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R&D collaboration: role of *Ba* in knowledge-creating networks

Malin Brännback[1]

[1] *Turku School of Economics and Business Administration/Innomarket, Lemminkaisenkatu, Turku, Finland*

Correspondence:
Malin Brännback, Turku School of Economics and Business Administration/Innomarket, Lemminkaisenkatu, 14-18C, FIN-202 Turku, Finland.
Tel: +358-2-481 4582;
Fax: +358-2-481 4268;
E-mail: malin.brannback@tukkk.fi

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Abstract

Research and development (R&D) collaboration between universities and business is a vital form of new knowledge creation in knowledge-intensive high-technology business environments. Increasingly, collaboration occurs in networks. A key element in forming these collaborate networks is shared knowledge creation, which is dependent on the *Ba*, the SECI process, and knowledge assets. This paper argues that *Ba* plays a major role for successful knowledge creation through R&D collaboration between university and business. A *Ba* is a perception of a place – which can be virtual – and a shared purpose. The absence of a *Ba* is a significant barrier to success, but building a *Ba* takes collaborative time and effort. This paper addresses the problems in the successful formation of such networks based on insights from biotechnology, an area where this type of collaboration has been and still is common, but not always successful or unproblematic.
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Introduction

Knowledge has become a principal source of competitive advantage for any firm. Therefore, knowledge management – the process by which organizations seek to deal with knowledge in a systematic way for creating competitive advantage – has attracted the interest of researchers and practitioners in the past decades. Not only has the discussion of *what is* knowledge been rampant but equally remarkable has been the *how to*, that is, the introduction of frameworks, techniques, and tools promising to alleviate the challenge of managing organizational knowledge. Methods of measuring knowledge and knowledge productivity have been introduced, but often leaving employees and management once more deeply frustrated (Pfeffer & Sutton, 2000).

Nonaka presented in his now classic article 'The knowledge creating company' a framework for knowledge creation (Nonaka, 1991), which has strongly influenced research in this area. On the other hand, there is a large bulk of research around the very same issues that entirely overlook the ideas of Nonaka despite the fact that the issues and the conclusions are basically the same (cf. Cohen & Levinthal, 1990; Kogut & Zander, 1992; Leonard-Barton, 1992; Levinthal & March, 1993; Henderson & Mitchell, 1997; Teece *et al.*, 1997). Therefore, in this paper we will build on Nonaka's (Nonaka has published alone, but a large proportion of this work has been co-authored. For simplification, we refer to these studies as Nonaka's, which does not mean that we undermine the contribution of the other authors (Nonaka, 1991; Nonaka & Takeuchi, 1995; Nonaka *et al.*, 2000).)

ideas and at the same time also show the links to these studies, which by and large explicitly build on the resource-based view of the firm, knowledge-based firms and learning organizations. Nonaka's ideas can implicitly be traced to the same ideas. Nonaka's model describes the way in which knowledge is converted from tacit to explicit and again to tacit through an SECI process. It is in terms of knowledge assets and management thereof that has been dominated by studies of competence-based competition and the resource-based view of the firm. Most studies, with some exceptions (Cohen & Levinthal, 1990; Kogut & Zander, 1992; Teece *et al.*, 1997), have focused on how competencies are managed within an organization, but surprisingly little attention has been given to inter-organizational knowledge creation and the importance of context knowledge for knowledge creation.

The role of context has been discussed in relation to innovations management and R&D, but again the connection to knowledge management has not been sufficiently explicated. Innovations management and R&D have been studied from numerous perspectives. It is widely acknowledged that there are different forms of innovative activity with different contextual origins and there has been substantial effort ever since the work by Schumpeter (1934) in defining common elements of a wide range of innovations (Dosi, 1988; Nonaka *et al.*, 2000). Rather recently R&D and innovations management have been explicitly linked to knowledge management and organizational learning where R&D and innovative activities are seen as complex search, learning, and problem-solving processes, which are as much based on existing knowledge as they create new knowledge (Dosi & Orseniego, 1988; Cohen & Levinthal, 1990; Levinthal & March, 1993; Grant, 1996a, b; Teece *et al.*, 1997; Ensign, 1999; Koschatzky, 1999; Pitt & Clarke, 1999).

Despite all this activity, there seems to be a lack of understanding of how new knowledge is created, and research into the process of creating new knowledge has not been very strong (Buckley & Carter, 2000; Teece, 2000), in particular when new knowledge creation transcends ontological dimensions. The evident contextual dependency of new knowledge creation processes emphasizes the managerial importance of knowledge management through an explicit need for purposeful coordination of action within the firm. It is also important to understand that networked knowledge creation will influence industry structure and served markets.

Context knowledge appears to – at least partially – explain why management research findings in one high-technology area may not provide meaningful insights in another (Deeds, 2001). For example, comparing innovative activity in the area of information technology (IT) with biotechnology is difficult if not altogether impossible because of fundamental differences in context (Audretsch & Stephan, 1996). Despite contextual differences the common denominator for high-technology companies – especially biotechnology – is that they are performing knowledge creation within networks (Shan *et al.*, 1994; Audretsch & Stephan, 1996; Deeds & Hill, 1996, 1998; Coombs & Deeds, 2000; Murray, 2002; Riccaboni & Pammolli, 2002). These networks can be between departments in a university or a business, between universities, between companies, or between universities and companies. Each of these elements form separate contexts, *Ba*, which through the network(s) form new knowledge context(s).

This paper focuses on the role of *Ba* in R&D collaboration transcending organizational boundaries where several *Ba* can co-exist. We argue that context knowledge is necessary for a successful SECI and for building knowledge assets within the *Ba* and also within other *Ba*. The paper seeks to describe a minimum set of characteristics, which are needed for a *Ba* transcending organizational boundaries, which can be intra- and inter-organizational. Illustrative examples are given from biopharmaceutical R&D. The paper is structured as follows. We first present Nonaka's framework for knowledge creation. Then we describe knowledge networking and the role of *Ba*. Next we apply the framework to biopharmaceutical R&D. Finally, we conclude and offer suggestions for future research.

Knowledge creation

For most high-technology high-growth companies, the *raison d'être* is to constantly create new knowledge. Zeleny (1989) defines knowledge as a *purposeful coordination of action*. This definition points to a process of action, which implicitly includes Nonaka's knowledge conversion process as well as the *dynamic capability* stream of strategic management (Henderson & Mitchell, 1997; Teece *et al.*, 1997; Teece, 2000; Deeds, 2001) and closely related contemporary views on organizational knowledge creation and organizational learning (Cohen & Levinthal, 1990; Levinthal & March, 1993; Kogut & Zander, 1992; Leonard-Barton, 1992).

According to the Nonaka framework, the knowledge-creating process consists of three elements: (i) a knowledge conversion process, the SECI, (ii) context knowledge, the *Ba*, and (iii) knowledge assets. All three are needed for new knowledge creation as they make up the inputs, outputs, and the moderator of the process. In reality, they are very tightly interconnected, and can hardly be separated, but for illustrative and perhaps pedagogic purposes they will be described here as if they were separate entities. Leonard-Barton (1992) expresses the same thing using four distinct entities, which are included in the Nonaka framework: (i) human knowledge and skills, (ii) technological skills, (iii) managerial systems, and (iv) values and norms, which are embodied and embedded in knowledge creation and control.

According to Nonaka, there are two types of knowledge: explicit and tacit. Although highly different in nature, they are inseparable in new knowledge creation

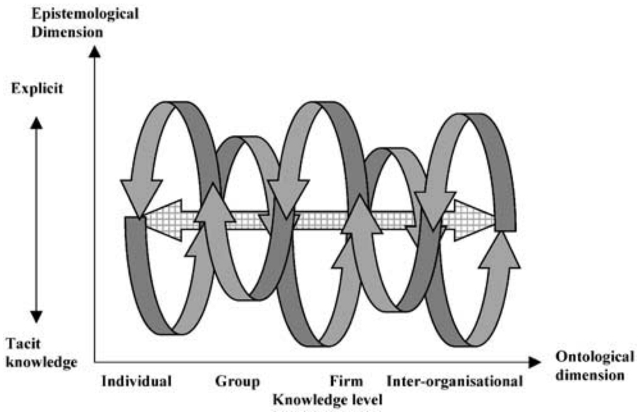

Figure 1 Knowledge conversion through context knowledge.

and form the epistemological dimension of knowledge. Explicit knowledge is formal, systematic language, often scientific formulae, and tacit knowledge is deeply rooted in action, procedures, routines, commitments, ideals, values, and emotions. Knowledge conversion through different ontological dimensions of *Ba* is shown in Figure 1, where the SECI process transcends in a spiral movement across different *Ba*'s.

Nonaka framework – SECI, *Ba*, and knowledge assets

SECI

In the knowledge conversion process, new knowledge is created through a knowledge spiral where key activities are socialization, externalization, combination, and internalization (SECI) through which tacit knowledge is made explicit in an iterative, spiral-like process (Nonaka, 1991; Nonaka *et al*., 2000). Accordingly, the SECI process starts with tacit knowledge being converted into new tacit knowledge through shared experience typically found in, for example, an apprenticeship. Once socialized, the knowledge is explicated, made explicit, allowing it to be shared. Concepts are created and documentations are made, thus externalizing new knowledge. When existing explicit knowledge, is combined with new explicit knowledge, it is disseminated through different ontological dimensions. Use of modern information and communications technology can be helpful here. Finally, explicit knowledge is embodied or internalized once again becoming tacit knowledge by individuals, thus becoming shared mental models or technical know-how.

Within an organization SECI is a fundamental element of competence development and as such the means for developing an organization's knowledge asset. This process does not stop once it has closed the circle, but continues into a new knowledge-creating spiral. Hence knowledge created through the SECI process can trigger a new spiral of knowledge creation expanding both horizontally and vertically across organizations. It is the process that transcends ontologically, across individuals, sections, departments, divisions, and even organizational boundaries. Knowledge is transferred beyond organizational boundaries, and knowledge from different organizations interacts to create new knowledge. New knowledge creation thus transcends the boundary between self and other, inside and outside, past and present.

Knowledge context or Ba

Knowledge needs a context to be created as it is context-specific. The context defines the participants and the nature of the participation. *Ba* is a place offering a shared context. This context is social, cultural, and even historical, providing a basis for one to interpret information, thus creating meaning, thus becoming knowledge. *Ba* is not necessarily just a physical space or even a geographical location – like a room or a house or a city – but a time–space nexus as much as a shared mental space. Our argument here will emphasize the cognitive dimension of this space. *Ba* is an interaction space involving language and communication. Knowledge is created through the interactions among individuals or between individuals and their environments. *Ba* is the context shared by those who interact with each other, and through such interactions, those who participate in *Ba* and the context itself evolve through self-transcendence in creating knowledge. Participants are not bystanders.

Ba sets a boundary for interactions by creating contexts of different ontological levels, and is at the same time boundary-free by allowing for a fluid flow of knowledge through these levels (Figure 1) showing the ontological plurality of *Ba*. According to this view, any form of new knowledge can be created regardless of the business structure as *Ba* transcends beyond formal business structures. Changes in *Ba* take place at both the micro- and macrolevels. Membership in community should not be confused with *Ba*, where membership is, according to Nonaka *et al*. (2000), not fixed; they change in the same way as networks, which are more flexible structures.

Nonaka *et al*. (2000) present four types of *Ba*: (i) originating *Ba*, (ii) dialoguing *Ba*, (iii) systemizing *Ba*, and (iv) exercising *Ba*, which can take place in two interactive and two media dimensions. The former is on an individual or a collective level and the latter is the media used in interaction, which can be either face-to-face or virtual. Originating *Ba* is face-to-face and individual, a context for socialization, that is, it forms the basis for knowledge conversions among individuals. Originating *Ba* can be structured but is more often less structured. Dialoguing *Ba* is collective and face-to-face, where knowledge is shared and converted into common terminology and concepts. Dialoguing *Ba* benefits from the participation of individuals with the *right* mix of specific knowledge and capabilities are coordinated in a purposeful way. Systemizing *Ba* is collective and virtual. Again, information and communications technology is effective in transmitting knowledge for example, through mailing lists, new groups, or net meetings. Finally, exercising *Ba* is individual and virtual, allowing for internalization of new knowledge through manuals, directories, or professional journals.

Knowledge assets

These form the basis for the knowledge-creating process. Nonaka *et al*. (2000, p. 20) define knowledge assets as '…firm-specific resources that are indispensable to create value for the firm'. This definition is strikingly similar to the definition of core competence provided by Bogner & Thomas (1994, p. 113): 'firm-specific skills and cognitive traits directed towards the attainment of the highest possible levels of customer satisfaction *vis-à-vis* the competitors'. Knowledge assets are the inputs, the outputs, and moderating factors, the most important assets of any size of a corporation enabling it to develop and sustain its competitive advantage. Knowledge assets are continuously evolving, they are deeply-rooted, and they are path-dependent. Knowledge assets form the knowledge base of a firm, which according to Nonaka *et al*. (2000) include four different types: experiential, conceptual, routine, and systemic.

Experiential knowledge assets are tacit knowledge shared through common experiences, that is, individual skills and know-how and also security, passion, and tension. Conceptual knowledge uses images, symbols, and language in explicating knowledge, for example, design and product concepts. These are further made explicit, systemized, and packaged using specification, manuals, databases, patents, etc., becoming systemic knowledge assets. Finally, once explicit knowledge has been internalized it also becomes routine knowledge assets, embedded and path-dependent, such as organizational culture and routines.

Nonaka *vs* contemporary research

The Nonaka framework contains elements and issues, which are visible in recent contemporary research on knowledge management and organizational learning as means of creating a competitive advantage. The problems reflected within the field of strategic management have dealt with building firm capabilities and competences and inter-organizational learning and knowledge transfer. In terms of inter-organizational knowledge transfer, it has been argued that this is dependent on an organization's absorptive capacity of the individual and within the different ontological forms (Cohen & Levinthal, 1990; Kogut & Zander, 1992; Henderson & Mitchell, 1997; Deeds, 2001, see also March & Simon, 1958).

Scholars on learning in terms of building knowledge assets have pointed out that experiential-based knowledge can be an important basis for creating a competitive advantage. However, at the same time they point to serious limitations of experience, which stem from adaptive intelligence (Cohen & Levinthal, 1990; Kogut & Zander, 1992; Deeds, 2001). Levinthal & March (1993) argue that experience is often a poor teacher since it is constrained by similar cognitive limitations as rationality. It involves inference from information, memory, pooling of personal experience, simplification, and specialization (see also March & Simon, 1958).

The role of context has not been explicitly discussed, but has been dealt with in terms of proximity between different *Ba*'s and their impact on new product development productivity, entrepreneurial wealth creation, and ability for firms to raise capital (Shan *et al*., 1994; Audretsch & Stephan, 1996; Deeds, 2001; Murray, 2002). This has been particularly popular within high-technology industries and appears to have been a popular approach in the case of biotechnology.

Finally, there is a growing body of research within a stream of strategy aiming at understanding how firm-specific capabilities can be a source of competitive advantage in a changing environment. This school of thought is named *dynamics capability* and has its roots in the resource-based view (Teece *et al*., 1997). The word dynamic refers to *action* and an ability to renew competences as the environment changes, creating a new logic of the organization, which is seen as the fundamental nature of knowledge creation. The dynamics capability approach – implicitly and explicitly – is increasingly winning terrain as a basis for studying innovations management in high-technology high-growth industries, and again biotechnology has drawn the attention of many researchers (Audretsch & Stephan, 1996; Henderson & Mitchell, 1997; Klavans & Deeds, 1997; Deeds *et al*., 1999; Deeds, 2001.

Deeds (2001) has studied scientific and technological capabilities and their impact on entrepreneurial wealth creation within biotechnology. The study is built on the dynamics capability approach and several of the above-mentioned perspectives. Deeds (2001) finds three distinct components that correspond with Nonaka's model: (i) internal scientific and technological capabilities through investment in R&D (knowledge assets), (ii) the firm's technical R&D capabilities, which are skills and knowledge that allow the firm to turn basic research into patents (SECI), and (iii) the firm's connection to an involvement in the external scientific community (*Ba*).

Deeds develops three hypotheses, where each element's impact on entrepreneurial wealth creation is tested. The findings are interesting. The results show that knowledge assets are positively related to entrepreneurial wealth creation. The support for SECI is significant but mixed, that is, SECI is negatively related to early-stage ventures but positively related to late-stage ventures. This would imply that SECI is dependent on organizational knowledge assets that the firm has acquired, and it certainly gives support for the claim that organizational knowledge is path-dependent and embedded. New ventures simply do not have these paths. This is consistent with Cohen and Levinthal (1990), who argue that learning is more difficult in novel domains.

Finally, there is very strong support for the role of *Ba*, which is an embodiment of an organization's absorptive capacity involving learning and acting on the scientific discoveries and technical activities *outside* the boundaries of the organization. This can be seen as an expression of how knowledge creation transcends different ontological dimensions of *Ba*. In other words, biopharmaceutical companies whose employees are members of scientific communities will learn more efficiently than those outside because there is an SECI spiral in place and existing knowledge assets to further develop.

Knowledge networking

A basic characteristic of networks is *boundary crossing* where traditionally guarded organizational borders are crossed or disappear. Members of boundary-crossing networks work across conventional boundaries, cooperating for mutual benefit, while *retaining competitive independence*. Networks thus hold the potential of offering three distinct advantages over independent integrated firms: power, speed, and flexibility. This is possible, according to Lipnack & Stamps (1997), provided networks are able to generate a *common purpose*, *effective links* enabling interaction with *interactive levels*, allowing for *multiple leaders*,and *independence of members*. In other words, these can be understood as a minimum set of requirements needed for networks to provide the benefit sought for by its members. For the sake of clarification, it is important to point out that we also need *people*, that is without people nothing takes place!

Purpose

From a knowledge creation point of view, the necessity of a common purpose is critical. The requirement of a common purpose can be found in *Ba*, where *Ba* was not simply a physical space but equally much a mental space and an interaction space facilitating individual and organizational absorptive capacity. *Ba* enables individuals to generate a shared cognitive orientation – a worldview – which is also the basis for path dependency of knowledge. We argue that *Ba* will be a necessity for creating a common purpose and that without a *Ba* the common purpose runs a real risk of becoming merely supported or advocated intentions rather than true commitment to shared pursuits of the network resulting in at best co-mingling but not collaboration which will facilitate co-development (Murray, 2002; Riccaboni & Pammolli, 2002). A network where the members have the same background or worldviews will have fewer problems with finding a common purpose and collaborate than a network where the members have different backgrounds. The cognitive orientation and mental models are assumed to guide an individual's and ultimately an organization's perception of the purpose for their activities. Defining an organization's purpose which is fundamental to its strategies and operations is already a demanding task and finding a common purpose within a network, which will commit all members of a network sufficiently, is hardly any less demanding.

Simplified, a company should define its purposes according to the business realities – what it is, should be, and will be. A university-based research unit defines its purposes accordingly but within another context. The company's purpose is to create a customer with a clear profit requirement added to the purpose. The university has a scientific and educational purpose to fulfill in the first place. Combining these two entities into a single successful economic unit such as a network constitutes a major challenge, a *strategic* one for both the firm and the university separately and jointly.

Links

The importance of links between the different *Ba*'s cannot be underestimated either and are explicated through the different types of *Ba*; originating, dialoguing, systemizing, and exercising. According to several studies (Audretsch & Stephan, 1996; Zucker & Darby, 1997; Zucker *et al*., 1998; Murray, 2002), the tacit nature of knowledge in biotechnology appear to suggest that knowledge transfer between different ontological dimensions is facilitated by face-to-face contact. Therefore, geographic proximity seems important and that location close to talent would be advisable. However, as already pointed out, findings are mixed. Audretsch and Stephan (1996) find that proximity matters when knowledge transfer is informal and this is supported by Murray (2002). It comes as no surprise that scientists who publish are more known outside their local network than those who do not, but publishing is a sign of scientific advances; however, there is a long way to commercial breakthrough. Zucker and Darby (1997) and Zucker *et al*. (1998, 2002) show that the existence of actual links between star scientists in biotechnology firms and university research units positively affects success. Co-authorship is a very explicit link and a visible proof of a *Ba* between individuals as well as across organizational boundaries.

Interactive levels

In networks, the interactions take place between individuals, between individuals and groups, between groups, and between groups and organizations, that is, in every possible way of combination across different ontological dimensions, where different types of *Ba* will occur. However, the fact that interactions may occur at various different levels will require managerial attention so that it is allowed and not prohibited, otherwise the entire idea of networking will fall apart. As the study by Murray (2002) shows, this may not be entirely unproblematic as co-development appears to be in fact merely co-mingling, which means that transfer of tacit knowledge occurs less than explicit knowledge.

Multiple leaders and independence of members

Since a network will consist of members in different ontological dimensions, there will be multiple leaders. Multiple leadership is also a cultural issue, that is, it may not be accepted in certain cultures (national) or within certain universities, or research groups. For example, the way to operate in big pharma is likely to be very different

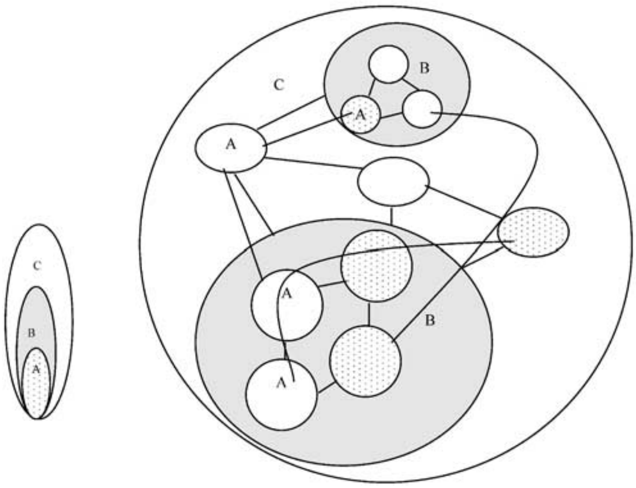

Figure 2 Networking within and across *Ba*.

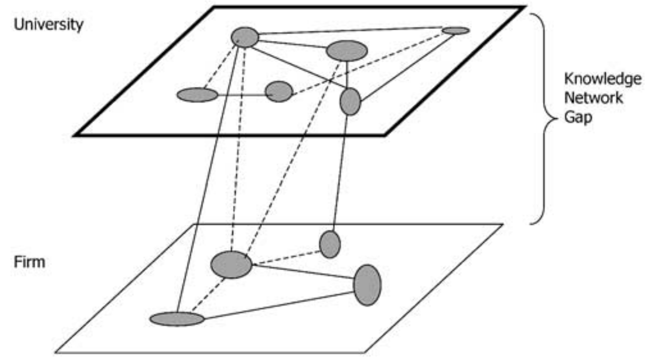

Figure 3 Networked knowledge sharing.

from a small biopharmaceutical firm and is certainly very different from a university unit, let alone the fact that universities operate differently. It can be expected that in certain cases multiple leadership may create managerial dilemmas. Closely tied to multiple leadership is also the independence of members. In shared knowledge creation a reasonable degree of independence of members to act will have to be allowed.

Purpose and links with the people form a simple system of inputs, processes, and outputs in a network. People represent independent members, which through shared leadership generate integrated levels. Purpose represents cooperative goals, which are pursued through interdependent tasks generating concrete results. Links can through multiple media allow for boundary crossing interaction leading to trusting relationships. In a close-up we find that competition and cooperation co-exist, where purpose and links are fundamental to cooperation, whereas independent members and multiple leaders are means of competition. Integrated levels form the interface between cooperation and competition requiring the specific attention of management forging these activities into a meaningful whole, which we call network. These entities enable the formation of *Ba* across different ontological dimensions (Figure 2).

In Figure 2, we show the different ontological dimensions, $A, B, C, \ldots, N$, where A can be on the individual level, and thus forms the basic form of *Ba*, which in turn can form an enlarged *Ba*, and then again even larger as in C. This can all be within the same organization or it can be perceived as if B represents separate organizations and C, for example, an industry. In our pursuit to study the role of *Ba* in networked shared knowledge creation, we take the SECI process as given and accept that this knowledge conversion spiral occurs within knowledge creation. Our concern is the role of *Ba*, how the emergence of *Ba* can be managed more efficiently, and perhaps most of all that the importance of *Ba* should be given sufficient managerial attention. Zucker *et al*. (1998, 2002) discuss extensively knowledge transformation within biotechnology and the diffusion of tacit knowledge and its effects on firm success. Their work thus implicitly addresses the ideas explicated in the model by Nonaka. Nonaka *et al*. (2000) conclude their article by pointing at an immediate necessity to examine how companies, governments, and universities can work together to make knowledge creation possible. Our conception of this conclusion is that it explicitly points at *Ba* within which knowledge assets are formed, maintained and developed as well as the 'perfection' of the SECI process takes place. We have mentioned the formation of science parks, which in some cases have proven successful but in others less successful (Saxenian, 1994). Many view science parks as governmental initiatives with the sole purpose of providing a physical place through real-estate and infrastructure and that there has been a failure in providing a mental space. The model by Nonaka *et al*. presents us with a conceptual model enabling us to go beyond real-estate and infrastructure to reach the state of knowledge catalysts.

Figure 3 depicts the network constellation, which transcends organizational boundaries in its simplest form. Each circle will represent an ontological entity, which at first is an individual within an organization as discussed above and shown in Figure 2. Here we have two organizations: a university and a firm. The individuals of the organizations will all have an individual *Ba*, which through interactions enables an organizational *Ba* to emerge. SECI takes place individually and between persons and in that contributes to the formation of not only individual knowledge assets but also organizational knowledge assets, which thus become path-dependent and embedded. Consequently, young organizations are likely to have strong individual *Ba* and the organizational *Ba* will grow and strengthen through time with shared values and beliefs and become the 'firm way to operate'. The way in which SECI takes place will establish itself over time and it becomes the responsibility of management and leadership to improve the SECI in order to stay innovative.

When the two organizations engage in collaboration, the individual *Ba* and organizational *Ba* will be challenged as a new SECI spiral evolves as well as a different ontological *Ba* – inter-organizational. Again, it is through leadership that these differences that constrain the SECI process and the formation of *Ba* can be alleviated. We call these differences a knowledge network gap. The larger the gap, the more difficult shared knowledge creation will be, thus attaining the potential benefits from collaboration. The task for management will be to allow for personal and organizational *Ba* to exist, all the while ensuring that an inter-organizational *Ba* evolves through the different types of *Ba*: originating, dialoguing, systemizing, and exercising.

When this system is further expanded into a network, it is obvious that the complexity of managing SECI, *Ba*, and knowledge assets increases. To further complicate matters different organizations are most likely to exist in different locations, even in different countries, for which the different types of *Ba* become necessary. Where the four types of *Ba* and their relevance on the lowest ontological level may not always be visible, their relevance becomes all the more evident when moving towards increased ontological complexity. The networked structure is displayed in Figure 4.

The formation of a network *Ba* most often starts from the originating *Ba* with face-to-face interactions on an individual level, between individual researchers from firms or universities. Then, these interactions become collecting involving more persons, where common interests, skills, and mental models are shared. It can be said that here the rudiments of a network is formed and here the common purpose should be explicated and externalized. Whereas the originating *Ba* can be quite spontaneous, the dialoguing *Ba* is deliberate, seeking a formalized structure. Both these *Ba* are tacit by nature and will in systemizing *Ba* become more explicit, taking the forms of documentation and databanks. Moreover, systemizing *Ba* benefits from the use of information systems facilitating interaction where explicit knowledge can be efficiently exchanged and diffused through the different ontological dimensions. Finally, the explicit knowledge is embodied to become, exercising *Ba* through joint action, purposefully coordinate action. Although the different types are described here as separate processes, they exist simultaneously – at least they should.

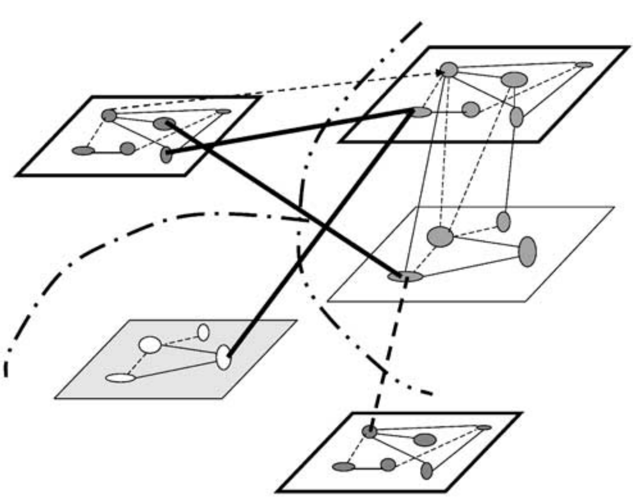

Figure 4 Networking across and within boundaries.

Knowledge-creating networks in biopharmaceutical R&D

In this section, we will describe changes within biopharmaceutical R&D on an industry and firm level, and university level, in particular in how R&D collaboration has moved from fully integrated to become networked-based. The first example concerns biopharmaceutical R&D in general, and the remaining two concern network constellations in Finland. The first concerns the possibility of forming an R&D network with both firms and university-based R&D units, and the second concerns the formation of a networked research center where university departments would cooperate to generate outputs for commercial enterprises.

Example 1

The development of new drugs has, during the entire post-war era, been dominated by large multinational corporations or fully integrated pharmaceutical companies (FIPCO) (Fisken & Rutherford, 2002). Scientific advances in biotechnology in the 1970s led not only to the emergence of a new scientific and technological paradigm (Dosi, 1988) but also to structural and strategic changes most visible in intensive new business development activities beginning in the US in the early 1980s (Deeds & Hill, 1996, 1998; Zucker & Darby, 1997; Zucker *et al.*, 1998, 2002; Robbins-Roth, 2000; Deeds, 2001; Oliver, 2000; Murray, 2002). In the 1990s, similar activities started to occur in Europe. In 2001 there were 1457 biotechnology companies in the US, 1879 in Europe, and approximately another 1500 in the rest of the world.

Although the field of modern biotechnology is young and very wide, most business and R&D activity is in human therapeutics. Biopharmaceutical R&D has the following general characteristics (Shan *et al.*, 1994; Deeds & Hill, 1996, 1998; Coombs & Deeds, 2000; McMillan *et al.*, 2000; Murray, 2002): (i) it is knowledge-intensive R&D driven; (ii) operations are networked-based demanding various services provided by, for example, contract research organizations (CROs), universities, and other biotechnology companies; (iii) the entrepreneurs have a strong science background but no or little prior business management experience; (iv) many companies are university spin-offs or spin-offs from pharmaceutical companies, or the entrepreneur has left the traditional pharmaceutical industry to start a biotechnology company; and (v) a majority of them are small, employing

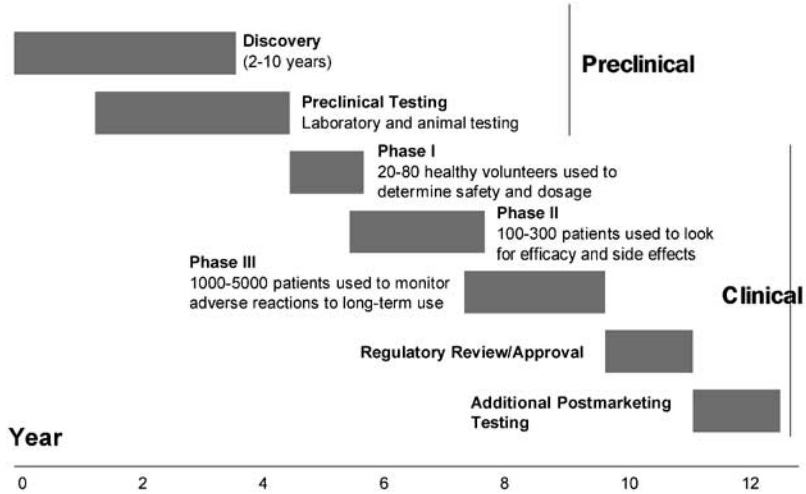

Figure 5 The drug development process as basis for business operations.

less than 50 persons and sometimes only five to 10 persons.

The biopharmaceutical industry possesses some structurally unique characteristics with an exceptionally long and expensive R&D process. The R&D process, which is strongly regulated, takes on average 15 years to generate an estimated €800 million of total cost (Tollman *et al.*, 2001). Earlier these costs were kept in-house as R&D was seen as a proprietary core knowledge (Bogner & Thomas, 1994). However, ever-increasing R&D costs and growing knowledge intensity most visible in a constant development of new technologies forced firms to abandon the FIPCO business model. Today, it is widely believed that new technologies such as genetics, genomics, proteomics, and glycomics can potentially shorten early R&D (discovery and preclinical phase, Figure 5), thus reducing costs by $300 million and shortening development time by 2 years. On the other hand, many of the R&D services needed in the early R&D phases are knowledge-intensive and often extremely laborious, especially preclinical studies where long-term experience becomes a fundamental source of competitive advantage. These reductions in cost can only be achieved through networking. Hence new knowledge creation and knowledge management have become fundamental sources of gaining competitive advantages and corporate success.

The entire pharmaceutical industry has thus since the early 1980s, largely due to increasing knowledge intensity and complexity, moved from a more or less fully integrated industry with large corporations dominating the field towards becoming a networked industry where large corporations and small start-up companies collaborate for mutual success. The universities have always had a strong knowledge-creating role in the industry, which has only been further enforced during the past 2 decades. In Figure 6 we have shown the types of firms and units participating in a biopharmaceutical network, collaborating within and across firm and industry boundaries and

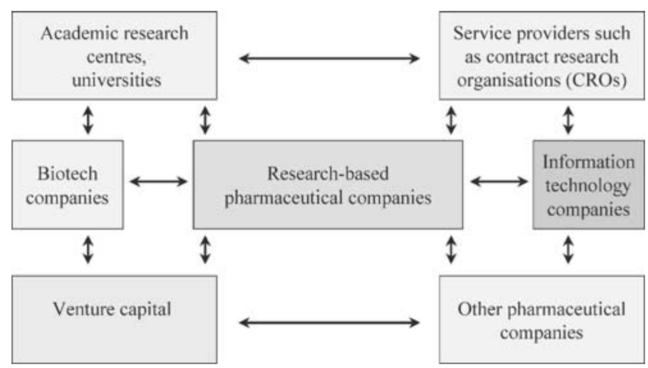

Figure 6 Biopharmaceutical knowledge network.

each forming separate knowledge contexts. Thus, as each box forms a *Ba,* there are multiple ontological dimensions within each box or *Ba* and together these form a networked biopharmaceutical *Ba*, which in its simplest form can be seen as a community, but which for the purpose of new knowledge creation should become a *Ba*.

Example 2

This example concerns the feasibility of the formation of a pre-clinical service network in Finland. There were 14 identified ‘players’, two of which were companies and the other units were university-based research groups. The study was initiated by the National Technology Agency, who saw it as a possibility for fragmented groups to become more homogeneous through a network constellation and enable more value-added service offerings. The groups saw this as a possible way of more efficient market access, a way of earning more money. To our minds, shared knowledge creation was the mechanism by which value-adding services would be generated. It was also perceived that these fragmented groups would, through a network, be able to access the international market, which otherwise would be considerably more limited if not impossible. The conclusion was eventually that forming a network with all 14 groups was not feasible, and the reasons pointed to the absence of *Ba* and an understanding of how *Ba* should be generated.

There was no shared common purpose of what exactly this network would set out to do. There were conflicts of interest between the firms, which were operating out of business realities on the one hand and the university-based units on the other. At most we could identify co-mingling (Murray, 2002) and some cooperation between some units and biopharmaceutical companies. The cooperation was in terms of basic research and here it was evident that the units would function as contract research service providers. There were identifiable concerns regarding mutual trust. There were problems with leadership. Above all, we found that many saw the network as attractive, however not for the purpose of shared knowledge creation but in terms of potential financial benefits a network might yield. However, there was no sufficiently visible commitment to what kinds of efforts a network might require in order to generate the sought-for benefits. In fact, implicitly it seemed as if a network was a replacement of management.

Example 3

Our third example concerns the establishment of a research center (RC) in one university in Finland. The RC has been functioning for 1 year. The intention for this RC is to function as a contract research organization on a commercial basis, but it is located within the university administration. Hence there is a clear commercial purpose, but at the same time there is a strong requirement for academic high-quality output. Needless to say, there is a fundamental problem with the *purpose*. Moreover, this unit should form one *Ba* within which various university departments forming their own *Ba* exist and which provide the inputs and the processes by which output is generated. There are serious problems with *multiple leadership*, *interacting levels*, and *independence of members*. The RC has a research director, who has been hired to ensure that the commercial goals are achieved. The leaders, mostly professors, of the various departments are involved as participants in projects and as guarantors for the academic quality of the output, and as it has turned out, as their primary concern. The *links* seem to be severely constrained by individual conflicts. This example shows the problem of creating a network even within the same knowledge context, but it points to the importance of the five elements needed to create *Ba*. Due to the novelty of this center, its 'ways to operate' have not yet been established, that is, developing ways by which the RC will operate according to commercial goals, but at the same time pursue academic goals. It seems evident that very soon a trade-off will have to be made and that this is indeed a strategic decision. And this trade-off seems to be on the individual *Ba* level, where it will be necessary to understand what requirements are primary in the academic *Ba* and what are primary in a commercial *Ba*. Ultimately it appears to show that an organization – in this case a university – may have multiple competencies but very few useful capabilities. It remains to be seen if the RC has the capacity to renew competencies in order to find a strategic fit into another *Ba*.

Conclusions and future research

Traditionally, economic systems have been based on independent firm systems typically found in capital-intensive industries. For the past three decades, networked-based systems have emerged within high-technology and high-growth industries. These horizontal networks of organizations have been able to become very specialized and at the same time expanding their special capabilities through collaboration with other specialists in networks. Typically, these networks are regional R&D. A majority of studies have argued that the proximity allows for repeated interactions that build not only shared identities and trust but also geographically localized knowledge spillovers based on shared knowledge creation, thus acting as *knowledge catalysts*. A study by Audretsch & Stephan (1996) show, on the other hand, that proof of the role of proximity is anything but overwhelming. Characteristic to these R&D networks is that they involve universities, technology, and science-based firms as well as larger corporations collaborating and simultaneously intensifying competitive rivalry. These knowledge networks have been particularly beneficial for small organizations facing the challenge of commercializing technology, but they also appear to speed up the transfer of basic research into firms.

Ultimately shared knowledge creation becomes an issue for an organization's *dynamic capabilities*, that is, capacity to renew competencies for the purpose of finding a strategic fit with changing environment. It requires organizational learning and calls for the existence of an organizational absorptive capacity. Put in Nonaka's terms there is a need for knowledge creation through an SECI spiral, which transcends multiple ontological levels, *Ba*, and it requires development and continuous upgrading of organizational knowledge assets.

We have described Nonaka's framework and then used it for describing network-shared knowledge creation. We have illustrated our discussion with three examples from the biopharmaceutical R&D to show that we have multiple forms of networks, but that the same problems occur in different forms in all three cases. A network needs five basic elements – apart from the people, which it obviously needs first. A shared purpose and links are elementary for enabling cooperation, whereas multiple leaders and independence of members allow the people to act within the network and also outside the network. Finally, interactive levels tie the network together.

There are several interesting avenues of future research opening up. One deals with identifying the true magnitude of new knowledge creation. Several studies have been conducted – mostly in the US – in using bibliometric data and patents as output measures. First, it would be interesting to replicate some of those studies in non-US settings, especially since the patent laws in Finland are different. The patent stays with the inventor, not the university, which means that there is a clear disincentive. However, the studies that have used bibliometric data and patents as output measures contain one serious problem. Patents are *not* output measures, they are input measures, especially if R&D productivity is measured, which again is an indicator of new knowledge creation. On the other hand, patents are outputs with respect to new knowledge creation in terms of basic research, but not from the point of new knowledge creation in terms of what can be commercialized. From a commercialization point of view, patents are inputs. Hence, there is a real need to develop more reliable output measures. Systematic and detailed studies of the R&D pipeline would be much more reliable and these data are available. State-of-the-art financial measures are not applicable given the nature of the business (most companies are not profitable and have no turnover, but are loaded with debts). Second, it would be necessary to include qualitative measures of output as well.

Another interesting area of research would be to study the nature of the networks biopharmaceutical companies operate in. In other words, what kinds of *Ba* are they active in, what kinds of knowledge assets are available, which are the independent members, and which are multiple leaders? Finally, in relation to this it would be necessary to study the nature of the links and their impact on shared knowledge creation. For example, what kinds of information systems are used, to what extent, and what is their impact on the nature of collaboration and ultimately the outcome, and indeed the Intellectual Property laws in general.

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About the authors

Malin Brännback, D.Sc. (Econ. & Bus.Adm.), B.Sc. (Pharm.), Professor in Marketing at Turku School of Economics and Business Administration (TSEBA), Finland. She heads the Innomarket research unit, which is focused on market analysis and research on venture development in high-technology industries, specifically in life sciences. Her current research interests are in innovations management, knowledge management, and strategic market management in high-technology industries.