

**LINKING TECHNOLOGICAL INNOVATION AND INTER-ORGANIZATIONAL
COLLABORATION : AN OVERVIEW OF MAJOR FINDINGS**

Faems, Dries (Katholieke Universiteit Leuven)

Promotoren: Bouwen, René (Katholieke Universiteit Leuven)
Janssens, Maddy (Katholieke Universiteit Leuven)
Van Looy, Bart (Katholieke Universiteit Leuven)



ABSTRACT

The purpose of this paper is to give an extensive overview of why, when and how organizations engage in inter-organizational collaboration. The paper illustrates that organizations can use both explorative and exploitative modes of inter-organizational collaboration to deal with technological uncertainty and to acquire resources that are difficult to mobilize and to imitate. This paper also shows that the process of inter-organizational collaboration can be described as a teleological change process that will be influenced by variables such as 1) the extent of trust between the partners, 2) the governance structure used to control and coordinate the collaboration, 3) the inter-organizational learning strategies applied by the collaborating partners, 4) the organizational similarity of the partners and 5) the environmental characteristics of the collaboration.

Keywords: inter-organizational collaboration; resource based view; exploration; exploitation

INTRODUCTION

Empirical studies indicate that, during the past 20 years, technological inter-organizational collaboration has become an important tool to supplement the internal innovative activities of organizations (Dodgson, 1993; Hagedoorn, 2002). Joint ventures, strategic alliances and contractual R&D partnerships have been recognized as useful structural tools by which innovative companies can minimize risks and costs of R&D activities and reduce technological uncertainty within turbulent environments (Dodgson, 1993; Hagedoorn, 1993; Harrigan, 1986; Mowery, 1988; Veugelers, 1998). Moreover, inter-organizational collaboration makes it possible to acquire the necessary technological and commercial resources to support the successful development of the organization's innovation strategy (Ahuja, 2000; Baum et al., 2000; Eisenhardt & Schoonhoven, 1996; Mitchell & Singh, 1996).

Using inter-firm collaboration to support technological innovation can, on the other hand, also harm the innovation potential of organizations. Collaborations with competitors, for example, will bring along a risk of involuntary knowledge spillovers, especially when this knowledge has imperfect appropriability (Teece, 1986, Veugelers, 1998). This risk of opportunistic exploitation by partners can weaken the competitive position of the organization severely (Baum et al., 2000).

This brief overview of benefits and risks illustrates that it will not always be easy to predict whether or not inter-organizational collaboration will be useful to support the innovation strategy of the organization. Therefore, in this literature review, we want to look at why, when and how inter-organizational can be used to support the technological innovation activities of organizations. In the first section we will define the concept of technological inter-organizational collaboration more clearly. Next, we will illustrate the variety that is present within the concept of inter-organizational cooperation by looking at different modes of inter-organizational collaboration. Subsequently, we will clarify why, when and in which way organizations will engage in technological inter-organizational collaboration. Finally, we will also take a closer look at the process of inter-organizational collaboration itself. In this way, we hope to give an overview of the issues that are considered important within inter-organizational research.

DEFINITION OF TECHNOLOGICAL INTER-ORGANIZATIONAL COLLABORATION

Defining technological inter-organizational co-operation is not a straightforward task. Inter-firm collaboration can take a wide variety of possibilities, which makes it difficult to construct a clear-cut definition for this phenomenon. We will now try to mark out this concept by illustrating what we do and do not understand under technological inter-organizational collaboration.

Following Yoshino and Rangan (1995) we exclude two types of inter-firm linkages from our definition of inter-organizational collaboration, namely equity arrangements that lead to the dissolution of the independent entities (i.e. mergers and acquisitions) and traditional contractual agreements (i.e. arm's length contracts, franchising, licensing and cross-licensing). The former type of inter-firm link is excluded because the involved organizations lose their independence, while the latter type is not considered because the extent to which these companies engage in joint activity is rather limited.

Although it is stressed that informal contacts with industry peers and lead users can indeed stimulate the technological innovation process to a large extent (Von Hippel, 1988), we also prefer to exclude these kinds of inter-firm contacts from our definition. The inclusion of such activities would bring along some methodological difficulties. After all, because of the informal character of these relationships, it will be very difficult to map these kinds of relationships on an organizational level. Moreover, Dodgson (1994) has stressed that informal relationships will often be translated later on in more formal collaboration agreements. Therefore, we only speak of collaboration when the contact between two or more independent parties has a formalized character.

Finally, we also want to make a distinction between technological alliances and market access alliances. Historically, market access alliances have generally been the most widespread form of inter-organizational collaboration (Doz & Hamel, 1997). Opposite to technological collaboration, this kind of alliances did not have a technological objective but rather a commercial one, namely getting access to markets (Harrigan, 1986). We however want to focus in this paper on technological collaboration which involves the sharing, transfer or creation of technology between the collaborating partners.

Based on the above considerations, we define technological inter-firm collaborations as a ‘formalized link between two or more independent organizations that brings along a substantial amount of joint technological activity, in which the independence of the original co-operating organizations is preserved’. We admit that this definition is still very broad, but we think it gives a first insight in what can be understood by technological inter-firm collaboration.

DIFFERENT MODES OF INTER-ORGANIZATIONAL COLLABORATIONS

The way in which organizations can collaborate can be very diverse. In this section we will try to give an overview of different modes of inter-organizational collaboration by looking at (1) the formal characteristics of the collaboration, (2) the identity of the partners involved in the collaboration and (3) the number of partners involved in the collaboration and (4) the objectives of the collaboration.

Equity and non-equity collaborations

We already indicated that Yoshino and Rangan (1995) make a distinction between contractual arrangements and equity arrangements. This distinction is used very often in the inter-firm collaboration literature (i.e. Haagendoorn, 1993; Tsang, 2000). In equity arrangements each partner has an equity position and expects a proportional share of dividend as compensation. Joint ventures and minority equity investments (i.e. alliances in which one or more partners take an equity position in the other(s)) are examples of such arrangements. Contractual arrangements on the other hand refer to a wide array of inter-firm linkages such as joint R&D, and strategic R&D alliances. Past research within the field of inter-firm collaboration has focused mainly on equity arrangements and more specifically joint ventures. However, during the last two decades contractual arrangements are used more and more by organizations to create inter-firm linkages. Hagedoorn (2002), for example, illustrates that the growth of newly made R&D partnerships since the early 1980s is largely caused by an overwhelming increase in the absolute number of contractual arrangements, while the number of R&D joint ventures did not increase substantially.

Upstream, horizontal and downstream collaborations

Another way to make a distinction between different kinds of inter-organizational collaboration is by looking at the relative position of the involved organizations on the value-chain. In this way we can make a distinction between upstream, horizontal and downstream alliances (Baum et al., 2000; Dodgson, 1993). Collaboration with universities, research institutes, government laboratories and suppliers are examples of upstream alliances, while alliances with clients and distribution or marketing companies can be called downstream alliances. Finally, horizontal alliances are most of the time collaborations with competitors or complementors.

Dyadic alliances, alliance constellations and alliance networks

Also the number of organizations that participate can be used to distinguish between different modes of inter-organizational collaboration. More specifically, a difference has been made between dyadic alliances, in which only two organizations collaborate, and alliance constellations, in which the collaboration involves more than two partners (Das & Teng, 2002; Doz & Hamel, 1997). The importance of this difference is illustrated by Das and Teng (2002) by using a social exchange perspective. They notice that dyadic alliances involve restricted exchanges which are characterized by direct reciprocity, while alliance constellations will bring along generalized exchanges in which the absence of direct reciprocity can lead to problems such as free riding and opportunistic behavior. By this, alliance constellations will be confronted with specific management problems related to conflict resolution and coordination (Doz & Hamel, 1998).

We also have to notice here that, next to dyadic alliances and alliance constellations, also the concept of alliance networks appears frequently within the literature (e.g. Gulati, 1998, Gulati et al., 2000; Tidd et al., 2002). By using the concept of alliance networks, researchers refer to the collection of an organization's dyadic alliances and alliance constellations (Das & Teng, 2002). So, while dyadic alliances and alliance constellations refer to individual collaborative agreements, an alliance network

represents the total amount of inter-organizational collaborations in which an organization participates.

Explorative and exploitative alliances

Different kinds of inter-organizational collaboration can also be distinguished by looking at the objectives of the collaboration. Hagedoorn (1993), for example, makes a distinction between inter-firm agreements that are aimed at improving the long-term perspective of the product-market combinations of the companies involved and inter-firm agreements that serve cost-economizing objectives in the short-term. R&D joint ventures, research consortia and joint R&D agreements will be most of the time examples of long-term strategic alliances, while technology exchange agreements and customer-supplier relationships will rather be categorized as short-term cost-economizing or revenue-generating alliances.

More recently, researchers have started to make a distinction between different kinds of inter-organizational collaboration by looking at the learning objectives of these collaborations. Applying March's (1991) dichotomy of exploration and exploitation, which has received a lot of attention within the organizational learning literature, researchers have made a distinction between explorative and exploitative alliances (Koza & Lewin, 1998; Rothaermel, 2001). In this way, it is emphasized that the firm's choice to enter into an alliance can be distinguished in terms of its motivation to exploit an existing capability or to explore new opportunities (Koza & Lewin, 1998). Within exploitative alliances, the main purpose is the enhancing of existing organizational competencies. Therefore, exploitation alliances focus on complementarities among the allied partners as they exchange explicit knowledge (Teece, 1992). Explorative alliances, on the other hand, are used to create new organizational competencies. This kind of alliance will be used to explore new technological opportunities that can bring along new organizational competencies. In this kind of alliance, not the sharing or transfer of tangible complementary assets will be the main issue, but rather the exchange of intangible knowledge by learning about each others competencies will be the most important objective.

WHY, WHEN AND IN WHICH WAY DO ORGANIZATIONS COLLABORATE

In the introduction we already mentioned that organizations feel a tendency to collaborate because inter-firm co-operation can cause multiple benefits such as a reduction of costs and risks of R&D, a better understanding of industry-wide technological developments and a better access to knowledge-based resources (Dodgson, 1993). These benefits give a first indication of why organizations want to collaborate. In this section we will give a more detailed overview of the inducements that organizations experience to engage in inter-firm collaboration and how they will translate this into concrete collaboration strategies. This analysis will be executed on both an industry and an organizational level.

Industry-based analysis of inter-organizational collaboration

A first way to analyze to what extent organizations engage in technological collaboration is to look at industry-related variables. Empirical research has shown that from the 1980s, high-tech industries such as pharmaceuticals, information technology sectors and aerospace and defense sectors have become dominant in R&D partnering (Dodgson, 1993; Eisenhardt & Schoonhoven, 1996; Hagedoorn, 2002; Tether, 2002). In this section we will illustrate why, when and to what extent collaboration is used in these sectors. As a guiding framework we will use the life cycle model that Cairnarca et al. (1992) constructed by conducting an empirical study within the information technology sector. This study provides a plausible analysis of the changes in extent and purposes of technological collaboration during the technological life-cycle of R&D intensive industries (Dodgson, 1993). More specifically, by making a difference between five stages in the technological life-cycle of industries (introduction, early development, full development, maturity and decline) this study has succeeded in illustrating that industry-related variables indeed influence the extent and the way in which organizations collaborate.

Industry-based analysis of the extent of collaboration

Based on their results, Cairnmarca et al. (1992) conclude that:

‘The propensity towards cooperation will be high in the introduction stage, where agreements are used by firms to cope with market and technological uncertainty, to lower mobility barriers and risks of sunk costs, and to obtain high adaptive efficiency. The propensity towards agreements will then reach its maximum value in the early development stage, allowing firms to gain rapid access, in step with the high dynamics of the market, to specialized assets complementary to innovations and essential for their commercial success. Again, during maturity, non equity collaborative ventures will be stimulated by the likely revitalization of technological trajectories, the stabilization of market structure, and attempts by firms to exploit residual oligopolistic rents by transferring technology to peripheral areas of the world market. On the contrary, the number of agreements concluded will drastically decrease during the full development and decline phases, owing to a marked contraction of non equity forms. In the full development stage, reduced appropriability of technology and growing competitive pressure, stemming also from threat of new entries, induce firms to internalize the control of specialized complementary assets: accordingly, internal growth and also acquisitions will tend to replace cooperation with other firms. During decline, characterized by the exhaustion of technological opportunities and the contraction of the market, write-offs and divestments will clearly prevail as vehicles for the rationalization of market structure. (Cairnmarca et al., 1992, p.60)’

These results indicate that, due to industry-related variables such as technological uncertainty and competitive pressure, the extent of collaboration will differ between the different stages of the technological life cycle. During the introduction, early development and maturity stage, collaboration will be a common tool to support technological development. During full development and decline phases, on the other hand, high competitive pressures and limited technological opportunities will limit the amount of inter-organizational collaboration.

These results also illustrate that the reason why inter-organizational collaboration is used will differ between the different technological life-cycle stages. Before technological maturity is achieved, organizations will collaborate for reasons such as technology watching and getting rapid access to specialized know-how. In this way organizations want to be able to deal with the radical, competency-destroying technological changes that can occur when a dominant design is not yet achieved

(Anderson & Tushman, 1986; Utterback & Abernathy, 1975). When, on the other hand, technological maturity is already achieved, organizations will use collaborations mainly to optimize incrementally the existing technology, to exploit the existing technology in peripheral markets or to improve the commercial and manufacturing possibilities of the involved technology (Cairnarca et al., 1992).

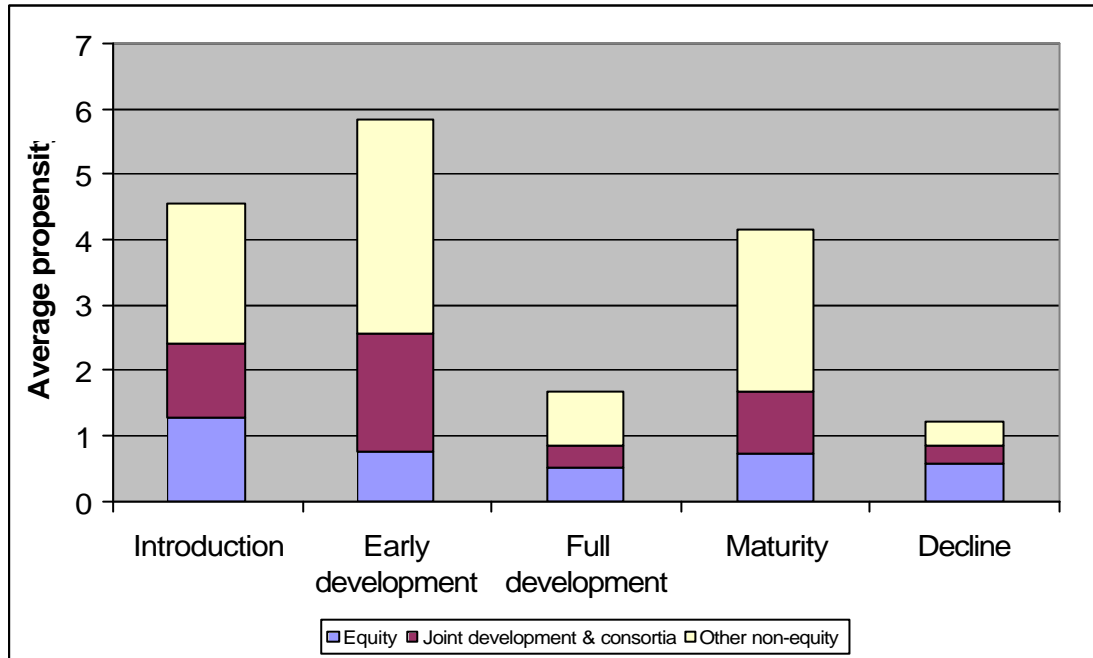


Figure 1 Average propensity towards agreements during the phases of the technological life cycle (average propensity = the average annual number of agreements in the period examined, normalized against the maximum value of the industry turnover in the U.S. in the 1980-1990 period, in billion U.S. \$, at 1980 prices.)

Industry-based analysis of structural preference for collaboration

We have already indicated that the variety present within the concept of inter-organizational concept is extended. Organizations can choose, for example, between equity and non-equity modes of inter-organizational collaboration. However, we did not yet indicate why an organization will choose a specific mode of inter-organizational collaboration. The model of Cairnarca et al. (1992) can help to clarify this by illustrating how the relative importance of equity and non-equity collaborations changes when an industry passes through the different stages of a technological life-cycle. More specifically Figure 1 shows that, while the amount of equity arrangements remains rather stable during the different stages of the life-cycle,

the amount of non-equity arrangements changes considerably when an industry moves from one stage to another. This seems to support the proposition that equity arrangements such as joint ventures can be seen as long-term arrangements that continue to exist when an industry moves from one stage to another, while non-equity arrangements are much more flexible modes of inter-organizational collaboration which are used to support very specific objectives during a specific time interval within the technological trajectory of the industry (Tidd et al., 2002; Hagedoorn, 2002). Moreover, Cairanrca et al. (1992) have also made a typology of inter-organizational agreements (Table 1) in which they link the type of agreement to the different stages of the technological life-cycle. This typology makes clear that different types of arrangements will be used to support different objectives during different stages of the technological life-cycle. In the introduction phase, for example, R&D agreements and scanning agreements will be used to deal with the technological uncertainty that is present during this stage of the technological life-cycle. In the maturity stage, on the other hand, asymmetric technological agreements and strategic alliances will be preferred to revitalize existing technologies within stabilized market structures.

Using the life-cycle model of Cairnarca et al. (1992) we can conclude that technological uncertainty and the amount of competition present within the industry will have an important influence on the extent, the reasons why and the way in which organizations use technological collaboration. Also other authors have stressed the importance of these industry-level determinants of technological collaboration formation (Dodgson, 1993; Hagedoorn et al., 2001; Koza & Lewin, 1998). By giving an overview of empirical work that has tried to explain the extent of inter-organizational collaboration, Dodgson (1993), for example, concludes that organizations will collaborate more intensive in pre-competitive stages, compared to later stages of industry development. Moreover, also he stresses that, before a dominant design has emerged, the purpose of technological collaboration will be the exploration of new technological possibilities, while later on the exploitation of existing technologies will be placed more central.

Stage	Type of agreements
Introduction Extreme uncertainty about technologies and markets Clusters of innovation High risk of sunk costs Search of adaptive efficiency	Significant proportion of equity agreements R&D agreements Horizontal and vertical agreements for product pattern and product-process standards Scanning agreements (non equity)
Early development Accelerated market dynamics Persisting uncertainty and risk of sunk costs Focusing process of technological trajectories Importance of complementary assets	Clear majority of non equity agreements Agreements on R&D, standards, joint development agreements Commercial and manufacturing agreements for access to complementary assets
Full development Stabilization of market dynamics Economies of learning and standardization Incremental and process innovations Prominent role of complementary assets Resource internalization strategies	Marked contraction in agreements in general, with major impact on the more volatile ones (non equity)
Maturity Stabilization of market structures Possible technological revitalization Strategies aimed at extending oligopolistic rents Market manipulation and collusion	Large component of non equity agreements Asymmetric technological/ manufacturing/ commercial agreements (small-large firms, North-South etc.) Strategic alliances
Decline Contraction of the market Rationalization and concentration Exit strategies	Large component of equity agreements Wide-range commercial and manufacturing agreements Defensive collusion agreements Agreements aimed at soft divestments

Table 1 The typology of agreements (Cairnarca et al., 1992, p.50)

Analysis of inducements to collaborate on the organizational level

Besides industry-related variables, also firm specific variables appear to be useful to assess when, why and to what extent organizations will make inter-firm agreements. Looking at the literature that tries to explain the phenomenon of inter-organizational collaboration on an organizational level, we can notice that the diversity of applied theoretical frameworks is substantial. For an extensive overview of the different theories that are used to explain the emergence of inter-organizational collaboration we refer to the reviews of Dodgson (1993), Gray and Wood (1991) and Smith et al. (1995). In this section we will limit ourselves to an overview of two theoretical perspectives that are used regularly to explain the inducements to collaborate: (1) Transaction Cost Theory and (2) Resource-Based View. The Transaction Cost Theory

will be discussed because it has been seen as the dominant theoretical model to explain why inter-organizational collaboration will be preferred in some circumstances above other modes of governance (Das & Teng, 2000) The Resource Based View, on the other hand, is interesting to discuss because it has been brought forward during the past decade as a theoretical model that can complement the Transaction Cost Theory to a large extent (Tsang, 2000).

Transaction Cost based explanations for alliance formation

Transaction Cost theory has become very popular within the strategic management literature to explain why organizations sometimes prefer to make something themselves instead of buying it on the market (Besanko et al., 1997). In this theory, it is said that, when the risk of opportunism is too high within a market context because of asset specific investments, it is better to use an internal governance structure as long as internal production costs are not too high (Coase, 1937; Williamson, 1975).

The original Transaction Cost theory did not anticipate the proliferation of various forms of inter-organizational collaboration in the 1980s (Tsang, 2000). To make up for this shortcoming, some authors have tried to extend the Transaction Cost theory in a way that makes it possible to include inter-organizational governance structures into the decision framework. Williamson has stated that hybrid modes of governance (= inter-organizational structures) will be preferred above markets or hierarchies when asset specificity and internal production costs are of an intermediate degree (Williamson, 1991). Kogut (1988) has made a more extensive analysis of situations in which alliances, and more specifically joint ventures, will be used to govern transactions. He states that 'inter-organizational collaboration will occur when high uncertainty over specifying and monitoring performance is combined with a high degree of asset specificity' (Kogut, 1988:320).

Although this transaction cost view has been used a lot within empirical strategic alliance research (e.g. Balakrishnan & Koza 1993; Hennart & Reddy, 1997; Pisano, 1990) and has contributed to the understanding of why organizations engage in inter-organizational collaboration, it also has some drawbacks. More specifically, its focus on cost minimization and individual transactions has been criticized extensively.

Hagedoorn (1993) has illustrated empirically that, within technological innovation settings, organizations use collaborations to support value-enhancing goals such as achieving technological complementarity, reducing the innovation time-span and improving access to markets. Cost-minimizing goals of collaborations such as reducing the costs and risks of R&D investments, turned out to be not really important issues for the organizations who decided to undertake technological oriented collaborations. However, because of its focus on minimization of transaction and production costs, the value creating properties of inter-organizational collaboration are neglected within a Transaction Cost based analysis (Das & Tseng, 2000; Tsang, 2000; Zajac & Olsen, 1993). This implies that it will become very difficult to get a complete picture of the inducements to engage in technological collaboration from a Transaction Cost perspective.

We also have to notice that Transaction Cost Theory will evaluate each transaction in isolation (Gulati, 2000; Tsang, 2000). However, technological collaborations such as joint ventures will have a long-term orientation (Hagedoorn, 1993) which will include multiple transactions over time. By this, the possibility exist that organizations will prefer to choose a specific governance structure that will be most suitable in the long-term, while, by looking at individual transactions from a Transaction Cost perspective, this option would not be advised (Eisenhardt & Schoonhoven, 1996; Tsang, 2000). Moreover, because Transaction Cost theory looks at transactions in an isolated way, it will neglect the fact that these transactions are embedded in personal relations and networks between and within firms (Granovetter, 1985; Gulati, 2000). These socially constructed networks or relationships can have an important impact on the motives to cooperate. It is shown, for example, that organizations that have collaborated successfully earlier on will be tempted to collaborate again with each other in the future (Ahuja, 2000) Because of its undersocialized view (Granovetter, 1985), Transaction Cost theory will not take into account these trust generating mechanisms that can compensate for the potential occurrence of opportunistic behavior (Beamish & Banks, 1987). By this, Transaction Cost theory will often underestimate the tendency of organizations, strongly embedded within networks, to collaborate.

Resource based explanations for alliance formation

Introduction to Resource based theory: Opposite to the Transaction Cost theory, the Resource based view will look at inter-organizational collaboration from a value-maximizing perspective (Tsang, 2000). The Resource based view has received a lot of attention within recent strategic management literature because of its focus on internal, firm specific resources. Originally this perspective has stated that organizations can only achieve a sustained competitive advantage, when they are able to accumulate resources that are valuable, rare, difficult to imitate and difficult to substitute (Barney, 1991; Dierickx & Cool, 1989; Peteraf, 1993). When internally build resources posses these characteristics, it will be impossible for competitors to acquire them on strategic factor markets (Barney, 1986). By this, these specific resources can constitute the basis for a sustained competitive advantage.

During the last decade the Resource Based View had been modified and extended. One of the major adjustments has been that some authors recognized that building resources internally is not the only option for organizations to achieve a sustainable competitive advantage. Also the sharing of valuable, rare, difficult to imitate and difficult to substitute resources, through an inter-firm agreement, can lead to the same result (Dyer & Singh, 1998; Eisenhardt & Schoonhoven, 1996). In this way, resource accumulating modes of inter-organizational collaboration such as joint ventures and strategic alliances have started to get a lot of attention within the Resource based literature.

Inducements to collaborate: Following the Resource Based View, a firm's inducements to form technological linkages can be related to its need for resources. Through inter-firm cooperation firms can obtain access to assets that create value, are not available for purchase in factor markets, and require time to build up (Ahuja, 2000; Das & Teng, 2000; Eisenhardt & Schoonhoven, 1996). Let us explain this statement more clearly.

When an organization wants to conduct innovative activities it will experience specific resource needs. Teece (2002), for example, stresses that an organization can only execute successfully innovation projects when it gets access to the necessary complementary assets. Following Miller and Shamsie (1996), these resources can be

classified into two broad categories: property-based resources and knowledge-based resources. Property-based resources are legal resources owned by firms, including financial capital, physical resources, human resources, etc. Knowledge-based resources refer to a firm's intangible know-how and skills, which have limited or no legal protection (Miller & Shamsie, 1996).

To acquire these resources the organization has three options: 1) transfer these resources into the organization by buying them on the appropriate market, 2) create these resources inside the organization by developing them internally and 3) create or transfer these resources into the organization by engaging into inter-organizational collaboration¹. Although the first two options will be most of the time more cost-effective ways than the third option to acquire property-based and knowledge-based resources, because of the lower governance costs that are associated with these two options, it will not always be possible to use these options. After all, some resources can not be bought against acceptable prices on markets because of their imperfect mobility or will take too long to develop internally because of their imperfect imitability. (Barney, 1991; Das & Teng, 2000; Dierickx & Cool, 1989; Miller & Shamsie, 1996; Peteraf, 1993). Property-based resources such as patents and trademarks will have these characteristics because of the legal protection that comes along with them. Also knowledge-based resources can have these characteristics. Specific organizational skills and knowledge, for example, will be often difficult to mobilize and to imitate because of their tacitness (Polanyi, 1966), the causal ambiguity that comes along with it (Lippman & Rumelt, 1982; Reed & DeFilippi, 1990) and their path-dependent development (David, 1985). In this way, we can conclude that for some resources, because of their imperfect mobility and imitability, it will be very difficult to buy them externally or to create them internally. To improve the familiarity with these kinds of resources, more embodied technology transfer mechanisms have to be used (Roberts & Bary, 1985). Therefore, we can state that, to acquire such resources, the use of inter-organizational collaboration seems to be the most plausible solution (Ahuja, 2000; Das & Teng, 2000; Teece, 2002). This means that, when an organization needs complementary assets that are imperfectly mobile

¹ Sometimes acquisition is added as a fourth option to acquire specific resources. However, following Barney (1986) we consider an acquisition as a specific case of the buying option. After all, conducting an acquisition can be seen as buying another organization on the strategic factor market for organizations.

and imitable, it will be induced to engage in inter-organizational agreements with organizations that possess these resources.

Opportunities to collaborate: Researchers that have studied the collaborative behavior of organizations from a Resource Based View have stressed that organizations do not only have to feel induced to collaborate, but also need to have the opportunity to collaborate (Ahuja, 2000; Eisenhardt & Schoonhoven, 1996; Sakakibara, 2002). Imagine an organization A that wants to get imperfectly mobile and imitable complementary assets from another organization B. Following the Resource Based View, these specific resources can constitute a sustained competitive advantage for organization B. In this way, it seems reasonable that organization B does not want to hand over these resources to organization A without any compensation. We can expect that organization B will only be willing to share or hand over these resources within an inter-organizational collaboration when organization A can come up with imperfectly imitable and mobile resources that are useful for organization B. This reasoning aligns with results of empirical studies in which has been found that organizations with large stock of technical, commercial and social resources will be more involved in inter-organizational collaborations than organizations with relatively low stocks of these resources (Ahuja, 2000; Eisenhardt & Schoonhoven, 1996; Sakakibara, 2002). At the same time, this also reveals what is perhaps the most fundamental irony of alliancing: firms must have resources to get resources (Eisenhardt & Schoonhoven, 1996).

When we discussed critically the Transaction Cost Theory, we already mentioned that the embeddedness of organizations within social networks is an important indicator to explain the collaborative behavior of organizations. Empirical studies, who have used the Resource Based View as a guiding framework to explain collaborative behavior, have integrated this variable by examining to what extent the 'social capital' (Ahuja, 2000) of the organization can influence the opportunities of an organization to collaborate. In these studies social capital is defined as the amount of existing strong and weak ties that an organization possesses with other organizations (Ahuja, 2000; Granovetter, 1973; Gulati, 1995). Within the different studies it has been found consistently that the more extended the social capital of the organization, the more likely it will engage in inter-organizational agreements in the future (Ahuja, 2000; Gulati, 1995, 1999; Sakakibara, 2002; Shan et al., 1994). To explain these findings,

we have to look at some positive effects that can be brought along by collaboration. It has been said that prior collaboration can provide information on collaboration opportunities and can signal the reliability of potential partners (Gulati, 1995, 1999). Moreover, by showing non-opportunistic behavior in prior collaborations, organizations can build themselves a reputation as a trustworthy partner (Ahuja, 2000). Finally, prior collaboration will also increase the expertise of organizations to handle the specific opportunities and threats that come along with collaboration (Ahuja, 2000; Luo, 2000). New information about collaborative possibilities, a reputation of trustworthiness, and expertise in alliancing can all be seen as knowledge-based resources that are difficult to mobilize or imitate (Das & Teng, 2000). As said before, this kind of resources will increase the opportunity for the organization to engage in inter-organizational collaboration. Therefore, we can conclude that conducting inter-organizational collaboration can bring along the creation of specific social resources which will increase the opportunity of the organization to form new linkages in the future.

Conclusion

In this section we have tried to give an overview of why organizations feel the need to collaborate. From an industry-based level we have concluded that technological uncertainty and the amount of competition present within the industry can be important predictors to explain the collaborative behavior of organizations. Moreover, we have illustrated that the extent and the reasons why organizations collaborate will differ according to the maturity of that particular industry. The collaborative behavior can also be assessed on an organizational level. Applying a Resourced Based framework as an alternative for the Transaction Cost Theory, we have shown that the need for imperfectly mobile and imitable resources explains why organizations feel induced to collaborate, while the possession of these resources will determine the extent to which organizations have opportunities to collaborate.

We also indicated that the maturity of the industry will have an important influence on the structural preference of the collaborating partners. Das and Teng (2000) stress that also the type of resources that will be transferred, shared or created within the collaboration will have a major influence on the choice for a specific mode of inter-organizational collaboration. More specifically, they state that collaborations which

focus on the exchange of property-based resources will have a different structure than collaborations which focus on the exchange of knowledge-based resources. In the figure below we have tried to combine both these industry and organizational-related characteristics to illustrate the variety that is present within the concept of inter-organizational collaboration. Looking at this categorization, we propose that inter-organizational collaboration can be used to exchange mainly property-based resources in industries that have low technological uncertainty or to exchange mainly knowledge-based resources in industries that have high technological uncertainty. Applying the exploration-exploitation dichotomy that we already mentioned, we can conclude that the former category can be seen as modes of exploitative collaboration that will be useful to enhance existing organizational competencies. The latter category, on the other hand, represents explorative modes of collaboration that can lead to the creation of new organizational competencies. Finally, joint ventures and minority equity alliances can be seen as modes of inter-organizational collaboration that can serve both exploitative and explorative strategic objectives.

	<i>Technological uncertainty present within industry</i>		
Type of resources exchanged	<i>Low Uncertainty</i>	<i>Medium Uncertainty</i>	<i>High Uncertainty</i>
Property-based Resources	Joint Manufacturing	Agreements for standards Manufacturing agreements for access to complementary assets	
Property and Knowledge-based Resources	Joint R&D with suppliers and distributors	Joint Ventures Minority equity alliances	Joint R&D with universities, research institutes and competitors
Knowledge-based Resources		Strategic alliances for access to complementary knowledge	Scanning agreements

Figure 2 Overview of possible modes of technological inter-organizational collaboration

- = Exploitative inter-organizational collaboration
- = Explorative inter-organizational collaboration

HOW DO ORGANIZATIONS COLLABORATE?

In the previous section we have focused on research that has explained why organizations engage in technological collaboration. If we want to find out what determines the successfulness of inter-organizational collaboration, we also have to understand how organizations collaborate. Therefore, we will take a closer look in this

section to the process of inter-organizational collaboration. First, based on existing studies that have examined inter-organizational collaboration from a process perspective, we will present a framework that illustrates how the process of inter-organizational collaboration will unfold. Next, we will identify these variables that seem to influence the process of inter-organizational collaboration to a large extent. Before we start this discussion we have to remark that, within the process-oriented inter-organizational literature, most of the time no distinction has been made between technological and other forms of inter-organizational collaboration. Therefore, also we will speak in this section about inter-organizational collaboration in general.

The inter-organizational collaboration process: a theoretical framework

Compared to the extended amount of research that has tried to explain why organizations engage in inter-organizational collaboration, the number of studies that focuses on the inter-organizational collaboration process itself is rather limited (Koza & Lewin, 1998). However, researchers such as Ring and Van de Ven (1994), Doz (1996) and Ariño and de la Torre (1998) have started to fill this research gap. Based on their insights, we have constructed a theoretical framework that illustrates how inter-organizational collaboration will evolve over time. Following these researchers, we see inter-organizational collaboration as a teleological change process (Van de Ven & Poole, 1995) in which learning-reevaluation-readjustment loops will reoccur continuously.

A first stage that is identified in this model is the start-up of the collaboration. During this stage, the involved parties will conduct negotiations that can lead to commitments about what action will be undertaken within the newly founded inter-organizational relationship. Negotiation can be defined as the total amount of formal bargaining and informal sense-making that will lead to joint expectations about their motivations, possible investments, and perceived uncertainties of a business deal that they are exploring to undertake jointly (Ring & Van de Ven, 1994). Next, the parties will commit to these expectations by reaching an agreement on the obligations and rules for future action in the relationship which will be codified in a formal legal contract or incorporated within a psychological contract (Ring & Van de Ven, 1994). In this way, the initial conditions of the alliance will be set. These initial conditions can be most

clearly understood as comprising a definition of the task to be performed, a design for the interface between the partners (i.e. governance structure), and a series of expectations about the performance of the alliance.

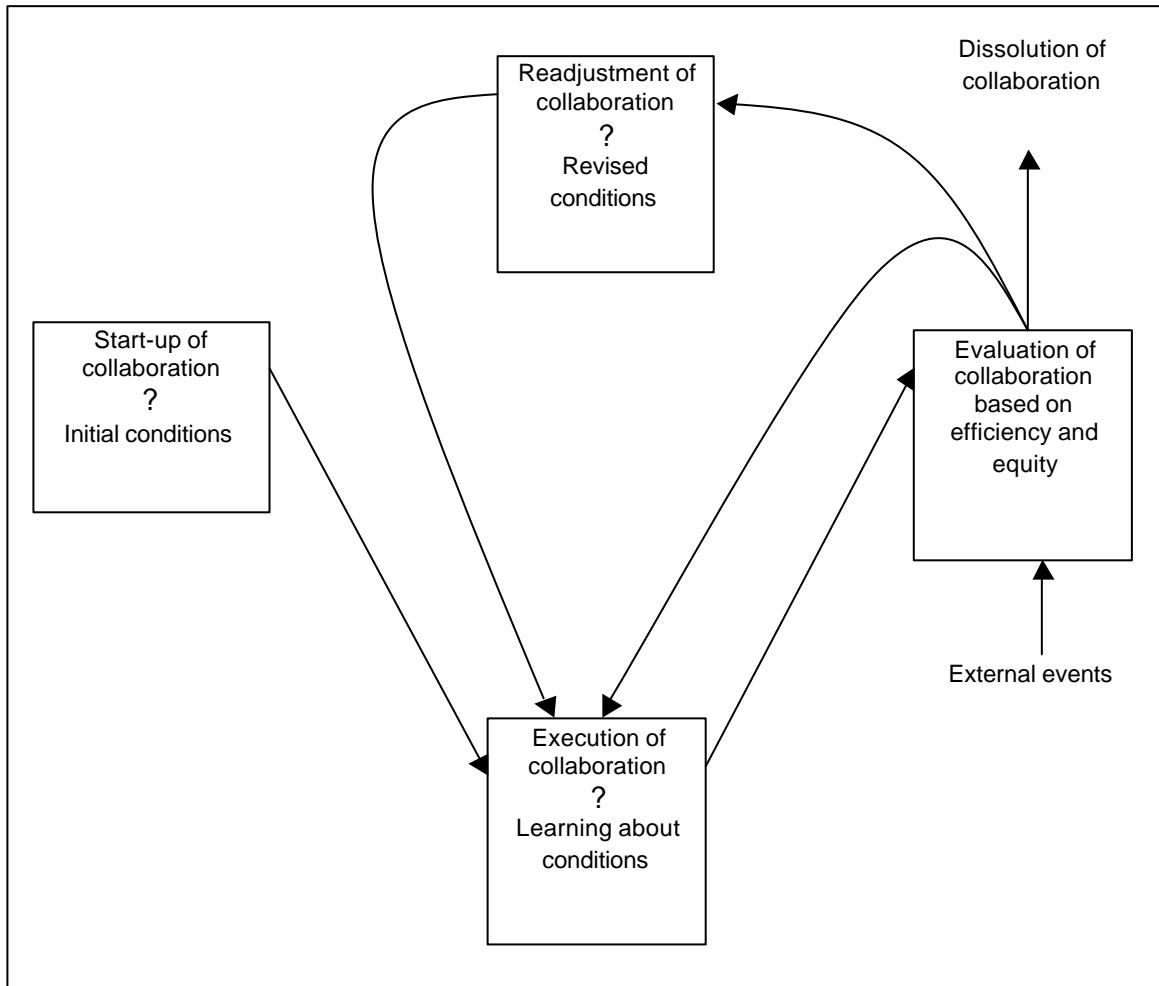


Figure 3 The process of inter-organizational collaboration

Next, in the execution stage, the commitments and rules of action are carried into effect; the parties give orders to their subordinates, buy materials, pay the amounts agreed upon, and otherwise administer whatever is needed to execute the agreement (Ring & Van de Ven, 1994). By doing this, the partners can start to learn about the initial conditions created during the start-up of the collaboration. Doz (1996) states that the execution of the collaboration will bring along five learning processes which represent five dimensions: environment, task, process, skills and goals.

The learning processes that will unfold during the execution stage will lead to the evaluation of the initial conditions. More specifically, it is stated that the inter-organizational collaboration will be assessed by looking at the efficiency and the equity of it (Ring & Van de Ven, 1994). An alliance is efficient in a Pareto optimal way if there is no other alternative arrangement that would leave one party better off without the other being worse off. The equity condition, on the other hand, requires that both firms are initially satisfied that the relative value of the alliance to each company is proportional to their respective contributions (Ariño & de la Torre, 1998). Not only learning can bring along the reevaluation of the collaboration, also external events can trigger the evaluation of the initial conditions of the inter-organizational relationship. External changes such as economic recession, new technological developments, changing legislation, changing competition and so forth can influence to a large extent the partner's perceptions of the efficiency and equity of the collaboration (Ariño & de la Torre, 1998; Woolthuis, 1998).

This evaluation will determine how the inter-organizational process will continue. If all the parties involved believe that the efficiency and equity of the collaboration are satisfactory, the partners will continue the execution of the main activities of the collaboration without changing the initial conditions (Ariño & de la Torre, 1998). If, on the contrary, the alliance is assessed as having a lower value than expected, or if one or more partners believe that there is an imbalance that violates equity conditions, alternative action is necessary. The parties involved will start to readjust the initial conditions of the collaboration if the efficiency problems or equity imbalances are not too problematic, if alliance partners believe that the other partner(s) have the necessary adjustment capabilities to change the initial conditions successfully (Doz, 1996) and if the quality of the relationship between the alliance partners is satisfactory (Ariño & de la Torre, 1998). If these conditions are not met, dissolution of the inter-organizational collaboration seems to be the most likely outcome of the evaluation.

When readjustment seems to be the most plausible solution to deal with perceived problems with efficiency and/or equity conditions, collaborating parties will start again to negotiate. This has to lead to commitments about how initial conditions have to be changed (Ariño & de la Torre, 1998; Ring & Van de Ven, 1994). If these negotiations are successful, new task definitions, interface designs and/or expectations will appear. Next, these revised conditions can guide the execution of the collaboration. In this way, a new learning-reevaluation-readjustment loop will be triggered (Ariño & de la Torre, 1998; Doz, 1996; Ring & Van de Ven, 1994).

Identification of influencing variables

We just described the inter-organizational collaboration process as a cyclical process in which some stages will reoccur continuously. Process oriented studies of inter-organizational collaboration have not only increased the insights in how the process of inter-organizational collaboration evolves over time, they also have tried to map which variables influence this process. Based on an extensive literature review, we have come to the conclusion that the variables, identified in these studies, can be categorized according to five dimensions: 1) the quality of the relationship, 2) the characteristics of the employed coordinating mechanisms, 3) the characteristics of the inter-organizational learning process, 4) the similarity of the collaborating partners and 5) time and space related characteristics of the collaboration. In this section we will discuss these five dimensions more detailed.

The quality of the relationship

A first dimension that influences how the inter-organizational collaboration process will unfold is the quality of the inter-organizational relationship. When we spoke about the readjustment stage, we already emphasized that alliance partners will only engage in this kind of activities when they perceive the quality of the relationship as satisfactory. The extent to which collaboration can be seen as qualitative will depend on, the personal bonds between key executives on both sides, on their trust in each other, and on the broader reputation the partners have for fair dealing (Ariño & de la Torre, 1998).

Especially the issue of trust has received a lot of attention. First, the concept of trust itself has been widely researched². The literature on inter-organizational trust suggests that this concept actually has two dimensions: one structural, referring to the ‘calculative’ trust based on the rational motivation of participating in value-adding resource complementarity, mutual hostages, reputation effects, etc.; and one behavioral, referring to the ‘pure’ trust based on the well-intended beliefs and optimistic expectations that another firm will perform positive actions and avoid negative actions towards one’s own firm (Larsson et al., 1998). Second, trust has been used in a lot of studies as an explaining variable for the successfulness of inter-organizational collaboration. More specifically, studies have illustrated that trust will create expectations that others will respond favorably (Browning et al. 1995), that trust will increase the willingness of partners to make larger and larger, as well as increasingly specific and irreversible commitments (Doz, 1996), that high levels of trust allow a relationship to run smoothly and may reduce some of the transaction costs (Yli-Renko, 2001) and that inter-organizational trust will empower inter-organizational learning (Larsson et al., 1998). From these results we can conclude that the amount of trust present within the collaboration will have a major influence on how the inter-organizational relationship will evolve.

It is also important to notice that trust is not a static concept. Doz (1996), for example, illustrates that by engaging continuously in learning-evaluation-readjustment loops, alliances will generate a dynamic that brings along greater and greater trust. This means that trust is not only an input to the success of the collaboration, but also an output of the interactions between the partners (Ariño & de la Torre, 1998, Ring & Van de Ven, 1994; Van de Ven & Walker, 1984).

Characteristics of the employed coordinating mechanisms

Inter-organizational collaboration will bring along a continuous stream of interaction between the different partners. An inter-organizational collaboration can only be successful if the quality of this interaction is high. This requires for example that, during negotiations, partners are willing to exchange company sensitive information and that, during the execution of the collaboration itself, partners hand over these

² for an extensive overview see the special issue of Academy of Management Review (1998), 23 (3) on trust

property and knowledge-based assets that are necessary to achieve the committed objectives of the collaboration. However, partners will only be willing to engage in this kind of interactions when they can be sure that they will be conducted in an efficient and equitable way. Therefore, an important objective for collaborating partners is to choose a governance structure that minimizes transaction costs, thereby enhancing efficiency and minimizes the risk of opportunistic behavior, thereby enhancing equity (Dyer & Singh, 1998; Tsang, 2000).

Different kinds of governance mechanisms can be used to achieve these objectives. On the one hand, alliance partners can rely on formal governance mechanisms such as legal contracts and financial or investment hostages. The former formal governance mechanism relies on third-parties (i.e. the state or a legitimate organization authority) to determine whether a violation has taken place (Telser, 1980). Financial and investment hostages, on the other hand, are formal forms of self-enforcement agreements that will bring along structural trust (Dyer & Sing, 1998; Larsson et al., 1998). After all, a financial hostage such as an equity agreement or an investment hostage such as a symmetric investment in specialized assets constitutes a visible collateral bond that aligns the economic incentives of the exchange partners. The structural trust that comes along with this kind of governance structures makes it for the collaborating partners economic rational to collaborate in a non-opportunistic way (Pisano, 1989). Moreover, since these investments may increase in value if the alliance partners cooperate, there is an incentive for the alliance partners to engage in value-creation initiatives (Dyer & Singh, 1998).

Although formal governance mechanisms are used often within inter-organizational collaborations, they seem to have some important drawbacks. Governance structures that rely on third-party enforcement (e.g. contracts) are most of the time costly to write, monitor, and enforce. In this way, higher transaction costs can be expected (Besanko et al., 2000). Moreover, Ring and Van de Ven (1994) stress that the exclusive use of this kind of governance mechanism can lead to excessive legal structuring and monitoring of the relationship which increases considerably the probability of dissolution of the inter-organizational relationship. Also governance structures that use structural trust to enforce a non-opportunistic behavior have their disadvantages. The more structural trust is present within an alliance, the more attractive it becomes to opportunistically exploit the others (Das & Teng, 2000;

Larsson et al., 1998). Hamel (1991), for example, found out that a lot of joint ventures, which have a high degree of structural trust because of the financial equity, will often end up in learning races in which different partners try to acquire as much knowledge as possible from the other(s) by conducting opportunistic learning strategies.

Next to these formal governance mechanisms, also informal safeguards can be used to enforce efficient and equitable interactions. It has been stated that the use of behavioral trust is the most effective and least costly means of safeguarding specialized investments and facilitation complex exchange (Dyer & Sing, 1998; Gulati, 1995; Uzzi, 1997). After all, the greater the ability to rely on trust, the lower the transaction costs required of parties to negotiate, reach agreements, and execute cooperative inter-organizational relationship (Barney & Hansen, 1994; Ring & Van de Ven, 1994; Sako, 1991).

However, also the use of informal safeguards has its liabilities. First of all, behavioral trust needs time to develop, because it requires a history of interactions and personal ties (Dyer & Sing, 1998). This brings along that at the start of collaboration, parties will be forced to use more formal governance mechanisms, which can be replaced later on by informal safeguards, when behavioral trust between the collaborating partners has increased (Gulati, 1995; Ring & Van de Ven, 1994). Second, also behavioral trust can be subjected to the 'paradox of trust' (Dyer & Singh, 1998). As Granovetter (1985) recognized, trust establishes norms and expectations about appropriate behavior, lowering the perception of risk in the exchange, but it also provides the opportunity for abuse through opportunism.

We can conclude that there seem to be different governance mechanisms that all have their advantages and disadvantages. Studies have indicated that the choice of a particular governance structure will depend on 1) the type of resources exchanged in the collaboration (Das & Teng, 2000; Van de Ven & Walker, 1984), 2) on the amount of past interactions among the collaborating parties (Gulati, 1995, Ring & Van de Ven, 1994) and 3) on the temporal duration of the inter-organizational collaboration (Dyer & Singh, 1998; Ring & Van de Ven, 1994). Moreover, Borch (1994) found out that many effective alliances use multiple governance mechanisms simultaneously.

Characteristics of the inter-organizational learning process

When we discussed the execution stage of the inter-organizational collaboration process, we already stressed that learning about the initial conditions would be an important outcome of this collaboration stage. Doz (1996) has illustrated that, during the execution stage, two learning processes can unfold: 1) cognitive learning processes which allow assessing the efficiency of the initial conditions and 2) behavioral learning processes which allow assessing the extent to which partners are able or willing to change inefficiencies that are brought along by the initial conditions. Moreover, Doz (1996) has found out that the extent to which partners engage in this kind of learning processes will have an important influence on the successfulness of the collaboration³.

Inter-organizational learning is not only an outcome of the execution stage within a collaboration, often learning will be one of the main objectives of the inter-organizational collaboration. When we spoke about inducements to collaborate, we indicated that organizations will often engage in inter-organizational relationships to acquire imperfectly mobile and imitable knowledge-based resources. The sharing, transfer or creation of this kind of resources is only possible by conducting successful inter-organizational learning between the involved parties. In our opinion the extent of inter-organizational learning will depend on two issues: 1) the learning strategies and 2) the partner-specific absorptive capacity of the collaborative partners.

Using the conflict behavior framework of Thomas (1976), Larsson et al. (1998) have developed a typology of five different learning strategies by distinguishing different levels of transparency (i.e. the cooperativeness of disclosing knowledge to the other organization) and receptivity (i.e. the assertiveness of absorbing the disclosed knowledge) (Figure 4). Moreover, by combining the possible learning strategies of collaborating partners in a dyadic alliance, Larsson et al. (1998) succeeded in constructing a strategy-contingent pay-off matrix that indicates the amount of

³ In his research, Doz (1996) observed two patterns of interaction between behavioral and cognitive learning. 1) when initial conditions allowed cognitive learning but blocked behavioural learning and adaptation, expectations of efficiency quickly suffered as managers became increasingly aware of the difficulties facing their alliance, and of the little progress they made in surmounting them, and initial conditions came to dominate alliance outcomes; 2) when initial conditions allowed both cognitive and behavioural learning to take place, often interactive sequences of actions and cognition bringing trust and self-confidence, and the capability to improve on initial conditions (Doz, 1996, p.77).

knowledge transferred and created (Table 2). Analyzing this matrix, we can conclude that the amount of knowledge transferred and created will be maximized when both parties employ collaborative learning strategies. At the same time, this matrix also illustrates what has been called the inter-organizational learning dilemma (Hamel, 1991; Inkpen & Beamish, 1997; Larsson et al., 1998). More specifically, the matrix indicates that, although the appliance of the collaborative strategy by both partners will maximize the knowledge transfer and creation in the alliance, individual organizations will be economically stimulated to employ a competitive learning strategy when the other organization uses a collaborative strategy. In this way, we get a situation which is very similar to the prisoner's dilemma described in game theory (Larsson et al., 1998). This inter-organizational learning dilemma can even bring along that none of the involved partners is longer willing to exchange knowledge (i.e. employing an avoidance strategy) which will make successful collaboration impossible. However, Larsson et al. (1998) stress that opportunistic learning strategies will be avoided when mutual inter-organizational trust is present within the alliance. In this situation organizations have confidence that the other partner will not shift from collaborative to competitive learning strategies, although this latter strategy is economically more favorable in the short-term.

Within the organizational learning literature, a lot of attention is being paid to the importance of absorptive capacity, which can be defined as 'the ability of a firm to recognize the value of new, external information, assimilate it, and apply it to commercial ends' (Cohen & Levinthal, 1990, p.128). Applied to the context of inter-organizational learning, Dyer and Singh (1998) emphasize that collaborating partners need partner-specific absorptive capacity which refers to 'the idea that a firm has developed the ability to recognize and assimilate valuable knowledge from a particular alliance partner' (Dyer & Singh, 1998, p.665). Dyer and Singh (1998) also illustrate that this partner-specific absorptive capacity is a function of: 1) the extent to which partners have developed overlapping knowledge bases and 2) the extent to which partners have developed interaction routines that maximize the frequency and intensity of interactions. In this way, it has been stressed that collaborating partners not only need similar learning strategies, but also need similar knowledge bases and knowledge sharing routines to maximize the exchange of knowledge-based resources by inter-organizational learning processes.

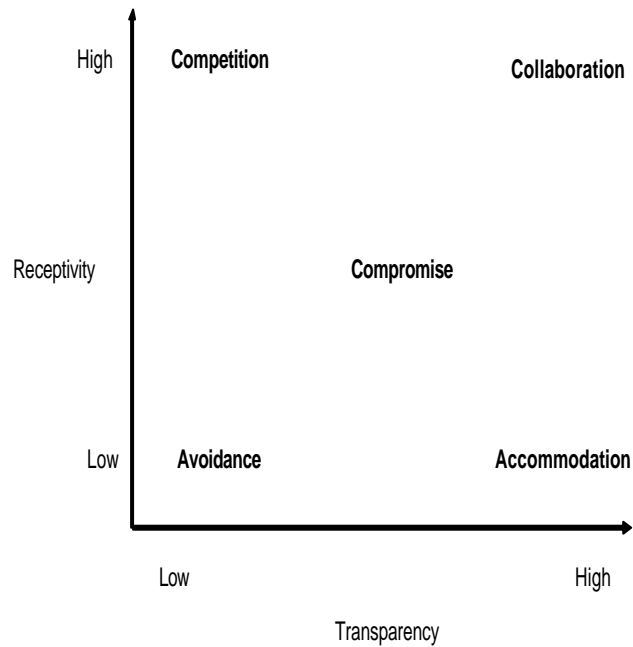


Figure 4 Individual learning strategies that can be applied by partners within collaborations (Larsson et al., 1998, p.289)

Org A	Organization B				
	Avoidance	Accommodation	Compromise	Competition	Collaboration
Collaboration		B ? A + c ? a	b ? a a ? b + c ? a&b	A ? B + c ? b	B ? A A ? B + C ? A&B
Competition		B ? A + c ? a	b ? a		B ? A + c ? a
Compromise		b ? a	b ? a a ? b + c ? a&b	a ? b	b ? a a ? b + c ? a&b
Accommodation			a ? b	A ? B + c ? b	A ? B + c ? b
Avoidance					

Table 2 Proposed inter-organizational learning outcomes (Larsson et al., 1998, p.290)

A ? B: High transfer of existing knowledge from A to B;

b ? a: moderate transfer of knowledge from B to A;

+ c ? a&b: moderate creation of new knowledge (c) that is appropriated by both A and B

The similarity of the collaborating partners

Collaborating partners do not only need similarity with regard to learning strategies and routines. Previous research suggests that a primary reason for failure of alliances is the lack of compatible operating systems, decision-making processes, and organizational cultures (Doz, 1996; Dyer & Singh, 1998). Doz (1996) illustrated, for example, that the alliance between a small entrepreneurial and a large commercial pharmaceutical firm failed mainly because their decision structures and organizational cultures were completely different. This incompatibility brought along that these organizations could not engage in behavioral learning which made it impossible to adjust inefficiencies present within the initial conditions of the collaboration. Also Dyer and Singh (1998) come to a similar conclusion. They state that: 'Although complementarity of strategic resources creates the potential for relational rents, the rents can only be realized if the firms have systems and cultures that are compatible enough to facilitate coordinated action' (Dyer & Singh, 1998, p.668).

Time and space related characteristics of the collaboration

Finally, also time and space related characteristics seem to have an important impact on how an inter-organizational collaboration develops. Therefore, we discuss now these two 'environmental' characteristics of the collaboration more detailed.

The longer an organizational collaboration exists, the more likely it will become that collaborating partners will continue to engage in learning-evaluation-adjustment loops. Ring and Van de Ven state that 'as the temporal duration of a cooperative inter-organizational relationship increases, the likelihood decreases that parties will terminate the relationship when a breach of commitments occur' (1994, p.107). This means that, the longer the collaboration exists, the more likely it becomes that partners will evaluate the collaboration in a positive way. Moreover, Luo (2000) found out that previous cooperation will increase the adaptability of collaborating partners. This brings along that, when initial conditions are evaluated as inefficient, successful adjustment of the initial conditions will be possible.

The temporal duration of the collaboration and the presence of previous collaborations do not only influence the successfulness of the inter-organizational collaboration process directly,

they also will exert an indirect effect by influencing the other characteristics we already discussed. When we spoke about the importance of the quality of the relationship, we already stressed that the amount of trust present within an alliance is not a static but a dynamic issue. If organizations engage in multiple learning-evaluation-adjustment loops, the amount of trust between the partners will increase over time (Doz, 1996; Ring & Van de Ven, 1994). We also already emphasized that the choice for a particular governance mechanism will depend on the temporal duration of the collaboration. More specifically, it seems reasonable to expect that in the beginning of the collaboration, formal mechanisms will be used, which will be later replaced by more informal ones (Dyer & Singh, 1998; Van de Ven, 1994). Larsson et al. (1998) propose that, next to the amount of trust, also the long-term orientation and the amount of prior-related interaction will have a major influence on the probability that collaborating partners employ non-opportunistic learning strategies. Finally, time related characteristics also will affect the similarity of the collaborating partners. The longer collaborating partners interact with each the more we can expect that they will learn about each others process systems, decision making routines and organizational cultures. In this way, it becomes also very probable that they will start to imitate each others organizational routines what will increase the similarity between the collaborating partners (Van de Ven & Walker, 1984).

Not only time, but also space can be considered as an important environmental variable. It has been recognized that innovation and the commercialization of new technologies take place disproportionately in clusters which can be defined as ‘geographic concentrations of interconnected companies and institutions in a particular field’(Porter, 1990). Organizations are induced to build innovation clusters with local suppliers and partners because the complementary relationships involved in innovating are more easily achieved among participants that are nearby (Porter & Stern, 2001). Physical proximity does not only increase the probability of cooperation, it will also influence how the collaboration will evolve. After all, several researchers have shown that physical proximity will bring along site-specific investments that facilitate inter-firm cooperation and coordination (Dyer, 1996; Nishiguchi, 1994).

CONCLUSION

In this paper we have tried to give a literature-based overview of why, when and how technological inter-organizational can be used by organizations to complement internal innovative efforts. We have stressed that organizations will use inter-organizational collaboration to deal with technological uncertainty and competitive pressure within the industry. Moreover, we illustrated that, by engaging in collaborative agreements, organizations can get access to imperfectly mobile and imitable resources that can constitute the foundation of a sustained competitive advantage.

We also indicated that, dependent on the amount of technological uncertainty present within the organization and on the type of resources needed, organizations will have a preference for a specific mode of inter-organizational collaboration. More specifically, we have shown that organizations that experience low technological uncertainty and have mainly property-based resource needs will choose exploitative modes of collaboration, while organizations within highly uncertain technological environments, which have knowledge-based resource needs, will prefer explorative modes of collaboration.

Finally, we also discussed how inter-organizational relationships evolve over time. Applying a teleological framework, we emphasized that the process of inter-organizational collaboration can be seen as a collection of learning-evaluation-adjustment loops in which initial conditions will be adapted according to the amount of cognitive and behavioral learning that takes place. Furthermore, by identifying the major influencing variables, we could conclude that the successfulness of the collaboration process will depend on 1) the amount of trust present between the collaborating partners, 2) the governance mechanisms applied within the collaboration 3) the amount of inter-organizational learning that takes place, 4) the similarity of the collaborating partners and 5) the environmental characteristics of the collaboration.

By giving this literature-based overview we hope that we have increased the reader's insight in the issues that are considered important with regard to technological inter-organizational collaboration. Moreover, we hope that this overview can help to stimulate further research within this domain to increase the understanding in why, when and how organizations engage in technological collaboration.

REFERENCES

- Ahuja, G. (2000) The duality of collaboration: inducements and opportunities in the formation of inter-firm linkages. *Strategic Management Journal*, 21(3): 317-343.
- Anderson, P. & Tushman, M.L. (1986) Technology discontinuities and organizational environments. *Administrative Science Quarterly*, 31: 439-465.
- Arino, A. & de la Torre, J. (1998) Learning from failure: towards an evolutionary model of collaborative ventures. *Organization Science*, 9(3):306-325.
- Balakrishnan, S. & Koza, M.P. (1993) Information asymmetry, adverse selection and joint-ventures. *Journal of Economic Behavior and Organization*, 20: 99-117.
- Barney, J. (1986) Strategic factor markets: expectations, luck, and business strategy. *Management Science*, 32: 1231-1241
- Barney, J. (1991) Firm resources and sustained competitive advantage. *Journal of Management*, 17(1):99-120.
- Barney, J. & Hansen, M.H. (1995) Trustworthiness as a source of competitive advantage. *Strategic Management Journal*, 15: 175-190
- Baum, J. A. C.; Calabrese, T., & Silverman, B. S. (2000) Don't go it alone: alliance network composition and startups' performance in Canadian biotechnology. *Strategic Management Journal*, 21(3): 267-294.
- Beamish, P.W. & Banks, J.C. (1987) Equity joint ventures and the theory of the multinational enterprise. *Journal of International Business Studies*, 18 (2): 1-16.
- Besanko, D.; Dranove D., and Shanley, M. (2000) *Economics of Strategy*. (second ed.) NY: John Wiley & Sons, Inc.

Borch, O.J. (1994) The process of relational contracting: developing trust-based strategic alliances among small business enterprises. *Advances in Strategic Management*, 10B: 113-135

Browning, L. D.; Beyer, J. M. & Shetler, J. C. (1995) Building cooperation in a competitive industry: sematech and the semiconductor industry. *Academy of Management Journal*, 38 (1):113-151.

Cairnarca, G.; Colombo, M. & Mariotti, S. (1992) Agreements between firms and the technological life cycle model.: evidence from information technologies. *Research Policy*, 21: 45-62.

Coase, R.H. (1937) The nature of the firm. *Economica*, 4: 386-405.

Cohen, W. M. and Levinthal, D. A. (1990) New perspective on learning and innovation. *Administrative Science Quarterly*, 35:128-152.

Das, T. K. & Teng, B-S. (2000) A resource-based theory of strategic alliances. *Journal of Management*, 26 (1): 31-60.

Das, T. K. & Teng, B-S (2002) Alliance constellations: a social exchange perspective. *Academy of Management Review*, 27 (3): 445-456.

David, P. A. (1985) Clio and the economics of QWERTY. *American Economic Review*, 75 (2): 332-337.

Dierickx, I & Cool, K. (1989) Asset stock accumulation and sustainability of competitive advantage. *Management Science*. 35:1504-1511.

Dodgson, M. (1993) *Technological collaboration in industry: strategy, policy and internationalization in innovation*. London: Routledge.

Dodgson, M. (1994) Technological collaboration and innovation. In: Dodgson, M. & Rothwell, R. The handbook of industrial innovation. Brookfield: Edward Elgar: 285-292.

Doz, Y. (1996) The evolution of cooperation in strategic alliances: initial conditions or learning processes? *Strategic Management Journal*, 17: 55-83.

Doz, Y. & Hamel, G. (1997) The use of alliances in implementing technology strategies. In: Tushman, M. L. & Anderson, P. *Managing strategic innovation and change: a collection of readings*. NY: Oxford University Press: 556-580.

Doz, Y. & Hamel, G. (1998) *Alliance advantages: the art of creating value through partnering*. Boston: Harvard Business School Press.

Dyer, J.H. (1996) Specialized supplier networks as a source of competitive advantage: evidence from the auto industry. *Strategic Management Journal*, 17: 55-83.

Dyer, J. H. and Singh, H. (1998) The relational view: cooperative strategy and sources of interorganizational competitive advantage. *Academy of Management Review*, 23 (4): 660-679.

Eisenhardt, K. M. and Schoonhoven, C. B. (1996) Resource-based view of strategic alliance formation: strategic and social effects in entrepreneurial firms. *Organization Science*, 7(2): 136-150.

Granovetter, M. (1985) Economic action and social structure: the problem of embeddedness. *American Journal of Sociology*. 1985; 91(3):481-510.

Gray, B. & Wood, D.J. (1991) Collaborative alliances: Moving from practice to theory. *Journal of Applied Behavioral Science*, 27: 3-22

Gulati, R. (1995) Social structure and alliance formation patterns: a longitudinal analysis. *Administrative Science Quarterly*, 40 (4): 619-652.

Gulati, R. (1998) Alliances and networks. *Strategic Management Journal*, 19(4): 293-317.

Gulati, R.; Nohria, N. & Zaheer, A. (2000) Strategic Networks. *Strategic Management Journal*, 21 (3): 203-215.

Hamel, G. (1991) Competition for competence and inter-partner learning within international strategic alliances. *Strategic Management Journal*, 12: 83-103.

Hagedoorn, J. (1993) Understanding the rationale of strategic technology partnering: interorganizational modes of cooperation and sectoral differences. *Strategic Management Journal*, 14: 371-385.

Hagedoorn, J.; Carayannis, E. & Alexander, J. (2001) Strange bedfellows in the personal computer industry: technology alliances between IBM and Apple. *Research Policy*, 30: 837-849.

Hagedoorn, J. (2002) Inter-firm R&D partnerships: an overview of major trends and patterns since 1960. *Research Policy*, 31: 477-492.

Harrigan, K. (1986) *Managing for joint venture success*. Lexington: Lexington Books.

Hennart, J.-F. & Reddy, S. (1997) The choice between mergers/acquisitions and joint ventures: The case of Japanese investors in the United-States. *Strategic Management Journal*, 18: 1-12.

Inkpen, A.C. & Beamish, P.W. (1997) Knowledge, bargaining power, and the instability of international joint ventures. *Academy of Management Review*, 22: 177-202.

Kogut, B. (1988) Joint Ventures: Theoretical and empirical perspectives. *Strategic Management Journal*, 9: 319-332.

Koza, M. P. & Lewin, A. Y. (1998) The co-evolution of strategic alliances. *Organization Science*, 9(3): 255-264.

Larsson, R.; Bengtsson, L.; Henriksson, K. & Sparks, J. (1998) The inter-organizational learning dilemma: collective knowledge development in strategic alliances. *Organization Science*, 9 (3): 285-305.

Lippman, S.A. & Rumelt R.P. (1982) Uncertain imitability: an analysis of inter-firm differences in efficiency under competition. *The Bell Journal of Economics*, 13: 418-438.

Luo, Y. (2002) Contract, cooperation, and performance in international joint ventures. *Strategic Management Journal*, 23: 903-919.

March, J.G. (1991) Exploration and exploitation in organizational learning. *Organization Science* 2 (1).

Miller & Shamsie (1996) The resource-based view of the firm in two environments; the Hollywood film studios from 1936 to 1965. *Academy of Management Journal*, 39 (3): 519-543.

Mitchell, W. and Singh, K. (1996) Survival of businesses using collaborative relationships to commercialize complex goods. *Strategic Management Journal*, 17: 169-195.

Mowery, D. (1988) *International collaborative ventures in US manufacturing*. Cambridge: Ballinger.

Nishiguchi, T. (1994) *Strategic industrial sourcing*. New York: Oxford University Press.

Peteraf, M. (1993) The cornerstones of competitive advantage: a resource-based view. *Strategic Management Journal*. 14(3):179-191

Pisano, G.P. (1989) Using equity participation to support exchange: evidence from the biotechnology industry. *Journal of law, economics and organization*, 5: 109-126.

Pisano, G. P. (1990) The R&D boundaries of the firm: an empirical analysis. *Administrative Science Quarterly*, 35: 153-176.

Polanyi, M. (1966) *The tacit dimension*. Gloucester, MA: Peter Smith.

Porter M.E. (1990) *The competitive advantage of nations*. New York: Free Press.

Porter M.E. & Scott, S. (2001) *Innovation: location matters*. MIT Sloan Management Review, 42 (4).

Roberts, E.B. & berry, C.A. (1985) *Entering new businesses: selecting strategies for success*. Sloan Management Review, 26 (3).

Reed, R., & DeFillippi, R.J. (1990) *Causal ambiguity, barriers to imitation, and sustainable competitive advantage*. Academy of Management Review, 15: 88-102.

Ring, P. S. & Van De Ven, A. (1994) *Developmental processes of cooperative interorganizational relationships*. Academy of Management Review, 19 (1): 90-118.

Rothaermel, F.T. (2001) *Incumbent's advantage through exploiting complementary assets via interfirm cooperation*. Strategic Management Journal, 22: 687-699.

Sakakibara, M. (2002) *Formation of R&D consortia: industry and company effects*. Strategic Management Journal, 23: 1033-1050.

Sako, M. (1991) *The role of trust in Japanese buyer-supplier relationships*. Ricerche Economiche, XLV: 449-474.

Shan, W.; Walker, G. & Kogut, B. (1994) *Interfirm cooperation and startup innovation in the biotechnology industry*. Strategic Management Journal, 15: 387-394.

Smith, K.G., Carroll, S.J. & Ashford, S.J. (1995) *Intra- and inter-organizational cooperation: Toward a research agenda*. Academy of Management Journal, 38: 7-23.

Teece, D.J. (1986) Profiting from technological innovation: Implications for integration, collaboration, licensing and public policy. *Research Policy*, 15(6): 285-305.

Teece, D.J. (1992) Competition, cooperation, and innovation: organizational arrangements for regimes of rapid technological progress. *Journal of Economic Behavior and Organization* 18: 1-25.

Teece D.J. (2002) *Managing Intellectual Capital*. Oxford: Oxford University Press.

Telser, L.G. (1980) A theory of self-enforcing agreements. *Journal of Business*, 53: 27-44.

Tether, B. S. (2002) Who co-operates, and why: an empirical analysis. *Research Policy*. 31: 947-967.

Tidd, J.; Bessant, J. & Pavitt, K. (2002) Learning through alliances. In: Henry, J. & Mayle, D. *Managing Innovation and Change*. second ed. London: SAGE.

Thomas, K.W. (1976) Conflict and conflict management. In: Dunnette, M., *Handbook of Industrial and Organizational Psychology*. Chicago: Rand McNally: 889-935.

Tsang, E. W. K. (2000) Transaction Cost and Resource-based explanations of joint ventures: a comparison and synthesis. *Organization Studies*, 21(1): 215-242.

Utterback, J.M. & Abernathy, W.J. (1975) A dynamic model of product and process innovation. *Omega*, 3 (6).

Uzzi, B. (1997) Social structures and competition in inter-firm networks: the paradox of embeddedness. *Administrative Science Quarterly*, 42: 35-67.

Veugelers R. (1998) Collaboration in R&D: an assessment of theoretical and empirical findings. *The Economist*, 149: 419-443.

Van De Ven, A. H. & Poole, M. C. (1995) Explaining development and change in organizations. *Academy of Management Review*, 20 (3): 510-540.

Van De Ven, A. H. & Walker, G. (1984) The dynamics of interorganizational coordination. *Administrative Science Quarterly*, 29: 598-621.

Von Hippel, (1988) *The sources of innovation*. New York: Oxford University Press.

Williamson, O.E. (1975) *Markets and hierarchies: analysis and antitrust implications*. New York: Free Press.

Williamson, O.E. (1991) *Comparative economic organization: the analysis of discrete structural alternatives*. *Administrative Science Quarterly*, 36: 269-296.

Woolthuis, R. K. (1998) *Entrepreneurial activity through inter-organisational relationships: a longitudinal approach to IOR development*. Twente: Research centre of the University of Twente Entrepreneurship Centre.

Yli-Renko, H.; Autio, E. & Sapienza, H. J. (2001) Social capital, knowledge acquisition, and knowledge exploitation in young technology-based firms. *Strategic Management Journal*, 22:587-613.

Yoshino, M.R. & Rangan, U.S. (1995) *Strategic alliances: an entrepreneurial approach to globalization*. Boston/Massachusetts, Harvard Business School Press.

Zajac, E.J. & Olsen, C.P. (1993) From transaction cost to transaction value analysis: implications for the study of inter-organizational strategies. *Journal of management studies*, 30 (1): 131-145