Management of R&D Cooperation

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ABSTRACT

Because of the high degree of technological complexity and the increasing convergence of new technologies, it is becoming more and more difficult to develop advanced products for those companies who solely rely on their own in-house `core competencies´. One possible response made to these rising requirements is the consideration of cooperation with other companies. Since prior research on cooperation is extensive in its theoretical scope and diverse in its disciplinary bases, it seems appropriate to give a short overview on the literature. In this article, we pursue two purposes: Firstly, we provide a brief and comprehensive picture of theoretical findings on technology-related cooperation pertinent to practitioners by using a process-oriented framework which helps us to integrate the existing literature from different academic disciplines. Secondly, while management scholars have primarily tended to focus on certain research streams, we draw attention to some issues not sufficiently covered by the literature today. We highlight the importance of the technological content (incremental vs. breakthrough and product vs. process innovations) as well as the orientation of the cooperation (horizontal vs. lateral) which should be considered in more detail in future research.

1 INTRODUCTION

Companies live in a world of uncertainty and change. Skyrocketing costs of product and process innovation, fragmented and demanding markets, increasing internationalization and high competitiveness of industries as well as the growing pace of technological change are predictably only some challenges which companies have to cope with in the next millennium. Most likely, no single firm can possess the capability to deal with all these challenges in order to fulfill customers` needs sufficiently from product, price and quality to service and delivery. It has been therefore increasingly accepted that firms have to focus resources on particular activities and `core competencies´ (Prahalad and Hamel, 1990).

However, because of the high degree of technological complexity and the increasing convergence of markets and new technologies, it is even becoming more and more difficult to develop advanced products for those companies who solely rely on their own in-house expertise. As a consequence, managers have to ask if their company has the internal competencies to gain a sustainable competitive advantage and reach the expectations and goals of its customers and shareholders. One possible response made to these rising requirements is the consideration of external resources of innovation. Basically, innovation can be jointly developed with other companies, suppliers or even customers. In the last few years, we could witness different types of technology-related cooperation in nearly all industry sectors. The awareness of importance of external innovation sources has been well recognized by the academic literature over the last few decades (Contractor and Lorange, 1988; Harrigan, 1986).

The literature on cooperation is extensive in its theoretical scope and diverse in its disciplinary bases. As a matter of fact, partnerships between companies are the focus of attention for a variety of different academic fields such as organization theory, economics, sociology, psychology, political science, technology and innovation management. Given this multi-disciplinary and diverse character of the literature, research on organizational alliances

and networks "[...] has currently entered into a period of chaos" (Osborn and Hagedoorn, 1997). Thus, the purpose of the presented article is two-fold:
Firstly, we provide a brief and comprehensive picture of basic theoretical findings on technology-related cooperation pertinent to practitioners by using a process-oriented framework which helps to classify the existing literature. Secondly, while management scholars primarily have tended to focus on certain research streams on cooperation, we draw attention to some issues not sufficiently covered by the literature today. We therefore outline and discuss the demand for future research.

2 A PROCESS-ORIENTED FRAMEWORK OF THE DEVELOPMENT OF A COOPERATION

There is a large body of literature on cooperation available and therefore, it seems to be appropriate to use a conceptual framework in order to give a brief overview of the main research streams. (In the following, the terms `collaboration´, `partnerships´, `alliances´, `coalitions´, and `cooperation´ are used as synonyms, for the purpose of this paper we define them generally as `partnerships among firms that work together to attain some strategic objective´ (Harrigan, 1988), this definition is used throughout the article, until otherwise is stated). Basically, prior research on cooperation can be structured in different ways such as paradigmatic, object-oriented and process-oriented. Since the development of cooperation can be decomposed into certain stages, we choose a process-oriented framework which enables us to structure prior research from a managerial perspective. Process-oriented frameworks have already applied to characterize the development of cooperation (Bronder and Pritzl 1992, Specht and Beckmann, 1996). By using a modified and further developed process-oriented framework based on the work of Bronder et al. (1992), we will be able to show main issues during the process of developing cooperation. This process-oriented framework has three important benefits:

1. It integrates empirical and theoretical findings on cooperation from different schools of thought

2. It gives practitioners a guide for the possible development of a collaboration, and

3. It shows `gaps´ in the literature which may serve as starting points for future research.

Essentially, the process of developing cooperation can be divided into certain stages: defining objectives, selecting partners, settling the appropriate organizational and contractual mode, managing the cooperation, and terminating the cooperation (see figure 1).

Based on the internal and external situation, a company may ascertain that it does not have the internal competencies in order to reach its desired strategic goals. In this first stage objectives are determined which are intended to be achieved during the cooperation. After analyzing these objectives and identifying the potential drawbacks and risks inherent in cooperation, the appropriate partner is chosen. This is an important step in the development of an alliance since the success of an alliance depends strongly on the role of the partner.

Given the multitude of different forms of collaboration, the next step is to find the appropriate mode of organization and contract design. Finally, since cooperation are often implemented for a certain period of time, a decision has to be reached whether to finish the cooperation or to extend it to further activities.

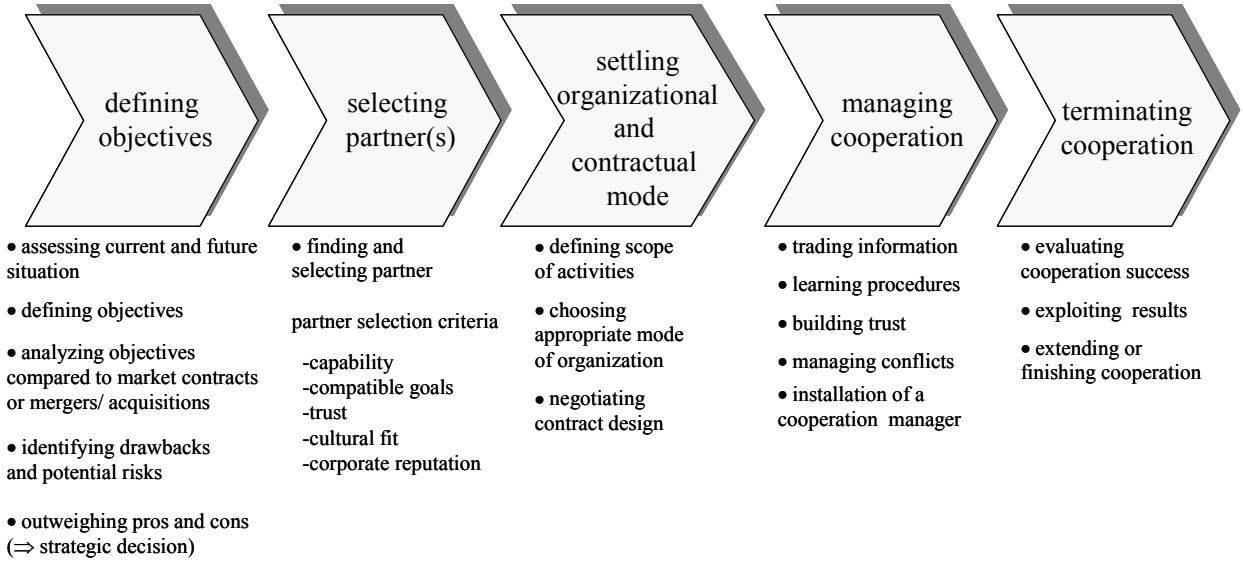

Figure 1 A process-oriented framework for the development of a cooperation, modified and enriched by the authors (see also Bronder et al., 1992; and Specht et al., 1996)

However, it is important to note that these stages can overlap and have an iterative character. Sometimes these stages do not occur in a sequential order as depicted in Figure 1 or do not follow a formal, rational process. For example, partner selection is often driven by informal, long-term personal connections which may eventually lead to formal collaborations. During such a process, formal partner selection criteria are not necessarily considered.

2.1 Defining objectives

Ideally, the first phase in developing a cooperation is to analyze the current and future situation of the company and its environment concerning technological and market opportunities and changes. In doing so, there are several `tools´ available (e.g. industry and environment analysis, analysis of strengths and weaknesses, portfolio analysis, scenario techniques). These tools are used to assess the competitive, the technological, the customer, the political, and the internal situation of the company. Based on a thorough assessment of the internal and external situation, companies should compare this with their own objectives. Significant theoretical explanations whether to use in-house expertise or external know-how are based for example on game theory (Sinha and Cusumano, 1991) and transaction cost theory (Williamson 1985). In the following we present some underlying objectives and then list some drawbacks and risks inherent in cooperation.

Many scholars have examined in detail underlying strategic goals for cooperation (articles for a brief overview see Brockhoff and Teichert, 1995; Hagedoorn, 1993). Despite the fact that these objectives sometimes overlap, they can be roughly divided into two categories: 1. market-driven, and 2. technology-driven objectives (shown in figure 2):

Market-driven objectives are results from risky and costly innovation processes. In many industries, skyrocketing budgets for innovation processes are a major concern. Traditionally, cooperation is seen to reduce the internal costs of product development by combining the resources of two or more parties. Thus, redundancies can be avoided and specialization on certain internal competencies can be achieved. Also, the uncertainty and the risk inherent in innovation processes are distributed among the partners. Similarly, reducing the average cost

per unit is another major motive for pooling the resources from different firms. Economies of scale were the main focus of research on manufacturing strategies (e.g. Hayes and Wheelright, 1984). Often, research has underlined the benefits of outsourcing components or the entire manufacturing process to contract manufacturers in terms of higher productivity, flexibility, quality and an improved process innovation development on the whole. Unfortunately, the literature on manufacturing strategy has mainly been concerned with matured industries such as automobiles and petrochemicals. Only a few studies have begun to investigate the relevance of process innovations in high-tech industries for non-assembled goods (Pisano, 1996). However, these recent findings on process innovation in high-tech industries have not yet intersected with the cooperation literature. Broadly speaking, research on cooperation in high-tech industries has primarily focused on product innovation processes and interdependencies to process innovations have been omitted so far.

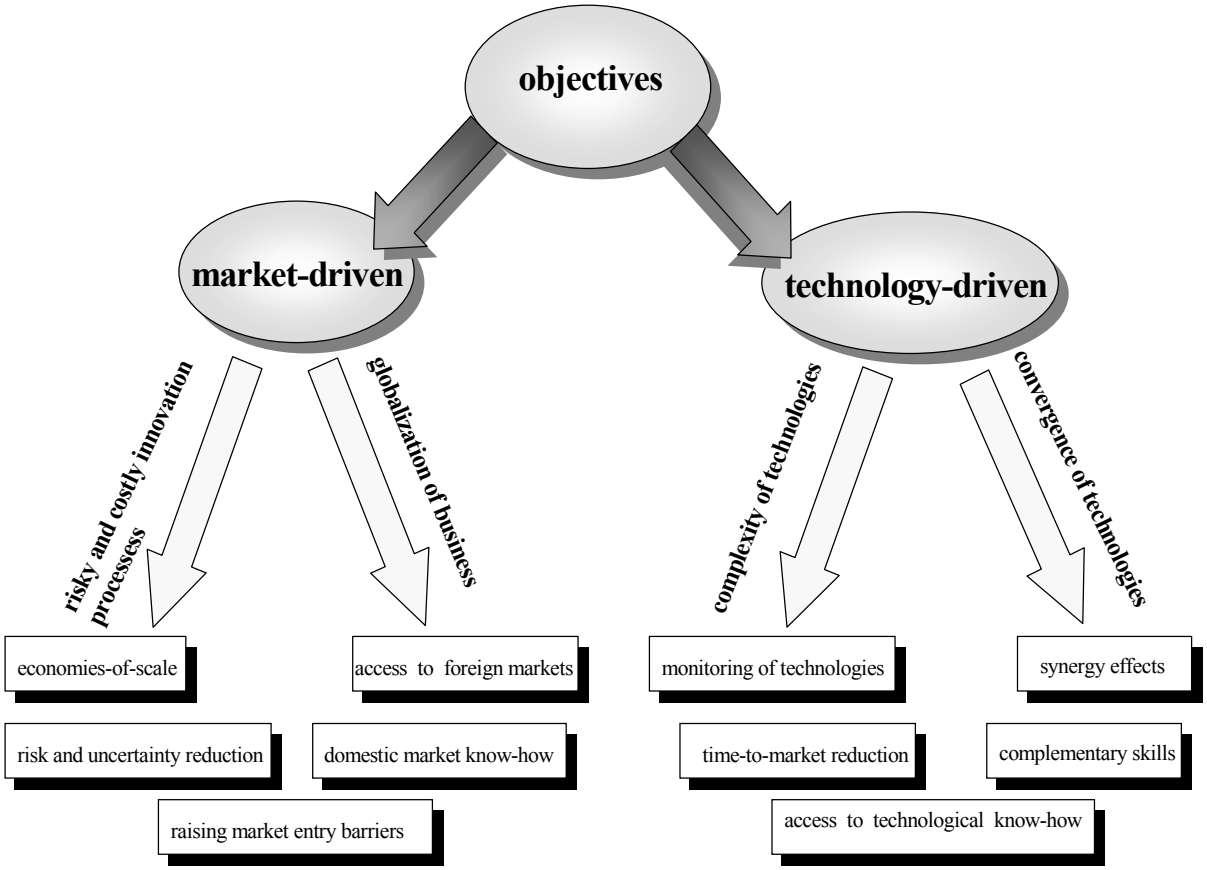

Figure 2 Objectives for entering into cooperation

Another market-driven objective is caused by the rising globalization of business. Global competition has forced companies to seek cooperation partners from abroad in order obtain access to local knowledge. There is considerably much less risk involved in expanding in a foreign market together with a partner who has the domestic market knowledge or has a well-developed distribution channel. Even companies which solely concentrate on the domestic market are affected by this global challenge, since foreign competitors may jeopardize its position. Since other competitors are expelled from certain technologies and knowledge, collaboration can also raise market entry barriers.

In the future the complexity and the convergence of technologies will force companies to search for external partners with complementary assets in order to reach synergies. In many studies these complementary assets are mentioned as a main technology-driven objective for entering into a cooperation (see e.g. Teece, 1986; Brockhoff and Teichert, 1995). Due to these synergy-effects, companies hope to reduce the time-to-market which is particularly important in times of shorter product life-cycles. An excellent example for a cooperation driven by complementary assets is the joint development of pharmaceuticals by biotechnology-oriented start-ups and large pharmaceutical global players. Start-up firms, on the one hand, possess the technological know-how but lack the financial resources required to take products through the costly clinical research phase. On the other hand, pharmaceutical companies commit primarily financial resources to the cooperation and expertise in dealing with the clinical trials. Often, later-stage process development and marketing including worldwide distribution channels are contributed as well. Besides, cooperation can also help to monitor technologies since two partners with complementary technological background can observe a much wider area of new emerging technologies.

Fundamentally, it has to be examined in more detail whether each of these objectives mentioned above can lead to a sustainable competitive advantage within a cooperation or whether a market solution or a merger/ acquisition may serve as good as a collaboration or even better. In the past market-driven objectives such as access to markets and economies of scale were the major reasons for engaging in cooperation. Basically, mergers or acquisitions may also serve as an alternative to reach economies of scale. However, cooperation has often the advantage over mergers and acquisitions in that it is more flexible in terms of deployment of financial and manpower resources. This flexibility is particularly favorable in the following situations:

1. cooperation may serve to monitor and to evaluate a potential candidate for a merger without taking on too much risk. Given the difficulty to assess the value of the target firm in advance, cooperation is an excellent and safe source for gathering additional information. In the case that the cooperative partnership turned out to be a failure, the agreement can be terminated easily and thus, considerably less resources were wasted compared to a merger or acquisition.
2. As already noted, cooperation can serve to monitor a wide range of technological opportunities and to gain access to complementary skills. This is especially important in fields with a rapid speed of technological change and with a convergence of technologies such as information technology, microelectronics, biotechnology, and more recently nanotechnology which can be employed in different industry sectors. Since companies run the risk of making major investments in these new emerging technologies that may show no spill-over effects or become obsolete soon after these investments are made, cooperation allows more flexibility compared to acquisitions. Also, these new technologies often require an interdisciplinary approach so that it can be hypothesized that the importance of cross-industry alliances will further increase.

Besides the high degree of flexibility cooperation may offer, Hennart and Reddy (1997) mention three other reasons which favor cooperative partnerships to mergers or acquisitions:

1. collaboration are more favorable if the desired assets are hard to separate from the many other assets owned by the potential partner. This is likely to be the case when the partner is large and not divisionalized.
2. management costs to integrate employees from different industries and countries involved in purchasing firms are often very high.
3. integration solutions such as mergers or acquisitions may encounter governmental requirements in some industry sectors, which made it difficult or even impossible to acquire or merge with foreign partners.

So far, we have presented the positive side of cooperation. However, many cooperation do not meet the expectations of one or all participants (Kogut, 1988; Harrigan, 1988). Thus, it seems to be worth identifying the drawbacks and potential risks inherent in cooperation (see figure 3). Based on the seminal paper by Coase `The nature of the firm´ (1937) and the work of Williamson (1985), transaction cost theorists often argue the costs involved in negotiation and transactions are disadvantageous to cooperation. Transaction costs encompass search costs, contracting costs, monitoring costs, and enforcement costs (Dyer, 1997). The exact quantification of these costs is difficult because of the high uncertainty and the nature of the transactions which cannot be expressed in monetary units. Besides these costs related to transacting, there is often the concern that proprietary know-how may leak out to rival firms, particularly in the case of cooperation with competitors.

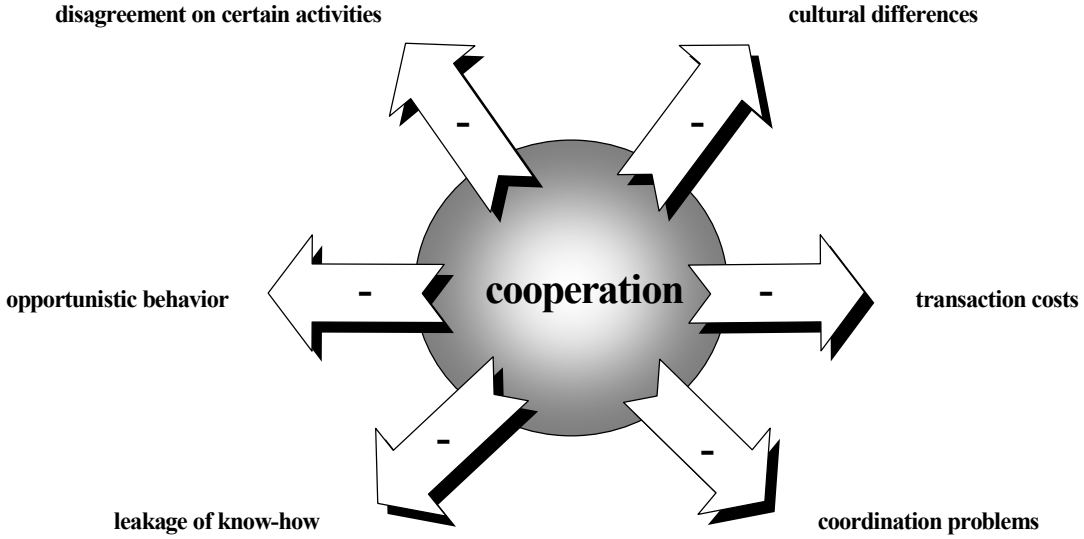

Figure 3 Potential drawbacks and risks involved in cooperation

More specifically, Hagedoorn (1993) mentioned that problems in managing cooperation derive from risks of sharing proprietary know-how, insufficient control mechanisms, coordination of different time-horizons, and from disagreement on certain activities during the cooperation. Another potential source of risk is opportunistic behavior. A prerequisite of any collaboration is that both partners act without a hidden agenda: In practice, there can occur certain situations in which the partners will cheat on each other in order to gain a

competitive advantage. This is for instance naturally latent if the companies were competitors for years.

Additionally, one firm may limit its contribution to certain activities with poorer performance. This is hard to estimate for the partner because of its lack of in-depth know-how about the partner's potential resources and abilities. It might happen that one partner conceals certain information relevant to the joint R&D project and uses these information to further develop the project internally. Similarly, uneven flows of information and resources may also exist between asymmetrical partners which in turn leads to an imbalance of benefits. Finally, differences in the corporate culture including different management systems may result in severe tensions during the course of time and this eventually has the consequence that both partners will diverge.

After assessing the current and future situation, defining and analyzing the objectives and identifying potential drawbacks and risks inherent in cooperation, a profound analysis can finally be drawn based on an evaluation of advantages and disadvantages and a comparison to other solutions such as market contracts and mergers or acquisitions. Outweighing pros and cons associated with collaboration is essential to reach strategic decision whether to use internal or external resources. When external sources of innovation are contemplated then a suitable partner should be selected with whom the goals are intended to be achieved jointly.

2.2 Selecting partners

In a second phase the aim is to select the appropriate partner who can help to reach the objectives. This phase is considered to be crucial to the performance of collaboration. Depending on the content of the objectives, the partner can be a company from the same industry (horizontal), from a different industry (lateral), suppliers, research institutes, universities or even customers (vertical collaboration).

One of the major partner selection criterion is the capability and the competence of the prospective partner to contribute to the cooperation. In order to assess these potential contributions, detailed information is required. However, if one partner provided a complete description of its capabilities before the contract was settled, some incentives to work together would be diminished. Thus, there is no up-front guarantee that the partner has the desired capabilities and is willing to offer all relevant corporate competencies. This is especially problematic in innovation-motivated cooperation since these projects consist of high uncertainties. Basically, capabilities and typology of the partners can be either symmetrical or asymmetrical. There is a controversy whether symmetries or asymmetries between the participants are more favorable. Some authors (Kogut, 1988; Harrigan 1988) argue symmetries among partners in terms of size and technological capability guarantee more stability. On the contrary, some empirical findings show strong evidence that asymmetries in size do not hinder the success of cooperation (see e.g. Senker and Sharp, 1997). Although these cooperation can involve coordination problems, they show advantages of pooling resources and creating synergies.

Besides this fundamental criterion for partner selection, there is also a strategically relevant dimension which has to be considered. To reduce the risk of strategic conflicts, an initial identification of the objectives is needed to find out if both companies have compatible goals. Conformity and clarity about the partner's goals may prevent that only one partner benefits during the cooperation.

Researchers often highlight the importance of a cultural fit between the partners (see e.g. Beamish and Inkpen, 1995). It is essential for the success of cooperation to be aware of these different corporate or national cultures since cultural attitudes may cause severe tensions. Basically, cultural diversity can be observed in many forms such as different languages, educational backgrounds, ideologies, management systems and even different leisure interests

between employees can be defined as cultural factors. Identifying cultural differences can be a little problematic because some cultural characteristics may be recognized first during the development of the collaboration.

Since potential contributions of the partner and cultural issues are difficult to assess in advance, companies should also rely on other sources of information. Previous successful participations in collaboration and the contributions to those are building up a reputation as a good cooperation partner. In a recent work Dollinger, Golden and Saxton (1997) have shown that corporate reputation has an impact on partner selection for strategic alliances. In their empirical study for the choice of a manufacturing partner for a joint venture they observed different dimensions of reputation such as product quality and innovation, management integrity and financial soundness. Their data suggest that reputation in different fields can compensate each other with the exception of product reputation. Furthermore, there are also spillover effects between these dimensions. On the whole, product and management reputation seem to be especially positive for the target firm's probability of being chosen for the alliance while financial reputation is less important.

In practice, partner selection is often not a formal process because the potential partner is already known from prior contacts or informal relationships. Even though these relationships have not made any or only little contributions so far, they sometimes impede the establishment of new cooperation with other partners which, by contrast, have greater promising prospects. Naturally, managers hold on to old collaboration which is built on trust. Any cooperation will be a fairly fragile construct without trust among the participants. However, managers have to ask whether cooperation with other foreign partners may outperform these older relationships.

To sum up, partner selection criteria should encompass the evaluation of partner's capabilities and its strategic goals as well as a cultural fit between the participants. Reputation based on past performance in other collaborations may also be meaningful. Since cooperation are not a static process, the evaluation should also consider the long-term contribution of the partner.

2.3 Settling the organizational and contractual mode

Before settling the organizational structure and the contractual design, it is essential to determine the scope of the joint activities. According to the concept of the value chain (Porter, 1985), a company can be divided into discrete activities: research and development, marketing, sales, production, and logistics. Mostly, it would go far beyond the scope of cooperation to perform all activities jointly. Thus, cooperation has to concentrate on certain selected activities. Basically, all activities in the whole value chain, provided that they do not pertain to the core competencies, can be developed externally within different organizational modes, ranging from marketing agreements through outsourcing of manufacturing to joint R&D projects. Since all activities in the value chain are strongly interwoven with each other, cooperative agreements should deal with these interdependencies very carefully. This may cause modifications for activities performed internally or it results in an expansion of the scope of the joint activities. Essentially, cooperation can fall into two types with regard to the scope of the activities (Porter and Fuller, 1986): cooperation across the borders of activities (so-called X coalitions) and cooperation within one activity (so-called Y coalitions) (shown in Figure 4). Often, cooperation across the border of activities occur among partners with complementary skills and different size. For example, a small firm leading on the cutting-edge of product development may lack the strength in manufacturing and it is therefore looking for a partner with strong process development know-how. Clearly, pooling together complementary skills is beneficial for both partners but it requires close coordination. Thus,

managing the interfaces among externally and internally performed activities in the value chain needs system optimization across activity boundaries but this may result in higher transaction costs of cooperation (Porter and Fuller, 1986). The importance of these X coalitions is well-recognized. Empirically, Hagedoorn (1990) found that collaboration concentrating solely on one activity is not very common, that could be also shown in the findings of Brockhoff et. al (1991) in a cross-industry survey of cooperative arrangements of 135 large German companies. While R&D including marketing within a cooperation seems to be less common (1,5 % of the cases), production in addition to R&D is very popular (42.2%).

Thus, it is very important to define precisely and in advance the scope of activities because of the closely intertwined character among them. Besides, it is also crucial to consider the information trading between externally and internally performed activities not only as a one-way process such as the one-directional knowledge transfer from external R&D to internal process development. Pisano (1996) argued that `building R&D's capacity to anticipate process problems in manufacturing requires feedback from manufacturing to R&D´.

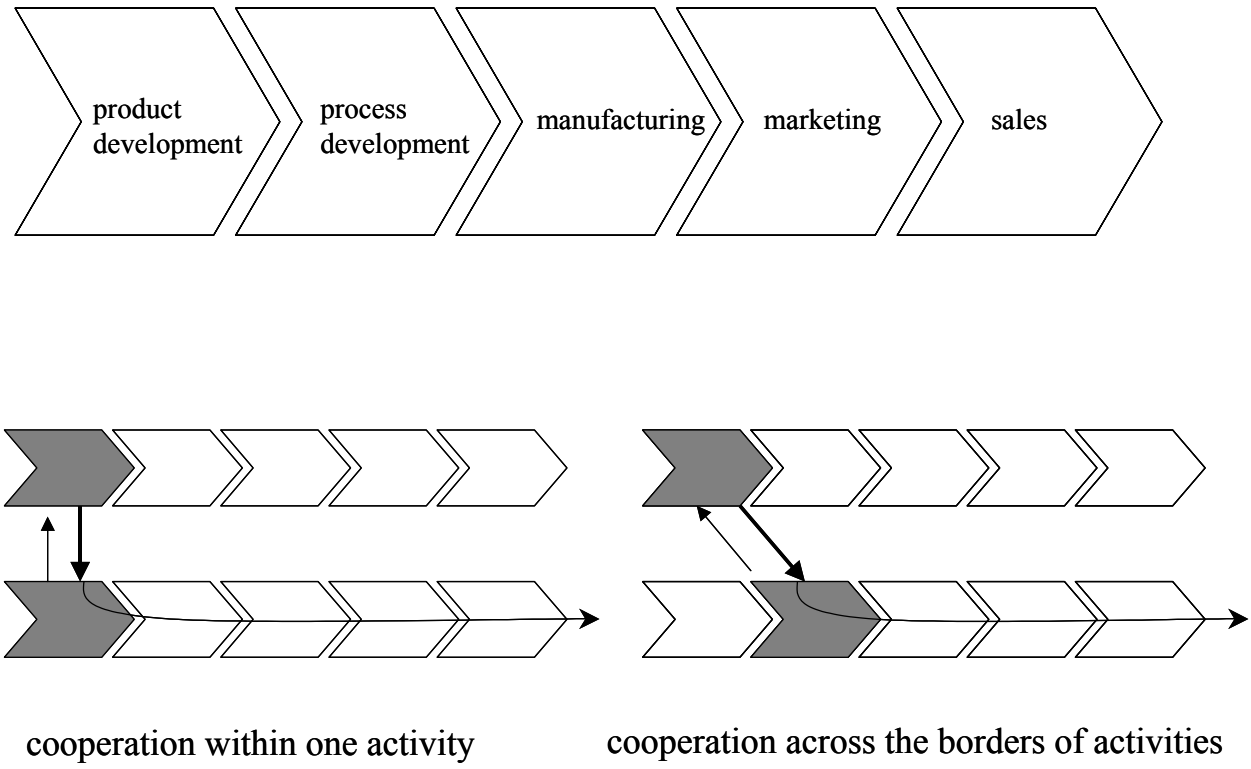

Figure 4 Scope of the activities involved in a cooperation using a simplified value chain (Porter, 1985)

After defining the scope of the cooperation, the next step is to find the appropriate organizational mode which finally leads to a contractual agreement. The research has identified different forms of collaboration such as joint ventures, strategic alliances, joint R&D, and market contracts. Traditionally, these forms are categorized along a continuum of the integration level between market (market contracts) and hierarchy such as mergers or acquisitions (see Figure 5). Unfortunately, no agreement has emerged on the exact definitions and the distinctions of these forms yet (see Hagedoorn, 1990; Chiesa and Manzini, 1998) since collaboration can be differentiated in different dimensions such as time horizon,

flexibility, formalization, impact on the firm, control, and time and costs for its establishment (Chiesa and Manzini, 1998). However, the distinction between different modes of organizations is important because their managerial implications differ significantly. For instance, strategic alliances are weakly bounded partnerships with a long-term oriented character which require a high degree of flexibility, whereas research contracts have a well-defined project character limited for a distinctive period of time.

Another problem arises from the fact that there is no simple direct correlation between the organizational mode and the purpose of the cooperation (Porter and Fuller, 1986). The same objectives can be reached with quite different organizational forms. For example, access to technological know-how can be gained either by a licensing or by a cooperative agreement resulting in different contributions of each partner. Chiesa and Manzini (1998) found, however, that mainly three factors determine the choice of a specific organizational mode for technological-oriented cooperation: the objective of the collaboration, the content of the collaboration (such as risk, familiarity, and appropriability of the technology), and the typology of partners (horizontal vs. vertical) involved. These factors should be ascertained and compared to the different legal forms of cooperation in order to find the most appropriate mode of organization.

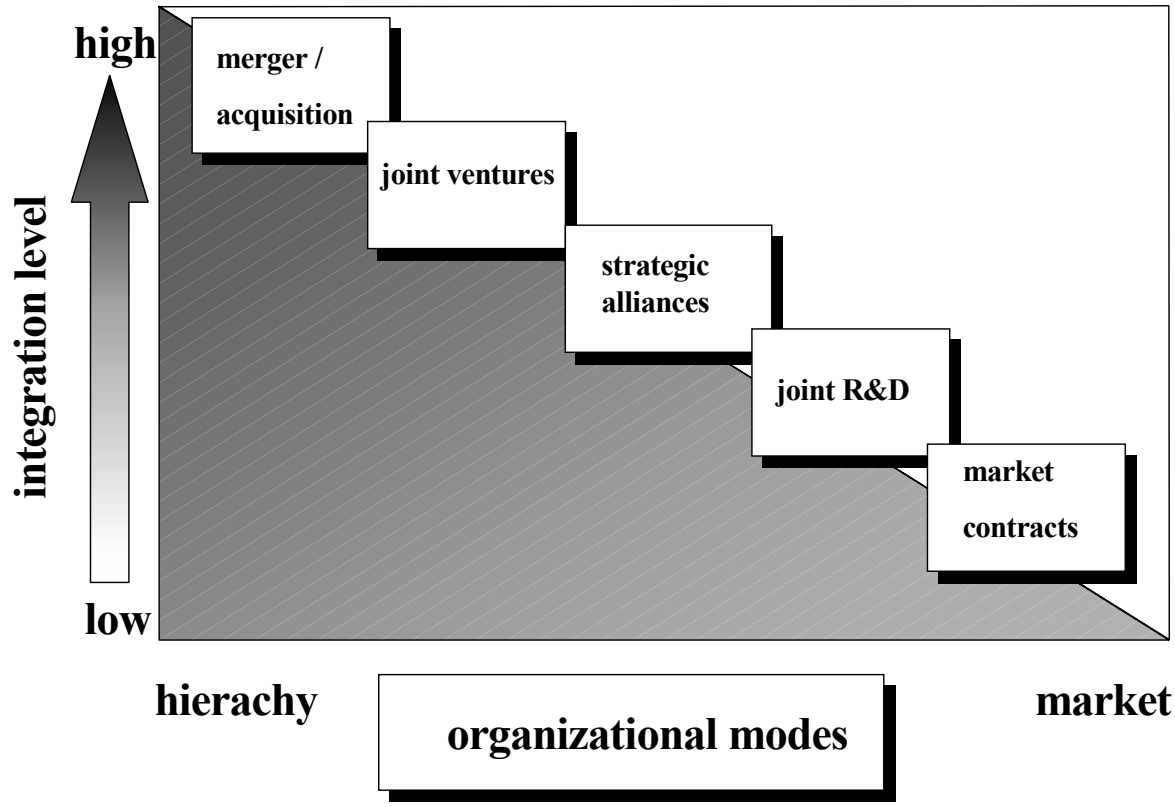

Figure 5 Modes of organization

The next step is to negotiate the contract design with the prospective partner. It is important to acknowledge that the content of the contract may change over time as the relationship develops. Clearly, it is unlikely that all future developments in the external and internal environment can be anticipated at the time the cooperation is closed. For instance, the relationship can be terminated all of a sudden if one partner has a change in its ownership

(e.g. Honda finished its cooperation with Rover after BMW took over the British car maker). A contract that takes all possible events into account is difficult or even impossible to frame and it is also costly to make conditions binding. A contract determines objectives, mode of organization, contributions of the partners, distribution of intellectual property and termination conditions. Although such an agreement could lead to higher stability of the cooperation, it certainly has its drawbacks. Conceivably, drawing up a detailed contractual agreement with all required compensations could turn a well-intended relationship into a fast end. Thus, controversial and time-consuming negotiations about the termination procedure are often postponed. Besides, the nature of a formal contract is sometimes too stiff and inflexible for an innovation project. It is crucial to be flexible in the sense that one has to accept the adaptation or even the termination of the cooperative agreement if the external or internal situations have changed adversely. Furthermore, the resources contributed to a cooperation are not easily measurable and comparable. For instance, one partner may supply financial resources and the other the technological know-how which is hard to quantify. While flexible contractual configurations are beneficial in the early phase and in the course of the cooperation, it raises some problems in the termination phase as we will discuss later in this article. The chosen organizational mode and the contractual agreement is then the basis for the management of the cooperation.

2.4 Managing cooperation

Managing a cooperation is a demanding task. Given the diversity of objectives, the difficulties of selecting the appropriate partner, and the complexity of the organizational and contractual structure, it is clear that there is no single `best-practice´ how to manage cooperation successfully. However, prior research has shown some `success´ factors (depicted in Figure 6) in managing a relationship between companies (see e.g. Teichert, 1993).

A fundamental factor for the successful management is a balanced relationship in terms of cost sharing, risk sharing, and exploitation of knowledge so that both partners benefit mutually. If only one partner benefits more from the cooperation, the relationship becomes one-sided and unstable. Traditionally, cooperation is seen to reduce the cost and risk inherent in R&D in times of rapid technological change. However, if the cost and risk is not spread evenly across the partners, the collaboration will no longer be in balance and will be terminated quickly by the victimized partner. Management has therefore to take care of an equivalent level of risk and cost shared by the parties involved. Unbalanced partnerships may also appear because of uneven exploitation of knowledge. One possible explanation can be the use of different learning approaches. Cooperation is often regarded as a `race to learn´, (Hamel, Doz and Prahalad, 1989) that could result in the fast learning dominating the relationship. In this case, no win-win situation can occur which makes the partnership inevitably unstable. Hamel et al. (1989) found in the case of alliances between Japanese and Western firms that the Japanese partner benefits more from the alliance. The main reason for this was that the Japanese had the willingness and ability to learn as much as they can from their partner. The authors reported: `We asked a senior executive in a Japanese electronics company about the perception that Japanese companies learn more from foreign partners than vice versa. `Our Western partners approach us with the attitude of teachers `, he told us. `We are quite happy with this, because we have the attitude of students´ (Hamel et al., 1989).

Thus, it seems to be crucial for the success to have efficient learning procedures in place in order to benefit from the complementary assets offered by the partner. Knowledge is often tacit and it is therefore difficult to transfer between the parties. Prior research has emphasized the important role of internal R&D capacities required for transferring and exploiting new technological knowledge between the partners. According to Cohen and Levinthal (1990), this so-called `absorptive capacity´ broadens the internal know-how base and enhances the

ease of adoption of external innovations since new technological knowledge can be better absorbed and applied with a basic understanding of the technology.

Innovation processes are basically information exchange processes and thus, efficient information trading between the participants is the basis for a successful innovation process. In order to achieve this, an effective corporate communication behavior should be installed. Ohmae (1989) suggested managers have to pay greater attention to such "softer" skills at the interface of the companies; he recommends "frequent, rapport-building meetings at at least three organizational levels: top management, staff, and line management at the working level". However, informal information trading is clearly not appropriate for all types of information and in all situations. In the worst case leakage of confidential information can result in a competitive advantage for competitors. Companies should be aware that most information is traded `by day-to-day interactions of engineers, marketers, and product developers´ (Hamel et al., 1989). It is therefore in the interest of the firm to control the gates between the partners and restrict the scope of informal information flow in order to limit unintentionally transfer of proprietary know-how. Additionally, Schrader (1991) suggested that companies have to `provide employees with an incentive scheme that motivates them to act in the interests of the firm and enables them to make well-informed decisions´. Thus, management of information trading is a trade-off between effective and efficient communication required for the success of the cooperation and the risk to leak out proprietary know-how to rivals.

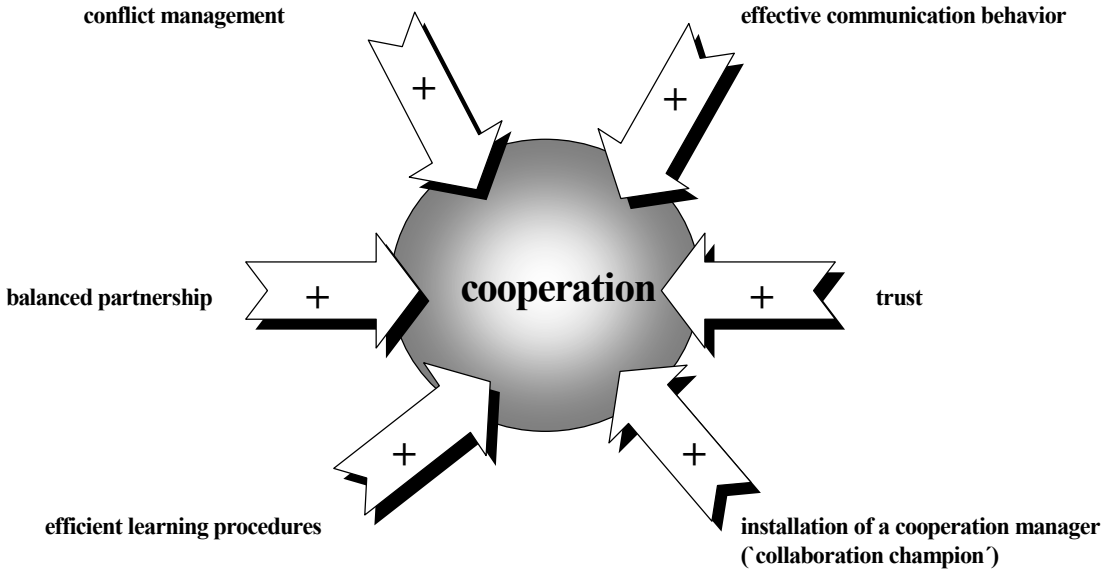

Figure 6. "Success factors" for cooperation

As noted before, the success of a collaborative agreement is essentially determined by the individuals involved in these information exchanges. It is clear that a successful management requires managers who are in charge of the cooperation. Similar to the notion of a product champion mentioned in the literature on innovation (Allen, 1977), some authors (see e.g. Bidault and Cummings, 1994) highlight the presence of a `collaboration champion´ who can control the information flow, establish inter-personal relationships and reduce tension among the participants. This key person or team has to be accepted by both partners otherwise the

champion will not have the power to mediate across the organizations for the sake of the cooperation project. A profound understanding of corporate culture and well-developed inter-personal relationships to participants from both companies are basically the key requirements to its success and finally to the cooperation success. Besides, an innovative cooperation project should also be supported by the top management of both firms in order to allow a certain degree of failure which is inherent in any innovation project.

Much of the literature focuses on these inter-personal relationships and stresses the key role of trust between the people involved in the cooperation. Building trust can limit opportunistic behavior, enhance inter-organizational effectiveness, serve as an alternative control mechanism and replace or supplement detailed contracts. The latter results in cost reduction since no precisely and lengthy negotiations are required. Dodgson (1993) pointed out that trust based on the individual level is not enough since it cannot survive problems of labor turnovers with the possible loss of key persons as well as communication breakdowns between individuals. He suggests that trust should be on a much broader basis, incorporated in all organizational routines, norms, and values.

In the case of an unbalanced relationship, mistrust or tensions among the participants, it is essential to have an understanding of how such conflicts can be overcome. It lies in the nature of interorganizational relationships that one can expect a certain amount of conflicts during the development of a cooperation. Thus, it is important to have an advanced conflict resolution management in place before any conflict may occur. According to Mohr and Spekman (1994), conflict resolution techniques can be grouped into three categories:

1. constructive resolution techniques such as joint problem solving and persuasion

2. destructive conflict resolution techniques such as domination and harsh words, and

3. other conflict resolution techniques such as outside arbitration and smoothing over or ignoring/avoiding the issue.

In their empirical work on vertical partnerships in the computer industry, the authors could show that the type of conflict resolution techniques has an impact on the overall success of a collaboration. While joint problem solving shows a significant positive effect on the relationship success, harsh words and smoothing over as a type of destructive techniques do not resolve the conflicting issues in the long run. Furthermore, mediation by external arbitrators is beneficial in apparently hopeless conflict situations. If any of these conflict resolution techniques do not succeed, the whole cooperation is likely to fail.

2.5 Terminating cooperation

Cooperation is often limited to a certain period of time. Generally, cooperative agreements should not be considered as an everlastingly fixed process, rather than a temporary project with room for adaptation to external changes. Although missing or insufficient agreements on the termination conditions in the beginning result in problems later on, it is difficult to formulate binding conditions in advance. Given the uncertainty of R&D outcomes and the rapid speed of technological change in the course of the cooperation, a rigid contract would also stifle the flexibility required for innovation processes. To further investigate the implications caused by the termination of the cooperation, we have to understand the reasons which lead to this decision.

According to Specht et al. (1996) cooperation is phased out because of the following possible reasons:

- the goals were achieved
- the cooperation has reached the limited period of time
- a change in the strategy of one or all partners makes the cooperation unnecessary
- unexpected barriers occur during the course of time
- the ability of one partner to contribute diminished which in turn decreases the incentive to cooperate for the stronger partner
- the cooperation runs out of resources

The first two reasons offer the possibility to extend the cooperation to further activities. Depending on the success of cooperation and the values of the outcomes, it may appear promising to further develop the project jointly or to expand the scope of activities which sometimes requires other organizational and contractual configurations. For example, two pharmaceutical companies from different countries joined forces in order to develop a new drug within a time-limited joint R&D project. The first results were very promising but the project turned out to have a long-term character and therefore, both companies decided to form a joint venture which required renegotiations about the project. Differently, in the case of a collaboration between a large and a small company, where the stronger partner often acquires its cooperation partner afterwards in order to gain complete access to its know-how.

Unfortunately, not all cooperation is finished in harmony. Empirical findings have shown high rates of failure (e.g. Kogut, 1988; Harrigan, 1988) mainly because many cooperation do not meet the expectations of one or all participants. During the lifetime of the partnership and at its end, it is necessary to evaluate the success of the cooperative project. A large number of alliances fail when the common objectives change over time and the conditions which favored the formation of the collaboration are not longer in force. However, it is important to note that no agreement on the appropriate definition and measure of success or failure has yet occurred in the academic literature (Geringer and Hebert, 1991). Based on prior research, Geringer and Hebert (1991) listed different indicators for success, ranging from objective performance measures such as profitability, growth, cost position, duration of the cooperation, and renegotiations of the contract to more subjective performances factors referring to the perceived success by each of the partners. The authors have shown that there is no consistency between subjective and objective measures of performance. Apart from this lack of a clear and distinctive definition, Pisano (1997) argues that the high rate of failure of partnered projects compared to internal development projects are due to `ex-ante project selection biases´ rather than performance differences between cooperative and non-cooperative projects.

However, if one or all participants are not convinced about the potential `success´ or the necessity of the cooperation or if barriers and other unforeseen changes occur during the course of time, the cooperation is ended up quickly. In that case the former partners have to negotiate the distribution of the outcomes. This is particularly difficult in the absence of a stringent contract. If only one partner can use the results, the other partner may receive a financial compensation. However, the situation is more intricate if both partners claim the property rights on components or on all outcomes. Then the distribution of the (incomplete) outcomes is impeded by two reasons: 1. the difficulty to asses their values, and 2. their highly-specific character.

If the cooperation partners have complementary skills, this means that each company lacks a detailed understanding of its partner's contribution. Thus, the firm will not have the information to assess the real value of the outcomes which makes it difficult for the firm to agree on its distribution between the participants. Additionally, it will further complicate the assessment when the project is incompleted so that one cannot surely predict its potential value.

Basically, R&D projects are very complex tasks assembled of many sub-processes which are strongly connected with each other. The results of these projects are therefore highly-specific and sometimes not separable so that it becomes very difficult or even impossible to transfer it to other applications, particularly, if the knowledge is tacit and cannot be transferred in a codified form.

3 CONCLUSIONS AND ISSUES FOR FUTURE RESEARCH

In the preceding sections we have presented a process-oriented framework which showed the different phases during the development of a typical collaboration. We described the certain phases involved, namely definition of objectives, partner selection, determination of organizational and contractual mode, management, and termination of the cooperation. This framework offers several advantages:

Firstly, it allows to integrate certain aspects from different academic research streams including industrial economics studies, strategic management views as well as an organization theory perspective. This integrated approach is in the line of the view of Osborn and Hagedoorn (1997) who `encourage researchers to abandon a singular, clear-cut description of alliances and networks based on the assumptions of a host discipline in favor of a more robust, sophisticated, multi-dimensional vision´ (Hagedoorn and Osborn, 1997).

Secondly, the proposed framework allows to give practitioners a guide how to develop cooperation. Because of its strong process-oriented character, the framework itself is based on a managerial perspective. However, this approach does not offer one `best-practice´ how to successfully manage cooperation so that there are still many degrees of freedom.

Thirdly, since this framework integrates the findings of different academic disciplines and provides a comprehensive picture of the research, it allows to show `gaps´ in the literature which we will outline in the following.

Prior research has studied in detail the underlying objectives leading to interfirm partnerships. Traditionally, the main objective of cooperation was economies-of-scale in order to reduce costs and share risks in the short-term. Empirical findings (Hagedoorn and Schakenraad, 1994), however, showed that technology-driven objectives have become more important in the last few years. Basically, the technological content of cooperation projects has a substantial impact on partner selection, determination of the organizational mode as well as the management of the cooperation. The technological content of an innovation project is primarily determined by the degree of innovation (incremental vs. breakthrough) and the type of innovation (product vs. process). Studies in interfirm cooperation do not explicitly distinguish between incremental and breakthrough innovations. However, there are some indicators in the innovation management literature that an understanding of the innovation degree, ranging continuously from radical/breakthrough to incremental innovations, is crucial in order to manage the product or process development effectively and efficiently (see e.g. Lynn, Morone, and Paulson, 1996). The perception of the degree of innovation may vary significantly among the participants, particularly in the case of asymmetrical partnerships. It can be concluded that this leads to the application of different management approaches which in turn may result in severe tensions. Basically, it has to be discussed whether joint R&D projects are appropriate for breakthrough innovations since

these radical innovations are of an highly unstructured process nature. Cooperation, by contrary, is often formalized with an high degree of coordination. In order to gain insight to this issue and to enhance our understanding of the managerial implications associated with breakthrough innovations within cooperative projects, we argue that further research should consider the degree of innovation in more detail.

The technological content of a project is not only determined by the degree of innovation, it is also defined by the type of innovation. Often, past research has implicitly focused on product development within joint R&D projects and there has been little work on cooperative process development projects. Gemuenden et al. (1996) suggest that process innovations need a different approach compared to product development. The authors have shown in their empirical study, based on a database of 321 high-tech companies, product and process innovation demand different types of organizational modes. They analyzed the technological `interweavement´ of companies with four groups of external actors: suppliers, customer, universities and consultants. They found that customers seem to be especially appropriate for product development projects and for process innovations interactions with universities and suppliers have shown a positive impact.

The technological content has also an impact on the orientation of the cooperation (horizontal vs. lateral). The literature on interfirm cooperation has, however, largely concentrated on horizontal cooperation. While horizontal collaborations are among companies from the same industry sector, an interfirm relationship is lateral oriented if the partners come from different industries. It can be hypothesized that cross-industry alliances will become more important in the near future because new technologies often require an interdisciplinary approach. To our best knowledge, there have emerged only a few studies on this topic yet (Bidault and Cummings, 1994; Steurs, 1995). According to Bidault and Cummings (1994) findings from a survey among information technology intensive companies, cross-industry are likely to be more innovative than horizontal alliances but, however, they have a higher rate of failure. Hence, we believe that there is a clear need for management scholars to investigate lateral partnerships in more detail.

Although the presented framework offers several advantages, it has certainly some limitations. This process-oriented framework confines the focus of attention to the development of only one single cooperation from a static perspective and neglects possible interdependencies with other already existing or evolving relationships. However, it is important to develop and manage cooperation not separately from each other since scientific knowledge is often spread over a wide range of partners such as firms from the same or different industries, suppliers, universities, research institutes, and users. This occurs particularly in fields with a rapid speed of technological change. Recently, there is a large and growing literature on innovations within such a network for cooperation and how companies can position themselves in this web (see e.g. Powell et al., 1996; Ingham and Mothe, 1998; Powell 1998). Powell et al. (1996) showed that the locus of innovation is found in a network of interfirm relationships rather than in one single cooperation. He could report from the case of a pharmaceutical company who not only has formal agreements but also handshake deals, informal collaborations, single informal information exchange among scientists from universities as well as from other companies. Thus, Powell (1998) argued that `successful firms positioned themselves as the hubs at the center of overlapping networks**,** stimulating rewarding research collaborations among the various organizations to which they are aligned, and profiting from having multiple projects in various stages of development´. Also, these cooperative ties showed a very dynamic nature. He reported in his study in the fields of biotechnology that `roughly 15 per cent of ties are terminated each year, but this does not necessarily end a relationship. An R&D alliance on a specific project may conclude, for example, and be replaced by a new research venture, a complex manufacturing and marketing agreement, or some other new arrangement´.

In this article, we described the termination phase of a cooperation including the termination conditions and their implications isolated from other existing or evolving cooperation. Although these termination conditions play an important role, their implications on other partnerships have been largely ignored in the literature. Thus, there is a clear need to study the termination phase thoroughly in order to ameliorate our understanding of the interdependencies among different cooperative R&D projects. Generally, a coherent cooperation model should take into account this dynamic and multi-institutional character which is not sufficiently considered in the presented process-oriented framework.

To sum up, the proposed framework serves as a means for integrating empirical and theoretical findings across various academic disciplines and for guiding practitioners through the development of a cooperation. Although this framework examines each relationship separately from a more static perspective, the issues derived from this framework are operationally significant to managers. Furthermore, it illuminates specific issues on the management of cooperation which have to be considered very thoroughly in future studies. For instance, we have drawn attention to the importance of the technological content (incremental vs. breakthrough and product vs. process innovations) as well as the orientation of the cooperation (horizontal vs. lateral). We hope that this paper will give practitioners a little guidance for the development of a cooperation and provide management scholars a stimulus for further research. Some of the issues addressed in this article are part of an ongoing research project on R&D cooperation in the pharmaceutical industry and will be reported in more detail in the future.

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