteristics of the coordination mechanisms adopted by SME hub firms. Because any asymmetry between the sizes of the different members of a network affects how alliance relationships are managed (Oliver, 1990; Vidot-Delerue & Simon, 2005), we wanted to determine whether or not the coordination mechanisms used when the hub firm is a small company were different from the mechanisms used by large hub firms. In addition, as size is not always synonymous with dependence, we investigated the effect of hub firm dependence on the coordination mechanisms used. The objective of the present article is to show that these two moderating variables must be taken into account if we are to understand the coordination mechanisms used by the hub firms of innovation networks.

The present article begins with a review of the literature on inter-organizational cooperation, which allowed us to define the notion of innovation network and gave us a better understanding of the coordination mechanisms used by hub firms. Focusing on the specific characteristics of the coordination mechanisms when the hub firm is an SME[1] led us to examine the notion of dependence. We then investigated seven innovation networks, in order to compare the coordination mechanisms used by six networks orchestrated by an SME with the mechanisms found within an innovation network consisting of large firms (reference case). This

[1] In the present article, the term SME is used to refer to any small firm (< 250 employees, which is the criterion used by Eurostat and by most French statistics.
(http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32003H0361:EN:HTML)

analysis led us to draw up a summary of the main coordination mechanisms as a function of the hub firm's degree of dependence and size.

1. COORDINATION MECHANISMS AND HUB FIRM DEPENDENCE

After presenting the main coordination mechanisms used by innovation networks, we will explore the concept of hub firm dependence in the specific case of SMEs. We support the idea that the coordination mechanisms used by hub firms vary according to how dependent the hub firm is on the other members of the network. In line with Assens (2003), Inkpen and Tsang (2005) and Dhanaraj and Parkhe (2006), we define an innovation network as a set of vertical and horizontal relationships with a variety of organizations (public/private, partner/service provider) that are orchestrated by the hub firm in order to exploit the hub firm's invention. The hub firm (or focal firm, or core, or pilot) is predefined, that is to say, it is the organization that has filed the patent(s) for whom the exploitation of its invention involves a number of other members. The hub firm's objective is to regulate the transactions within the innovation network (Fréry, 1997). In the present article, we use the notion of hub firm, rather than broker, because a hub firm can be a single organization that plays the three roles of conception, coordination and control, whereas, in the case of brokers these roles are played by three different organizations (Lecocq, 1999).

1.1. COORDINATION MECHANISMS AND INNOVATION NETWORKS

Coordination mechanisms are seen as arrangements between economic units, which govern the ways in which the units cooperate in order to develop the innovation project (Grandori & Soda, 1995). The advantage of this definition is that it focuses on interactions at a strategic level, rather than at an operational level (such as the division of tasks or means of communication). The coordination mechanisms used by innovation networks are generally divided into two categories: exchange regulation mechanisms, and incitation and sanction mechanisms.

1.1.1. Exchange regulation

The notion of exchange regulation encompasses the type of exchange (formal/informal) and the presence (or absence) of trust between the members of the network.

The members of an innovation network must set down, either formally or informally, rules for acceptable behaviors, for the way in which results are divided, and for resolving conflicts, etc.

(Poppo & Zenger, 2002). Formal modes of exchange, which are explicit and written, include standardized procedures, technical reports, analytical accounting, budgeting and planning methods, as well as confidentiality agreements and contracts (Martinez & Jarillo, 1989; Gulati, 1995; Das & Teng, 1998). Informal exchanges, which are implicit and verbal, include the setting up of joint teams (Grandori & Soda, 1995), seminars, meetings and transfers of personel (Martinez & Jarillo, 1989), as well as decision-making methods. Informal modes are less costly (Gulati, 1995), increase strategic flexibility (Young-Ybarra & Wiersema, 1999) and reduce the risk of conflict (Nooteboom, Berger & Noorderhaven, 1997). However, they take a long time to set up (Das & Teng, 1998) and, in an innovation network, any delay in launching the resulting product onto the market may lead to that product being obsolete.

Inter-organizational trust[2] is defined as an underlying psychological condition that may be the cause, or the result of, a behavior (as is cooperation) or a choice (as is a risk) (Mothe & Ingham, 2003, p.12). Variations in risk and in interdependence can change both the degree and the form of trust (Cullen, Johnson & Sakano, 2000). Trust is often considered to have a direct influence on the success of partnerships (Morgan & Hunt, 1994), especially in the uncertain environment of an innovation project, where trust can be used to predict the behavior of a network's members (Ring & Van de Ven, 1994). In innovation networks, the unexpected occurs daily, so cooperation contracts can never be fully comprehensive (Hart & Holmstrom, 1987; Shavell, 1998). This is even more the case when such agreements are too formal (Cullen, Johnson & Sakano, 2000).

1.1.2. Incentive and sanction mechanisms

If the regulation of the exchange characterizes the means employed by the members of an innovation network to ensure coordination, the incentive and sanction mechanisms determine how the network is coordinated on a day-to-day basis.

One of the keys to cooperation is the division of results (Brousseau, 1993). An **equitable** division of results is often perceived as an incentive for the members of a project to work harder, and it is considered to improve the performance of an innovation project (Kabanoff, 1991). Conversely, an **equal** division of results is seen in terms of uniformity and a lack of differentiation between the members of the project. Every member of the innovation network receives an equal share of the results, no matter how much that member contributes in terms of resources and/or expertise (equal share of results, whatever the investment). This type of sharing

[2] In line with Mesquita (2007), we believe that inter-organizational trust has its own status. For a review of the literature on trust see Mesquita (2007), Mothe and Ingham, (2003) or Simon (2007).

is risky when the members of a network make unequal contributions to the project, as it can lead to a feeling of unfairness in the division of results.

Guarantee systems, otherwise known as opportunistic behavior prevention mechanisms (Fréry, 1997), provide protection against potential damage by making it expensive for opportunistic members to withdraw from the network.

Different types of guarantee have been described. For example, Fréry (1997) has shown that financial integration is not the only way of guaranteeing the loyalty of members; other methods include logistic integration (control of capital circulating from a member), media-based integration (promotion of a brand that will be spontaneously recognized by all the network's customers) and cultural integration (use of organizations that have a relationship with the hub firm that is not exclusively economic). Rubin (1990) proposed using two types of hostage: reputation[3] and/or specific assets. Future business opportunities are considered a form of guarantee because an opportunistic member will experience a decrease in the number of its future business relations (Wu & Choi, 2004). Brousseau (2000) points out that not all guarantee mechanisms can be contractual, as it is often very difficult for a legal authority to determine whether or not the members have correctly fulfilled their contractual obligations.

Innovation networks do not always resort to guarantees. Three situations are possible (Brousseau & Fares, 2002):

- Absence of any guarantee system;
- Unilateral application of guarantees: an agent designates a hostage for one or more members of the innovation network. This hostage becomes the property of the other if promises are not kept;
- Multilateral application of guarantees: each agent designates a hostage for its partner in order to create mutual dependence.

Furthermore, guarantee mechanisms (direct and indirect) are not mutually exclusive within an innovation network. It is possible to accumulate several guarantee mechanisms, especially when the risk of opportunism is particularly high.

Mohr and Spekman (1994) identified several conflict resolution strategies. However, they only carried out a dyadic analysis, whereas in an innovation network it is necessary to consider all possible interactions: two-to-two, one-to-several and several-to-several (Gomes-Casseres, 1994). Hence, if a conflict arises between two technical partners, another member of the network (most likely the project bearer or hub firm) may intercede to resolve the problem. This

[3] Kiong and Kiong (1998) also address reputation as a guarantee mechanism used by *keiretsus.*

type of situation has not been addressed in the literature. Conflict resolution mechanisms in innovation networks are complex, as not only is it impossible to foresee how an innovation project will unfurl or to know what its final outcome will be, the level of commitment of the network's members is very heterogeneous. Thus, it is very difficult to give any *ex ante* definition of a conflict resolution mechanism. Mohr and Spekman (1994) described six conflict resolution mechanisms in bilateral relations. We have retained five of these mechanisms (in the present case, domination is considered to fall within the category of coercion), which we believe are useful for describing the multilateral relationships within innovation networks:

- **Joint resolution** of a problem: the different parties agree to work together to find a mutual solution to a problem;
- **Persuasion:** one of the parties tries to persuade the other members that solution A or B provides the best way to emerge from a conflict situation;
- **Coercion**: one partner forces the others to choose its preferred solution for resolving the conflict;
- **Sanction**: the network member is expelled;
- **Introduction of a third party**: recourse to arbitration between the parties (arbitrator or legal action).

Mohr and Spekman (1994) believe that involving a third party can have positive consequences for future cooperation, but internal resolution (absence of external parties) strengthens the relationship over the long term.

The main coordination mechanisms are summarized in Table 1

Type of coordination	Question	Coordination mechanism
Exchange regulation	How is the innovation network coordinated?	**Degree of formalisation**: existence (or absence) of a contract and the number of clauses
		Trust (or mistrust)
Incentive and sanction mechanisms	What types of mechanism are used?	**Division of results**: equal or equitable
		Guarantees: ∅ (no guarantee), direct and/or indirect
		Conflict resolution: joint, persuasion, coercion, sanction, use of a third party (arbitrator or tribunal)

Table 1: Coordination mechanisms for members of an innovation network

The above work underlines the importance of coordination mechanisms in understanding the internal functioning of inter-organizational relationships in general and of innovation networks in particular. Nevertheless, no one has studied the influence of hub firm dependence on each of

these mechanisms. Therefore, the following section considers the main sources of a hub firm's dependence within an innovation network.

1.2. HUB FIRM DEPENDENCE AND NEGOTIATING POWER

Every situation involving the interdependence or mutual dependence of partners (Mohr & Spekman, 1994) brings to light the power relations that exist within innovation networks. The essence of power arises from one party's dependence on another (Blau, 1964). Thus, power is rooted in the interdependence of the parties in achieving their objectives (Crozier & Friedberg, 1977). Power can be defined as the ability to impose one's will on others; the power of A over B is the ability of A to make B do something that it would not have done without the intervention of A (Dahl, 1957). Power relations emerge from different situations: the expected coordination of the partners' activities, the "operational" side of the interdependence, the uncertainty of the situation, the unpredictability of the partners' behaviors (not all their behaviors can be regulated and specified in agreements), the uncertainty associated with the absence of complete convergence of the partners' objectives, and the generation of cooperation rent (Klein, Crawford & Alchian, 1978), the sharing of which is an extremely important aspect of the relationship (Tinlot & Mothe, 2005).

In an innovation network with no contractual links between interdependent but autonomous parties, dependence arises from the hub firm's need to maintain its relationship with one or more members in order to attain its objectives, that is to say, the launch of its innovation project and production of a profit. Thus, the degree of interdependence determines the amount of power held by each of the parties in the relationship, the two being inversely correlated (Emerson, 1962). This power manifests itself as a negotiating power that is determined by the following factors: size of the partners, resources, strategic importance and urgency of the cooperation (Tinlot & Mothe, 2005). The size of the hub firm should have a substantial impact on the other variables. The smaller the hub firm, the greater its need for partners in order to gain access to resources and skills that it does not control. The strategic importance of the innovation network and the urgency of the cooperation will also be greater for a small hub firm. However, our case studies show that small size is not always synonymous with dependence

Partner size. A key factor in determining the respective negotiating power of each partner is the relative sizes of the partners. A larger partner generally has greater negotiating power in the inter-organizational relationship (Oliver, 1990). In an innovation network containing a small firm and a large firm, the small firm will often be in a position of dependence. The small firm will always need the extra assets provided by its partners; therefore, the innovation network will

be strategically more important for the small firm than for the large firm. This creates a balance of power that is unfavorable for the small firm.

Partner resources. Each partner's negotiating power is determined by the resources it provides (Yan & Gray, 1994), which can be either tangible (e.g., finance, competences, expertise) or intangible (e.g., reputation of a partner, network of relations). The nature of the resources provided determines a partner's level of dependence with respect to the other members and hence its power (Blau, 1964). The question of resources is even more important in the case of asymmetric innovation networks of complementary type in which the hub firm's objective is to obtain access to the resources of its partner(s) (Hamel, 1991). This is particularly the case for innovation networks. Certain resource characteristics tend to strengthen a partner's negotiating power. These characteristics include the degree of specificity of the assets provided (Williamson, 1985; Baudry, 1992; Brousseau, 1993), the availability of the resource (Pfeffer & Salancik, 1978), and its intrinsic value.

The strategic importance of the inter-organizational relationship. The larger the proportion of the business taken by the innovation network, the greater the partner's dependence on the other members (Thompson, 1967; Pfeffer & Salancik, 1978) and the weaker its power. If an innovation network is of strategic and long-term importance to the hub firm, the hub firm is placed in a position of dependence on its partners. Hence, there is a strong correlation between a hub firm's dependence on the innovation network and the strategic importance of its innovation project (Yan & Gray, 1994).

The urgency of the cooperation. The time factor also affects the relative powers of the partners in an innovation network, as time is an important factor in determining a party's room for maneuver (Crozier & Friedberg, 1977). In a power relationship, a lack of pressing time constraints is a considerable advantage. Members of an innovation network that need to achieve results within a fixed and limited time frame (for example, in the case of strategic redeployment or of an opportunity that can only be seized through cooperation) will be at a disadvantage with respect to the other members of the network (Harrigan & Newman, 1990; Schelling, 1956). The urgency of the cooperation depends on the strategy adopted by the hub firm (arbitrage between cost/time/quality) and on the hub firm's economic situation (Harrigan & Newman, 1990).

Uncertainty[4]. Power relations are also linked to uncertainty, which can weigh upon the partners, most notably in terms of the unpredictability of their behaviors (Crozier & Friedberg, 1977). The existence of alternatives (Bacharach & Lawler, 1980; Yan & Gray, 1994; Inkpen &

[4] Uncertainty is not taken into account here because any cooperation involving innovation is, by its very nature, uncertain. As a result, this factor does not vary from one innovation network to another.

Beamish, 1997) can make a partner's behavior unpredictable and reduce its dependence (Aldrich, 1979; Olk & Young, 1997; Thompson, 1967), thereby giving it increased negotiating power. A firm that is free to choose whether it provides or withholds a resource vital to an innovation network can make demands on its partners, even if these demands are not advantageous for the partners (Harrigan & Newman, 1990).

In order to protect against the opportunism that may result from this situation of initial imbalance, a hub firm will generally introduce suitable coordination mechanisms. The degree of dependence and the resulting negotiating power will therefore be reflected in the coordination mechanisms set up in the innovation network by the hub firm (figure 1):

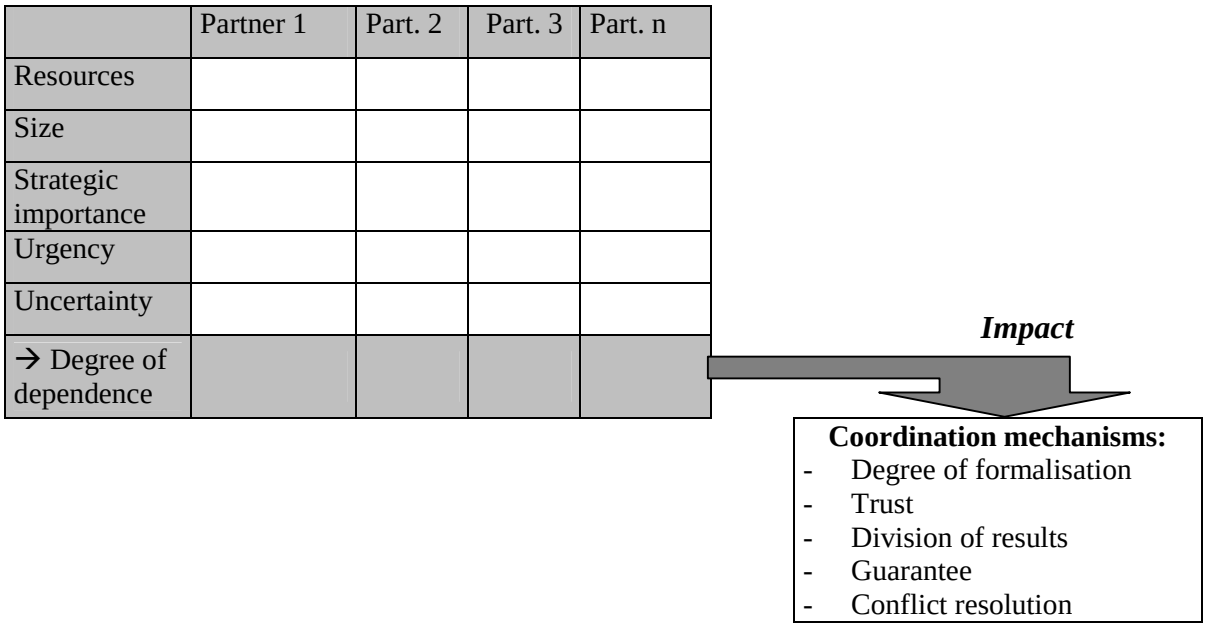

Figure 1: The impact of degree of dependence on coordination mechanisms
Source: based on Tinlot & Mothe, 2005, p.35

In the six case studies of innovation networks orchestrated by small firms, presented below, we first verified that the hub firm was in a situation of dependence with respect to its partners, and then we carried out an empirical analysis of the coordination mechanisms used by the hub firms as a function of their degree of dependence. Finally, we compared these coordination mechanisms with those adopted by a large hub firm (in an innovation network labeled G).

2. EXPLORATORY STUDY OF SEVEN INNOVATION NETWORKS

To date, no research has been carried out into the link between coordination mechanisms, on the one hand, and the dependence and size of the hub firm, on the other hand. Consequently, we decided to carry out an exploratory study that would allow us to examine the impact of these

two aspects on the coordination mechanisms set up by SMEs that are hub firms in innovation networks.

2.1. METHODOLOGY AND FIELD

A qualitative methodology was adopted in the case studies during the research process, as the phenomenon in question is vast, complex and largely unexplored. Our research is therefore of an exploratory nature, in the sense that the literature has not yet developed a precise hypothesis regarding the relationship between coordination mechanisms and the size and the dependence. It is for this reason that our interviews began with an in depth questionnaire in order to take the different dimensions of potential coordination mechanisms into account. Moreover, to understand the impact the size and dependence have on the mechanisms, we met with the project bearers at least once every two months over a period of six to twelve months (depending on the start date of the case).

We carried out 57 interviews of which 33 were tape-recorded. Due to confidentiality reasons, the remaining 24 could not be audio-recorded (**Table 2**).

Each of the seven case studies relies on three information collection tools to ensure data triangulation (Yin, 1994): interviews, direct observation and secondary data analysis. We chose these particular seven alliance networks because each of them was developing a technological innovation in collaboration with at least three other organisations (see Table 2). Fifty-seven interviews were carried out with different members of the innovation networks: the project bearer and the financial, technical and industrial members. By carrying out semi-structured interviews over an average of one and a half hours each, we hoped to gain a better understanding of the innovation networks' history, the different conflict resolution mechanisms implemented in these networks, and the difficulties experienced and their consequential repercussions on the innovation project. This research was equally executed using secondary data:

- **Internal:** emails exchanged between different project members, the project bearers' internal notes during the project advancement presentations, business plans and contracts between members.
- **External:** internet; press releases and articles and newspaper clippings.

And last, a passive observation was carried out (regular presence: one day every two months over 6 to 12 months in the project bearers' offices), to capture the actual environment and working atmosphere (the eventual tensions or, in contrast, the joyful periods linked with the

innovation project). For each case, we examined a range of relationships (around 100 in total[5]) between the hub firms and the technical, financial, industrial, commercial and legal members of the network.

The multi-site case studies constitute a theoretical sample (Glaser and Strauss, 1967). This critique allowed us to select the cases that correspond to our research question. Thus, we carefully chose innovation networks of different sizes and from different activity sectors that aimed each at successfully executing a technological innovation project. We specifically chose cases that shared enough common traits (technological innovation, networks with at least three collaborators, etc.) with the others but that could be clearly distinguished from one another in many other ways (Hlady Rispal, 2002).

Project[6]	**Hub firm**	**N° of members[7].**	**Subject**	**Business sector**	**Characteristics**	**N° of interviews**
Project A	SME (12 people)	65	Essential component for automobile manufacturers	Automobile	Very ambitious project: very high investment and very technical	13
Project B	SME (2 people)	8	Product for estheticians (B to B)	Large-scale retail	Very conflictual situation: the commercial and industrial partner was claiming property rights on the patents already filed)	9
Project C	Independent (1 person)	11	Product for every-day use	Large-scale retail	Stagnant project: oligopolistic target market leading to distribution problems	6
Project D	SME (3 people)	9	Machine improving the efficiency of the manufacturing process of small parts	Industry	Opportunistic behavior of a commercial partner: complementary patent filed without notifying the project sponsor	7
Project E	SME (6 people)	24	Protection product for sports people	Sport and leisure	Project that is successfully moving forward without too many problems	10
Project F	Independent (1 person)	6	Specialist sports protection product	Sport and leisure	The hub firm benefited from the experience of another project sponsor	8
Project G	Large firm	7	High-technology engineering parts	Industry	Heavy and formal negotiations	4
Total number of interviews						**57**

Table 2: Summary presentation of the seven innovation networks studied

[5] For example, in project A, the pivot had relationships with 29 technical members: 11 partners and 18 service providers. The lack of precision in the number of relationships studied is due to the complexity of the subject of our study. The parties frequently referred to a group of members (for example, the technical members), rather than to individual firms.

[6] For reasons of confidentiality, we have not given the names of the innovation projects.

[7] Mean number of members during the year of observation. The term "member" is used to denote an organization, rather than an individual.

Innovation networks are selected in collecting case data, because this type of innovation manifests the typical features of high-risk and uncertainty (Lin, Haibin and Demirkan, 2007). Actually, most of the cases of innovation networks that were studied previously were in biotechnology or information technologies (Baum, Calabrese and Silverman, 2000; Gilsing and Nooteboom, 2005; Roijakkers, Hagedoorn and van Kranenburg, 2005). That is why in this paper we selected cases from other sectors, which we believe, are often neglected in the literature (see table 2).

Moreover, we checked that the hub firm SMEs were in a situation of dependence, classifying the sources of dependence as a function of their frequency[8] for each of the six case studies in which the hub firm was a small company:

- The necessary acquisition of resources and competences from outside the hub firm was the most frequently encountered source of dependence (five cases out of six: A, B, C, E and F). If a hub firm does not have all the resources and competences needed to advance a project (production equipment or distribution channels), it has almost no choice other than to seek partners, and the need for resources and competences becomes a constraint. Because of their small size, the six networks orchestrated by SMEs did not have the resources and competences needed to develop their projects. All other things being equal, the smaller the hub firm, the greater the need to call upon external resources.
- Three of the six hub firms (cases A, C and F) were specially created to develop the innovation project and are thus single product firms. If the project fails, the firm has no further reason to exist and it will disappear;
- Hub firms A, C and D were developing innovations for which several other substitutable technologies could be developed. Consequently, they had to get their products on the market very quickly if they wanted to avoid seeing another technical standard take over. For example, for project A, the recent regulatory and political trend favoring the development of energy-efficient and environmentally friendly vehicles explains the explosion of projects to develop hybrid engines, but not all of these projects will find a place in the market.

For each of the six networks orchestrated by an SME, we identified the members on whom the SME was dependent. This gave us a better understanding of the reasons for imbalances between

[8] Our literature review revealed four possible sources of dependence for a pivot. In this section we present only discuss three of these sources, as firm size, which is the central factor explaining dependence, is discussed separately in section 2.3.

the members of each network: imbalances that could have an impact on the coordination mechanisms set up by the hub firm. **Table 3** presents a summary of the relationships in which the hub firm was in a position of dependence[9]. For example, for project B, the commercial members are not indispensable because hub firm B, given its core business, is itself capable of marketing the product. In this case, the project centers around the product's technical feasibility, hence it is the technical partner that is essential to the project's success. In contrast, for project C, the indispensable members are the industrial and commercial partners.

Projects developed by small firms	The hub firm is not dependent on…	The hub firm is dependent on…
Project A	Technical service providers Legal service provider	Financial partners and service providers Industrial partner Technical partners
Project B	Industrial service provider Commercial partner and service provider	Legal partner Technical partner
Project C	Legal partner Technical service providers Industrial service provider	Commercial partner Technical partners Financial partners and service providers
Project D	Industrial service provider (highest dependence on the member)	Commercial partner Public financial partners
Project E	Industrial service provider Technical partners and service providers Commercial partner (competition phenomenon introduced by the hub firm)	Public financial partners Technical and financial partner
Project F	Technical partners Industrial service provider	Technical partner [10] Financial partner

Table 3: Dependence of the hub firm with respect to other project members

In innovation networks, the number of members is an important parameter (Dhanaraj & Parkhe, 2006). Even when the hub firm is very small, it will not be dependent on all the members. This aspect differentiates our research from previous work into the degree of dependence in inter-organizational relationships, which has generally been limited to studies of bilateral alliances (Tinlot & Mothe, 2005). For example, for project D, the hub firm is dependent on its commercial partner but not on its industrial service provider.

[9] Unlike dyadic inter-organizational relationships, the pivot of an innovation network may be dependent on some, but not all, of the members of its network.
[10] The technical partner is the hub firm of project E.

2.2. COORDINATION MECHANISMS THAT VARY ACCORDING TO THE DEPENDENCE OF THE HUB FIRM

In this section we present only those coordination mechanisms that varied according to the degree of dependence of the hub firm, that is to say, division of results, guarantees and conflict resolution.

Division of results. In the case of innovation networks, there are two main types of result to be divided:

- Ownership and user rights for the patents and/or plans and models. The way in which they are divided will depend on the size of the hub firm. A small hub firm will wish to keep most of the ownership rights, in order to avoid increasing its dependence on the other members. However, its small size is a weakness that makes it difficult for it to hold onto a majority of the rights.
- Financial income that will be generated by the innovation project. Most hub firms offer to remunerate members via a system of recurrent royalties, payable on a monthly or quarterly basis. These royalties are usually calculated as a percentage of the turnover generated by the project.

When the hub firm is in a position of dependence with respect to the other members, these other members are indispensable to the success of the project. In most of the cases studied here, the results were divided equitably, as the members of the networks consider this mode to be the fairest. With this mode, there are fewer conflicts over the division of results:

> *"I provided X (the hub firm) with an essential building block, therefore it seems right that I should be remunerated accordingly. At the time, X could not provide financial remuneration, which is why we came to this technology transfer agreement". (commercial partner, project D, 21/09/2006)*

If there is no dependence, egalitarian sharing is used, as long as the member has been part of the project from the beginning and has contributed as much as the hub firm:

> *"The Jump project is a bit like our second baby. We are there for the bad times as well as the good. We see the hub firm regularly and we decide together which is the best direction for the project". (technical partner, project F, 05/07/2006)*

Guarantees. The greater the hub firm's dependence, the greater its tendency to protect itself with direct guarantees. The withdrawal of indispensable members can endanger the future of an innovation project. Hub firms introduce direct guarantees to protect themselves against opportunistic behaviors and to make it costly for members to withdraw from the project:

> *"In the contract, we stated that he had to invest in specialist machines and that we would pay the invoice three months after delivery. At least, if there were faults, we*

would have time to find them and to file any necessary claims. And there are penalties for late delivery". (hub firm, project F, 01/08/2006)

Conversely, the less dependent the hub firm, the less frequently direct guarantees are used, as such guarantees generally take longer to set up (investment in specific assets, financial guarantees requiring the signature of contracts) and they are less worthwhile compared with the risk facing the hub firm:

"We couldn't waste time on useless guarantees. It is as if you were to take out fully-comprehensive insurance for a car that spends all the year in the garage. What's the point? (hub firm, project F, 01/08/2006)

Conflict resolution. In our SME-orchestrated innovation networks, persuasion is the most commonly used conflict resolution method when the hub firm was dependent, as patents alone do not give a hub firm sufficient protection. In innovation projects, the hub firm is highly dependent on the other members because neither the technical feasibility nor the commercial viability has been proven and the hub firm must convince the other members of the value of its project. This partially explains why the hub firm accepts the conditions imposed by the other members – its small size and its dependence do not allow it to impose its own solution. Even if the hub firm remains an independent entity[11], it must be prepared to accept the choices of the other members, or risk seeing the project fail:

"You know, when you start, it is very hard to find partners. Therefore, you lower your sights a little and try to resolve the problem amicably, through discussions and by ensuring that all the parties can express their point of view". (hub firm, project B, 09/11/2006)

Conversely, when the hub firm is not dependent on the other members, removing a partner will be the preferred method for resolving disagreements. If members can easily be substituted, the hub firm will prefer to quickly change a partner before there is a significant transfer of resources and competences:

"We wouldn't put the project at risk for a member that can easily be replaced. If we spend half our time trying to satisfy everyone, the project won't get anywhere. We are a small company and we don't have time to waste". (hub firm, project E, 05/07/2006)

2.3. COORDINATION MECHANISMS THAT VARY ACCORDING TO THE SIZE OF THE HUB FIRM

The previous section highlighted the influence an SME hub firm's degree of dependence can have over certain coordination mechanisms. In this section, we aim to determine whether or not the size of the hub firm influences the coordination mechanisms used when the hub firm is in a

[11] Our definition of an innovation network only includes independent bodies. Consequently, joint ventures were not included in this study.

position of dependence. We will show that three of the coordination mechanisms differ according to the size of the hub firm: the degree of formalisation, trust and conflict resolution.

Degree of formalisation. Four of the six SME hub firms did not have any written agreements (except the contract of confidentiality) with the members that they knew and on which they were not dependent (easily substitutable members). On the other hand, the hub firms preferred to have written contracts with new members because they cannot anticipate their potential behaviors. In general, the SME hub firms tried to reduce the degree of formalisation, even if only because they did not have the legal resources to draw up the necessary documents:

> *"We try not to make things more complicated than they have to be. In addition, for reasons beyond their control, small companies, such as X (the hub firm), do not have a legal department or a full-time lawyer. Our company has a legal department but, if we try to get them involved in this area, we will spend months in discussions and the project will be slowed. This is why we try to use quite simple contracts when we work with very reactive companies with few staff". (technical partner, project E, 27/07/2006)*

In contrast, large hub firms draw up detailed cooperation or service provision contracts, in order to try and protect themselves as much as possible against potential opportunistic behaviors. Project G (between large firms) was not vital for any of the members and each member has its own legal department. Contractual negotiations were very long and every version of the contract had to be checked by each member's legal department:

> *"We started falling behind on the technical objectives we had set ourselves. It is important to have a cast-iron consortium agreement, but it is to the detriment of the project. You have to accept that it is impossible to put everything in the contract because there are many aspects that we don't know where they will lead. I think that, now, we have to reach an agreement on the property rights and then get on with things". (industrial partner 2, project G, 10/01/07)*

This high degree of formalisation is rarely seen in the case of small firms because the absence of an internal legal department means small firms need outside help to draw up legal documents.

Trust. In the networks studied, the degree of trust varied according to whether or not the members had collaborated in the past. This trust is built up progressively through interactions and working together. It also depends on each member's level of commitment:

> *"Confidentiality and trust are easy to achieve when you are working with four people but, if you are working with tens of thousands of people, it is better to set things down more formally". (technical partner, project E, 27/07/2006)*

In the case of project G, there is *a priori* trust between the three companies, even though they have never before worked together. Their reputations and their corporate image are sufficient to create this mutual trust:

> *"It is true, we have never before worked with companies X and Y but we know they can be relied on, as their head offices are less than 100 km from ours, so, of course,*

we have already had dealings with these companies and we know the weight they carry in the local industrial fabric" (hub firm, project G, 24/11/06).

Conflict resolution. When the hub firm is an SME that is not dependent on its members, expulsion is the most frequently used method for resolving conflicts. Conflicts arising from substitutable members are seen as threats to the long-term future of the project:

"I asked myself if I could succeed without them. After a few sleepless nights and with help from Mr X (technical partner), we concluded that no one was indispensable. As I knew I didn't want to work with them, it was pointless carrying on with the discussions". (hub firm, project B, 26/06/2006)

Numerous confrontations occurred during the first few months of project G, notably between the three industrial companies and research laboratories. Frequent tensions appeared, but they were brief and did not threaten the future of the project. Unlike the other six cases, the members of project G could not easily withdraw from the project because they were under contractual obligations to cooperate:

"We could be sure that we wouldn't have to go to war. In the contract, we named an arbitrator, if we really couldn't agree on something. But first we try to discuss matters and bring our points of view together". (hub firm, project G, 24/11/06)

In project G, a large majority of the conflicts arose over the division of property rights between the industrial companies and the research laboratories. At first, the members met every month to discuss disputes and to find solutions together. Later, after failing to reach a consensus, the companies resorted to coercion to try and impose their point of view on the division of property rights on the research laboratories.

Analysis of our seven case studies shows that hub firm size influences the degree of formalisation, trust and conflict resolution (**Table 4**). The degree of dependence affects the division of results, the guarantees that are put in place and the mechanisms used to resolve conflicts.

Coordination mechanisms	Key moderating variables
Degree of formalisation	Size
Trust (or mistrust)	Size (if no previous relations)
Division of results	Degree of dependence
Guarantees	Degree of dependence
Conflict resolution	Degree of dependence and size

Table 4: Key moderating variables for different coordination mechanisms

Table 5 presents the coordination mechanisms use by the hub firms as a function of hub firm size and degree of dependence. This table shows, for example, that the division of results is

generally egalitarian when the hub firm is not dependent on the members of its network and equitable when it is dependent on its members (influence of dependence). In addition, the degree of formalisation is very high when the hub firm is a large company and moderate when the hub firm is an SME (influence of the size of the hub firm). Nevertheless, Table 5 only provides a schematic vision of a complex reality, as the number of parameters it uses was purposely restricted to enable us to explain and/or manipulate them (Charreire & Durieux, 1999).

<table>
<tr><th rowspan="2">Key moderating variable(s)</th><th rowspan="2">Coordination mechanisms used by the hub firm</th><th>Network orchestrated by a large firm (no dependence)</th><th colspan="2">Network orchestrated by a small firm</th></tr>
<tr><th colspan="2">Hub firm not dependent</th><th>Hub firm dependent</th></tr>
<tr><td rowspan="2">Size of the hub firm</td><td>Degree of formalisation: existence (or not) of a contract and number of clauses</td><td>Very high: every large firm has its own legal department. Contractual negotiations are long (1 year)</td><td colspan="2">Moderate: the absence of an internal legal department means a firm has to use, and pay for, the services of an external supplier. The time taken to draw up contracts is short (1 to 2 months)</td></tr>
<tr><td>Degree of trust: (if no previous relations)</td><td>Strong: even if the members have never before worked together, trust is rapidly built up, as the members of the network are large and have reputations to protect</td><td colspan="2">Weak to strong: trust is most frequently the result of previous relations</td></tr>
<tr><td rowspan="2">Dependence of the hub firm</td><td>Division of results: egalitarian or equitable</td><td colspan="2">Egalitarian: as long as the members have been involved in the project from the beginning</td><td>Equitable: the results are divided on the basis of the contribution made by each member of the project</td></tr>
<tr><td>Guarantees: ∅, direct and/or indirect</td><td colspan="2">Indirect (image and name recognition): The organizations involved in project G have a national, or even an international, reputation that could be stained by opportunistic behaviors</td><td>Direct and indirect (future opportunities): the hub firm is only known locally and cannot rely on its brand image. SMEs favor sanctions against future business opportunities.</td></tr>
</table>

Dependence and size of the hub firm	**Conflict resolution:** joint, persuasion, coercion, sanction, recourse to a third party (arbitrage or tribunal)	**Discussion** then **coercion:** recourse is not made to tribunals or to expelling members. Expelling certain members could have consequences in terms of receiving public finance	**Expulsion:** at the beginning of the project, as members have not yet carried out significant transfers of resources or competences, the hub firm will favor expulsion in the case of conflict	**Persuasion by the dominant member:** thanks to its negotiating power, the strongest member can dictate its choices because the threat of its withdrawal could threaten the future of the project

Table 5: Coordination mechanisms as a function of size and degree of dependence

DISCUSSION

The present research was designed to improve our understanding of the coordination mechanisms used by hub firms in innovation networks.

From a theoretical point of view, our research shows that a single logic of cooperation underlain by informal or tacit modes of exchange (Thorelli, 1986; Jarillo, 1988) is unrealistic. None of our case studies revealed a stable network exempt from conflicts of interest or power struggles. Contradictions and divergences of opinion between members are almost inevitable in innovation networks (Miles & Snow, 1992). Conflicts of interest and rivalries over power prevent networks from operating harmoniously. It is for these reasons that we studied coordination mechanisms as a function of the degree of dependence of the hub firm.

From an empirical point of view, we studied the coordination mechanisms used by the hub firms of innovation networks. We built on previous work (Grandori & Soda, 1995; Tinlot & Mothe, 2005) by explaining how the hub firm's degree of dependence and size influence the coordination mechanisms used. These two contextual variables call into question the univocity of the relationship between coordination mechanisms and innovation projects. Table 4 provides a summary of the main coordination mechanisms as a function of the dependence and/or size of the hub firm, as not all coordination mechanisms vary as a function of the same criteria. Table 4 gives a schematic and simplified view – although the reality is highly complex – in the sense that degree of dependence and size are analyzed as dichotomous variables (dependent or not and small/large), rather than as continuums.

We also show that for hub firms small size is not always synonymous with dependence, as the members of innovation networks do not always hold monopolies over certain resources or competences and these resources and competences may be easily substitutable. For example, if an innovation network contains two members capable of fulfilling the same role, the hub firm can choose which member to favor. This type of strategy has the advantage of reducing the hub

firm's dependence but it also has the disadvantage of increasing the intrinsic costs of the innovation network. It is probable that such situations occur, but they were rare in the cases studied. In fact, hub firms are frequently dependent on the other members of the network, as, due to their small size, SME hub firms cannot be self-sufficient in terms of the resources and competences required for the project (Park, Chen & Gallagher, 2002 ; Leyronnas, 1998 ; Marchesnay, 2001). This is particularly true in the early stages of an innovation project because the hub firm must prove that the project is both technically and commercially viable.

CONCLUSION

The present study investigates the influence of a hub firm's dependence and size on the coordination mechanisms used within innovation networks. Analysis of seven innovation projects shows that (1) the division of results and the guarantees put in place vary as a function of the degree of dependence of the hub firm, (2) trust and the degree of formalisation depend on the size of the hub firm and (3) ways of resolving conflicts are influenced by both size and degree of dependence.

Future research could further the limits of the current research. However, these contributions must be contextualised. Coordination mechanisms can vary depending on the position of the innovation in the value chain (final product, integrated product). Future quantitative research could relieve the insufficiency of data for generalising results. Future work could demonstrate that it is necessary to take the moderating role of the project advancement phase of an innovation network into account, as well the type of members and relationship. Further work is needed also to examine the influence of the innovation process on the coordination mechanisms used by innovation networks. Although the present study looked at the influence of dependence in a static way, future studies could analyze how the degree of dependence evolves as the project advances. For example, during the early stages of a project (R&D and production), a small hub firm is likely to be highly dependent on the other members of the network but, as the project advances, the hub firm will try to reduce this dependence. Thus, a hub firm's dependence is not static and any initial asymmetry can be turned around (Tinlot & Mothe, 2005). Finally, more research is needed to confirm and generalize these results through the use of empirical studies, although such studies will not be easy due to the extreme diversity of the members of innovation networks.

In terms of the management of innovation networks, the present research will help SMEs to choose the most appropriate coordination mechanisms for their innovation networks. As we have seen, the coordination mechanisms used by hub firms vary according to their size and

degree of dependence. These two parameters are often vital concerns for hub firms, particularly for SMEs, and the results presented here throw light onto the implications they have on the choice of coordination mechanisms.

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ANNEXE A : extract from the coding grid

Each interview was coded (Miles & Huberman, 2003). The coding was carried out as soon as possible after each interview, and the codes were progressively refined during the research.

Code characteristics of the hub firm	Code Type of coordination mechanism	Verbatim
SMALL SIZE DEP	FORMALISATION	"When you start out, even if you know the area well, you have to watch your back. The first thing, before discussing any aspect of the project whatsoever, is to sign a confidentiality agreement" (hub firm, project A)
SMALL SIZE DEP	GUARANTEE	"At the beginning of the project, we were simple service providers, but we did more than was required of us by the specification. And it paid off, as now we are partners" (technical service provider, project A)
LARGE COMPANY ∅ DEP	GUARANTEE	"We work in different business sectors. However, all three of us are based in the Rhône-Alpes region. We met regularly in meetings that showed the value of cross-sector cooperation. As a result, each of us knew that any opportunistic behavior would make it difficult to form new complementary alliances" (industrial partner, project G)
LARGE COMPANY ∅ DEP	FORMALISATION	"We started falling behind on the technical objectives we had set ourselves. It is important to have a cast-iron consortium agreement, but it is to the detriment of the project. You have to accept that it is impossible to put everything in the contract because there are many aspects that we don't know where they will lead. I think that, now, we have to reach an agreement on the property rights and then get on with things" (industrial partner, project G)
SMALL SIZE ∅ DEP	CONFLICTS	"I asked myself if I could succeed without them. After a few sleepless nights and with help from Mr X (technical partner), we concluded that no one was indispensable. As I knew I didn't want to work with them, it was pointless carrying on with the discussions" (hub firm, project B)
SMALL SIZE ∅ DEP	GUARANTEE	"Oh, of course, after the launch we don't have as big a stick as before if they try to pull a fast one. Our only recourse is to call into question their professionalism when we are talking to other companies" (hub firm, project F)
SMALL SIZE DEP	TRUST	"For me, trust cannot occur instantaneously. It is difficult to explain but, for me, trust is built up as we get to know each other and through the feedback we get. First, we negotiate with such and such a company because they have specialist skills. Then, through our discussions with the people at that company, we start to build links with these people" (technical partner, project F)