Knowledge sharing in technology alliances

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Working Paper 03.24

Department of Technology Management

Technische Universiteit Eindhoven, The Netherlands

November 2003

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Introduction

In this paper we will focus on collaboration in high-tech industries and more specifically on alliances that aim at innovation. These so called 'technology alliances' have typical knowledge and technology related issues that differentiate them from other types of alliances, such as collaborative distribution, production or sales agreements. This focus on technology alliances is relevant because recent years have shown a large increase in the use of alliances by high-tech firms in their efforts to innovate. Alliances could be set up between actors in their supply chain on a dyadic level (*e.g.*, early supplier involvement in product development projects), but could also encompass numerous partners including competitors (*e.g.*, large research or standard setting consortia) (Hagedoorn, 1993; Gulati, 1998; Ahuja, 2000; Powell *et al.*, 1996). Hence, alliances are important organizational building blocks in the development and evolution of supply chains and business networks.

The general interest in technology alliances of both practitioners and researchers seems justified. Technology alliances promise fast innovation and sustained competitive advantage for companies in high-tech industries, where a single company rarely has the full range of knowledge or expertise needed for timely and cost-effective innovation (Grotenhuis & Weggeman, 2002). Alliances seem to have several specific advantages over more traditional organizational means for innovation and knowledge acquisition such as mergers and acquisitions, or internal R&D. But we also do know that alliances are complex and difficult to manage. Moreover, collaboration could lead to erosion of competitive advantage, as competencies, markets, knowledge and technologies are shared and dispersed among the partners. These advantages and disadvantages of alliances make the life of practitioners and

managers complicated. Initiating, executing and ending an alliance need careful managerial attention and a thorough assessment of trade-offs. To shed some light on these important issues concerning alliances, technology and innovation in high-tech industries, the following paragraphs will address four questions: What are 'technology alliances' and why do firms collaborate in their efforts to innovate? What are specific characteristics of technology alliances related to knowledge sharing and learning? Which factors influence the successfulness of technology alliances? And which issues are still not well understood and need future research attention?

To answer these questions we will make use of the growing body of research literature on alliances and innovation. More specifically we focus on research that is concerned with alliance design, alliance management and performance, and knowledge sharing and interorganizational learning. We will not incorporate research on firm innovation and learning at network levels of analysis, although many interesting theories have been developed concerning these issues (*e.g.* social capital and social network theory) (Burt, 1992; Nahapiet & Goshal, 1998; Tsai & Goshal 1998; Gulati, 1998). For this chapter we have made a selection of some of the most important publications on these issues in the past ten years. The selection is limited to publications that have appeared in international scientific journals and are often cited in later publications concerning the subject. In this way we hope this chapter will represent the current state-of-the-art of thinking on alliances, technology and innovation.

Technology alliances, modes and motives

In this paragraph we will discuss different modes and motives of strategic technology alliances. As already stated, the nineties of the last century show a large increase in the use of inter-organizational modes of cooperation in high-tech industries (Hagedoorn, 1993; Hagedoorn, 2002; Powell *et al.*, 1996). High-tech industries are characterized by a high R&D intensity, which means that a rather large part of firm investments are spent on research and development. Industries which are listed as high-tech are, for instance: biotechnology, microelectronics, telecommunications, new materials, aviation, defense, and medical instruments (Hagedoorn, 1993). In these industries collaboration on technology

development and research related issues occur frequently. We call these collaborations 'strategic technology alliances'. The formal definition of a strategic technology alliance that we will use in this chapter is:

> Inter-firm cooperation for which a combined innovative activity or an exchange of technology is at least part of the agreement. The strategic character of the agreement relates to the expected long-term effects of the agreement on the product-market positioning of at least one of the firms (Hagedoorn, 1993).

The above definition resembles the more general statements of Gulati (1998), who defines a strategic alliance as voluntary agreement between firms involving exchange, sharing, or codevelopment of products, technologies or services. Technology alliances can take a variety of forms and result from a wide range of (combined) motives and goals. To get a grasp of the definition and the large variety of forms and motives, regard the next three examples (based on press statements):

> *Mobile phones & digital cameras*
> "…Nokia and Kodak announced a collaboration agreement that will offer Nokia mobile phone users convenient solutions to store and print digital images…Nokia and Kodak will jointly develop kiosk printing services and other retail printing solutions to empower mobile users to turn their favorite pictures into prints…" (Nokia, 2003).

> *Portable music & athletic experience*
> "…Philips and Nike join forces to bring technology to sport and create a new market…the alliance will deliver innovative, technological solutions to enhance the athletic experience…Nike and Philips bring unique strengths to the venture. Nike has exceptional expertise in sports and material technology, marketing and innovation…Philips is a leading innovator of "wearable electronics" technologies and has a long heritage of technology innovation, especially in the digital arena…" (Royal Philips Electronics, 2002).

Research skills & marketing power

"…Ligand Pharmaceuticals and Eli Lilly and Company will extend … their research collaboration focused on discovering novel drugs for type II diabetes and cardiovascular disorders…Under the terms of the collaboration, Ligand receive research funding from Lilly. Lilly is responsible for the development and registration of any products resulting from the collaboration, and pays Ligand milestone payments – which may total more than $ 10 million per product - as products move through the development process. Lilly has exclusive worldwide marketing rights to products resulting from the research…" (Ligand Pharmaceuticals, 2003).

As we can see in these three examples technology alliances often have mixed motives. Some relate to research or technology development and others to market access or market development. Hagedoorn (1993) has made an extensive overview of different motives of technology alliances (see table 1.). The most important motives in high-tech industries are (Hagedoorn, 1993; Hamel, 1991):

1) *Seeking technological complementarities*; because of the increased complexity and interdisciplinary nature of new technologies, most companies do not posses all the necessary competencies for innovation. Collaboration offers these companies access to complementary skills and technologies, and enables the partners to capitalize on economies of scope through joint efforts.

2) *Reduction of the innovation time span*; because of fast developments in the market environment, rapid technological change and thus shortened product-lifecycles, it is increasingly important to reduce the period from invention to market introduction. Collaboration could help in shortening the innovation process. Sourcing technology or gaining access to competencies from your partner helps to reduce the time-span of your own innovation process.

3) *Seeking market access or influencing market structure*. Through collaboration, companies are able to gain access to new (formerly inaccessible) markets. This is especially relevant if companies pursue an internationalization strategy and lack experience with foreign markets. Moreover, through collaboration with competitors or suppliers and customers, companies are able to influence the structure of the market and improve

their market share. In a number of industries, networks and groups, rather than firms, have become the level at which firms compete with each other (Gulati, 1998; Gomes-Casseres, 1994).

Other motives which have been identified in literature and practice are summarized in table 1.

Table 1. Motives for technology alliances (as mentioned by Hagedoorn, 1993).

Motives related to basic and applied research:
– Increased complexity and interdisciplinary nature of new technologies
– Monitoring of evolution of technologies
– Access to scientific knowledge or to complementary technologies
– Reduction, minimizing and sharing of uncertainty in R&D
– Reduction and sharing of costs of R&D
Motives related to concrete innovation processes:
– Capturing of partner's tacit knowledge of technology
– Technology sharing
– Technological leapfrogging
– Reducing the period between invention and market introduction.
Motives related to market access and search for opportunities:
– Monitoring of environmental changes and opportunities
– Internationalization, globalization and entry to foreign markets
– New products and markets, market entry, expansion of product range

Strategic technology alliances are not only motivated differently, but also exist in very different inter-organizational modes of governance. These modes range from large joint ventures or research corporations, to minority investments, to small-scale research contracts and technology exchange agreements. Complex modes of governance, such as joint ventures and minority investments are commonly associated with alliances that have a combination of technology and market related motives. We will briefly elaborate on the different modes of governance (as mentioned by Hagedoorn, 1993; 2002):

Joint ventures & research corporations exist when at least two separate companies combine their economic interests in a 'distinct' firm; profits and losses are usually shared according to equity investment. Market and technology related motives are both important in most joint ventures.

Minority equity investments are understood as cooperation, especially in the case a large company invests in a smaller 'high-tech' company, which in the long run could affect the technological performance of at least one 'partner', in particular if such minority sharing is coupled with research contracts.

Joint R&D agreements are joint research pacts and joint development agreements which focus on joint undertaking of R&D projects with shared resources.

Technology agreements concern technology sharing agreements and cross-licensing agreements. Companies both agree to partake in such an agreement and agreements are often exclusive. Cost economization is the main motive in this type of agreement.

Customer-supplier relationships refer to co-production contracts, co-makership relations and research contracts that regulate R&D cooperation on the longer term between the partners.

Research shows that complex modes of governance (joint ventures, minority investments) are for a larger part motivated by market related reasons than by technology related motives. Contractual arrangements are primarily motivated by technology related issues (Hagedoorn, 1993). However, this is not prescriptive, as can be seen in the example of Philips and Nike, which have not structured their collaboration as a joint venture, although market and technology related issues are of primary concern. They have agreed on product development, manufacturing, and marketing contracts to enable flexibility and speed, and reduce the loss of investments in the case of market failure. Hence, in turbulent environments it could be wiser to use more flexible and simple modes of governance, instead of more complex modes as joint ventures. Further research is necessary to determine in which situation, which mode of governance is most appropriate.

The next paragraph will look deeper into some characteristics of technology alliances that differentiate them from other types of alliances, such as sales, production or sourcing

alliances. These characteristics point to specific managerial issues that should be addressed during the initiation and execution of alliances. Obviously, these characteristics concern technology, knowledge and learning related aspects of these alliances.

Knowledge sharing and learning in technology alliances

Technology alliances focus on innovation and research and development. Primary objectives of these alliances concern the development and sharing of new technology and knowledge by the partners. The realized strategic value of these alliances depends partly on the successfulness of technology and knowledge generation within the alliance, and the absorption (or internalization) of new knowledge and technology by the partnering firms (Cohen & Levinthal, 1990). With absorption we mean that newly developed technology and knowledge surpasses the stage of generation, and is actually applied in new products, markets and business processes. Hence, to create successful technology alliances it is of great importance to manage knowledge and technology related processes very carefully, within and across the boundaries of the alliance itself. These knowledge and learning processes differentiate technology alliances from other types of alliances such as collaborative production, distribution, or marketing and sales agreements. Recent research has paid specific attention to these knowledge processes and dynamics in technology alliances (Inkpen & Dinur, 1998; Hamel, 1991; Simonin, 1999; Lane & Lubatkin, 1998; Mowery, *et al.*, 1996; Khanna, *et al.*, 1998; Steensma & Corley, 2000). It is found that specific characteristics of knowledge and technology (and related processes) partly explain the performance of technology alliances. Here we will look deeper into three specific characteristics. We will elaborate on the *nature* of knowledge which influences the possibilities of sharing. We will examine briefly the problems of *valuation* of contributed knowledge to an alliance. And, finally, the possible occurrence of *learning races* and combined competitive and cooperative behavior in alliances is explained. We will address these issues before we elaborate on alliance design and management factors that influence alliance success. We think these three aspects partly determine which choices practitioners have to make regarding design and management.

To develop an understanding of important characteristics of knowledge in technology alliances, let us examine the Philips & Nike collaboration. One of the primary objectives of this alliance is to develop new 'wearable' electronic products for the sportive consumer, such as light-weight MP3-players or shock-proof disc-mans. The team of the alliance will have to integrate technology and knowledge from both Philips and Nike in the product development process. Technological knowledge about miniature electronics, materials, electronic design and ergonomics will have to be shared and integrated. Also, marketing know-how and facts about consumer preferences and performance demands will be used in the product-development process. Next to the integration of these knowledge and technologies, Philips could be very interested in the marketing and branding processes and strategies of Nike. Nike is a world-know brand and is renowned for its state-of-the-art marketing and branding skills. On the market for young people (14-24 years old) Philips is confronted with strong competition from Sony. Sony has strong marketing and innovation skills, just like Nike. If Philips could learn from Nike how they succeed in their innovation and marketing effort, Philips could use this knowledge in other markets to compete more effectively with Sony.

Tacit versus explicit knowledge

This example shows us that not only mixed motives are discernable in this alliance, but that it also concerns very different types of knowledge. In the example we talked about technological knowledge, facts, data-sheets and designs (*e.g.*, electronics, materials, ergonomics), but also about know-how, skills, and processes (*e.g.*, miniaturization, marketing and branding skills, consumer responsiveness). Important difference between all these types of knowledge is its relative explicitness or tacitness. The distinction between tacit and explicit knowledge is one commonly made in research literature. Tacit knowledge refers to the notion that we know more than we can express (Polanyi, 1962). Tacit knowledge was defined by Polanyi (1962) as knowledge that is non-verbalizable, intuitive and unarticulated. Tacit knowledge can be best understood as knowledge that has not yet been abstracted from practice. Tacit knowledge is highly context specific, and has a personal quality, which makes it difficult to formalize and communicate (Nonaka, 1994). Tacit knowledge is associated with skills, competencies, attitudes and beliefs, which are embedded in social groups or individuals. Explicit knowledge is knowledge that is transmittable in formal, systematic language and may include facts, axiomatic propositions, and symbols (Zander & Kogut,

1995). It can be codified or articulated in manuals, training tools, handbooks, designs or procedure. The distinction between tacit and explicit knowledge is important for the choices in design and management of the alliance. If knowledge is largely tacit it is far more difficult to share or exchange between partners than when it is largely explicit. The distinction between tacit and explicit should not be interpreted as a dichotomy, but rather as a spectrum ranging form explicit to tacit knowledge. Hence, knowledge can be more or less tacit or explicit. In the management and design of the technology alliance practitioners should take this distinction into account. There are different alliance design options which either enhance or reduce the possibilities for the sharing and exchange of tacit and explicit knowledge. In the next section we will elaborate on this in more detail.

Knowledge valuation

Another important aspect of knowledge and technology in alliances is the issue of knowledge valuation. At the initiation of the alliance and evaluation of possible partners, it is difficult to determine the value of the partner's knowledge. Partners cannot show the precise value of their knowledge without invalidating the worth of the knowledge itself. Moreover, the future value of the knowledge generated during the collaboration is not known beforehand. Hence, negotiations about knowledge and resource contributions to the 'knowledge-rich' alliance tend to be complex and rather vague. Some research suggests that for these alliances partners have favored non-equity forms because of their flexibility, even though his administrative form offers fewer protections (Osborn & Hagedoorn, 1997; Steensma & Corley, 2000). However, other research suggests that in general, equity-based alliances were a more effective means of sourcing technological capabilities from partners, than were contract-based alliances. This difference is attributed to the higher level of integration of equity-based alliances (Mowery, *et al.*, 1996). In the next section about successful technology alliances we will discuss this governance issue in more detail.

Learning races

Although sharing of knowledge between partners seems an obvious thing to do to make the technology alliance successful, this is certainly not always the case. Partners do not always give the other an opportunity to learn. They often 'hide' proprietary knowledge or technology from the alliance partner, or block knowledge flows into the alliances. If

knowledge or technology is of great strategic importance to one of the partners, this partner could reduce the opportunities for the other to learn about this knowledge. Imitation of its knowledge (whether it is a competency or a technology) could lead to erosion of the firm's competitive advantage. So we see that, although partners are aware of the fact that alliance success is partly dependent on successful sharing and generation of knowledge, they also purposefully withhold or hide knowledge from their partners. We can explain the occurrence of these behaviors from a 'learning race' perspective (Hamel, 1991; Khanna *et al.*, 1998). Hamel (1991) proposed to perceive technology alliances, in which complementarity of skills or technology is important, as a 'learning race'. In a learning race partners try to outlearn the other partner as fast as possible. Outlearning your partner reduces the dependency on this partner. Central assumption in the concept of a learning race is that an alliance is still a very uncomfortable position for firms to be in. The only reason why you would start an alliance is when you don't posses necessary skills or technologies and intent to learn (and absorb) these from a partner. When you have outlearned your partner and absorbed his skills and technologies, then you are able to terminate the alliance. As a consequence of the learning attempts of a partner, the other partners could decide to actively limit the opportunities for learning (*i.e.* their transparency) (Hamel, 1991). Hence, a dynamic process evolves of attempts to outlearn, to limit unwanted knowledge transfer, and to control necessary knowledge sharing to still meet alliance objectives.

Khanna *et al.* (1998) have made one of the first attempts to explain when these learning races are most likely to occur in alliances. Underlying theme in their research is that firm's incentives to learn are driven by their expected pay-offs, and that the structure of pay-offs that each partner expects is complex, interdependent and changing over time. The incentives to learn are high when private benefits within alliances are higher than common benefits that accrue to the firms in the alliance. This means that if a large part of the knowledge within the alliance can also be applied outside the scope of the alliance (in unrelated products and markets) for one of the partners, this partner is likely to have higher private benefits than common benefits. A higher ratio of private to common benefits leads to a stronger incentive to outlearn and to greater departures from cooperative toward competitive behavior. Hence, cooperative and competitive behaviors are both likely to occur in these technology alliances. Cooperation arises from the fact that each firm needs access to the other firm's know-how,

and that the firms can jointly use their knowledge to produce something that is beneficial to them all (common benefits). While competition is a result of each firm's attempt to also use its partner's knowledge for private gains, and of the possibility that greater benefits might accrue to the partner that out learns the others.

In this section we have mentioned three important aspects of knowledge and learning in technology alliances. The degree of tacitness of knowledge determines the possibilities for knowledge transfer and sharing. The valuation of knowledge is difficult (partly because of its tacit nature) which favors rather simple and flexible modes of collaboration. And, when private benefits are high, learning incentives will be strong, and partners will try to outlearn each other. Hence, both cooperative and competitive behavior will be present in (technology) alliances. In the next paragraph we will relate these general aspects of knowledge and learning to organizational variables that together influence alliance performance.

Design and management of successful technology alliances

In the previous part we addressed three specific aspects of technology and learning in alliances. These aspects interact with the decisions practitioners make regarding the design and management of technology alliances. Here we will structure some of these decisions and aspects from a more managerial point of view. This overview specifically focuses on technology and knowledge management related issues. Other relevant aspects of the design and management of alliances in general, will be left out of the overview. We will address three different categories of factors influencing alliance performance, namely: partner choice, governance choice and organizational design, and process management. In research literature these categories are commonly used to investigate alliance management and performance (Hamel, 1991; Inkpen, 2000; Inkpen & Dinur, 1998; Kale *et al.*, 2000; Lane & Lubatkin, 1998; Mowery *et al.*, 1996, Simonin, 1999).

Partner choice

If learning from a partner or technology sharing is important, selection of a partner with similar knowledge and organizational characteristics positively influences alliance

performance. Similarity of the firm's knowledge base (or technological overlap) eases common understanding and knowledge sharing (Lane & Lubatkin, 1998; Mowery, *et al.*, 1996). Of course, collaboration is often motivated by seeking complementarities and not similarities, but some overlap in basic knowledge is necessary to enable effective knowledge sharing (*e.g.,* basic biochemistry knowledge in biotech – pharmaceutical alliances). Next to this, it is found that similarity of the firm's dominant logic and organizational problem set enhances alliance performance (Lane & Lubatkin, 1998). If a partner is familiar with the other partner's set of organizational problems (*i.e.* products and markets) it is able to understand better why specific knowledge and technology are important to develop and apply. Knowledge and technology are more easily absorbed by the partners if these partners apply it in similar problem situations. The final partner characteristics we would like to mention is the partner's collaborative know-how or prior alliance experience. When a firm has prior experience with alliances in general or with the same partner in particular this greatly enhances the performance of the alliance (Simonin 1999; Kale *et al.*, 2000). Of course, a firm cannot "choose" its own level of collaborative know-how and experience, it has to develop this by learning-by-doing, but it can select a partner which does have alliance experience. Hence, alliance experience is an important selection criterion.

Governance choice and organizational design

The choice of the mode of governance has important implications for the performance of the alliance when we look at knowledge transfer and technology development. Steensma and Corley (2000) have examined the interaction between mode of governance and attributes of technology (*i.e.,* its uniqueness, imitability and dynamism). They suggest that difficult to imitate technology and tacit knowledge favor tight coupling governance structures such as joint ventures and acquisitions. A more tightly coupled collaboration (equity investments, strong alignment of objectives, and frequent interaction between partners) enhances the opportunity to learn and share more difficult to imitate technologies and knowledge. Mowery *et al.* (1996) also show that interfirm transfer of technology is more enhanced in equity joint ventures, than in contract-based alliances. However, if the technology's dynamism is high, more loosely coupled governance structures are favored (Steensma & Corley, 2000). Thus, when the length of the technology lifecycle is rather short and the likelihood of future competence-destroying developments is high (in a turbulent

environment) contract-based alliances enhance the performance of the alliance and offer necessary flexibility.

Closely related to the choice of the legal and financial structure of the alliance is the organizational design of the alliance. Organizational design concerns the structure of tasks, interfaces and resource allocation of the alliance. When technology and knowledge are difficult to imitate or highly tacit, close cooperation enhances the opportunities to learn (Hamel, 1991; Simonin, 1999; Inkpen & Dinur, 1998). This means that the execution of multiple joint tasks and the existence of multiple linkages between personnel at several hierarchical levels of the partnering firms, positively influence the transfer of technology and knowledge. Proper resource allocation to the alliance also enhances alliance performance. This is not only a matter of financial resource allocation; in the case of knowledge sharing and technology development this specifically concerns the allocation of qualified human resources and expertise. Especially when knowledge is complex and tacit, the allocation of experienced personnel to the alliance and the set up of cross-organizational and cross-functional alliance teams greatly improves alliance performance. Personnel should have experience with the technology and knowledge, but should also have experience with alliances and the partner (Hamel, 1991; Simonin, 1999).

Process management

As argued in the former paragraph (technology) alliances show complex process dynamics. Managing the occurrence of combined competitive and cooperative behavior (learning races) is a challenge to most alliance managers. Partners are trying to learn and are also trying to protect. If a firm contributes too little to building the relationship, the alliance may be doomed to fail; on the other hand, if it contributes too much and too openly, its partner will gain the upper hand (Kale *et al.*, 2000). A proper governance structure will help to solve possible conflicts about knowledge sharing and knowledge protection. However, not all possible conflicts and issues can be predicted up front and hence, *a priori* defined contracts and regulations have their limits. For practitioners it is thus important to develop capabilities and instruments to manage the alliance when it is running. Relational capital and integrative conflict management are both such capabilities which can be developed and applied to enhance alliance success. Relational capital refers to mutual trust, respect and friendship at

the individual level between alliance partners. It resides upon close interaction at the personal level (Kale *et al.*, 2000). Integrative conflict management entails joint management of conflict with mutual concern for 'win-win' situations for all concerned. It is a communicative and contact-intensive process with honest and open lines of communication. Organized monitoring of concerns and conflicts leads to higher levels of procedural justice and trust (Kale *et al.*, 2000). Research has shown that the greater the relational capital that exists between partners, the greater will be the degree of learning achieved. This also applies for integrative conflict management. Moreover, the greater the extents to which conflicts are managed in an integrated way, the greater will be the partner's ability to protect core assets from each other. Kale *et al.*, (2000) show that the development of relational capital and application of integrative conflict management offer the possibility to learn and protect concurrently. These process instruments are just as important as the choice of the proper governance structure (equity vs. non-equity) or organizational fit (complementarities and compatibility) of both partners. We have summarized all factors influencing technology alliance performance in table 2. We acknowledge that this overview is not exhaustive, but only indicative. We have limited ourselves to knowledge and technology related factors and interactions which we have mentioned in this section.

Table 2. Some factors influencing technology alliance performance

Category	*Success factors*
Partner choice	Similar basic knowledge base Similar organizational problem set Prior alliance experience and know-how
Governance choice & Organizational design	Equity alliances in the case of highly tacit knowledge Contract-based alliances in the case of highly dynamic knowledge Multiple joint tasks in the case of highly tacit knowledge Multiple organizational interfaces in the case of highly tacit knowledge Experienced personnel allocation in the case of highly complex knowledge
Process management	Development of relational capital

	Application of integrative conflict management

Moreover, we have limited this overview to determinants which have been empirically tested. This means that there still remains a lot to be investigated and discovered. In the last section we will shortly discuss some interesting research gaps.

Research gaps and opportunities

In the former paragraphs we have highlighted different aspects and issues of technology alliances. And, as we can see, many issues are still unsolved and theory is still fragmented or too simplistic. We have identified four different themes that need future research attention, namely: innovation performance of alliances versus other organizational forms, the governance choice, knowledge and learning at the individual level, and alliance evolution.

Technology alliances versus internal development and market transactions

Although firms use different motives to start collaboration with partners, and hence expect several advantages of collaboration which cannot be achieved individually, it is still unclear whether alliances are superior to other forms of organization with respect to innovation. For instance, recent research of Almeida *et al.* (2002) shows that multi-national corporations (MNC) outperform alliances and market transactions with respect to cross-border knowledge development. So, although alliances are a 'hot topic' in research and practice, we need to be critical about the true value and performance of alliances with respect to other forms of innovation and R&D. Complicating factor in comparing research results is that most studies use different performance measures and focus on different processes. As a consequence of this, a definite answer or integrated overview of the pros and cons of internal or external development of technology cannot yet be given. Hence, comparison of organizational forms and innovation performance (and organizational performance in general) is still an important, but also complicated theme for future research (*cf.* March & Sutton, 1997).

Governance choice

As we have seen, many researchers have studied the influence of governance structure on alliance performance. However, still no complete and integrated picture has emerged.

Researchers tend to focus only on economic reasons, or only on opportunistic behavior or technology and knowledge attributes. Moreover, in most research gross simplifications of the many different forms of governance are made (*e.g.* equity vs. non-equity). This does not do justice to the many types of partnerships and organizational modes of cooperation which can be found in reality (*cf.* Hagedoorn, 1993). Hence, it is worthwhile to unpack the issues of governance and its interactions with other relevant aspects of technology alliances such as learning, environmental turbulence, organizational design and process dynamics.

Knowledge, technology and research levels

Most of alliance research has studied alliance structure, processes and performance at firm-level. There exists a lack of research at the individual and behavioral level of alliances. Attitudes, perceptions and actions of alliance managers and alliance team-members are relatively under-studied. We assume that managerial behavior in *non*-hierarchical work situations and across firm-boundaries is indeed different from that of behavior in hierarchical work relationships (Osborn & Hagedoorn, 1997). It seems worthwhile to study these aspects with respect to the dynamics of the alliance. Also with respect to inter-organizational learning processes and knowledge processes it is important to study these at a more individual level. Learning and knowledge sharing occurs (firstly) at the individual level and is embedded in communication processes between organizational members. It seems plausible that managerial behavior and team members' actions should have large implications for learning and knowledge sharing between people (*cf.* Hamel, 1991).

Alliance evolution

The last research opportunity we want to address here is alliance evolution. Longitudinal studies of alliances are limited in number and hence, our understanding of process dynamics and evolution of alliances is also limited. Only little research has focused on these process issues, of which the research of Doz (1996) is worth mentioning. The research on learning races (Hamel, 1991; Khanna *et al.*, 1998) has shed some light on alliance dynamics. However, the models used to explain the occurrence of learning races are rather simplistic, and are based on narrow game-theoretical interpretations of firm behavior. The existence of learning races has not yet been empirically tested, and seems to exist primarily in the interpretations

of academics (Inkpen, 2000). Longitudinal event studies of alliances could enhance our understanding of alliance dynamics greatly.

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