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COLLABORATIONS AND MANAGEMENT OF AND THROUGH NETWORKS

LITERATURE REVIEW

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SUCCESS: Actors and Organization.

The present literature review is prepared as a part of the SUCCESS[1] project; a pilot project launched by the EIT with the purpose of benchmarking past and ongoing collaborations in the knowledge triangle of research, education and innovation in the European Union. The empirical focus is the field of climate and energy research. This field is in specific need of more efficient collaborative models that can facilitate knowledge sharing and thereby ease the development of new sustainable energy technologies. Still, the present literature review draws on research done on collaboration in various fields; collaborating on innovation, research or educational aims is imperative to many actors struggling to keep pace in a complex, uncertain and dynamic environment. Thus vital empirical experiences and essential theoretical knowledge about the organizational and managerial dimensions of collaboration may be found in various fields of research, inside as well as outside the field of climate and energy research.

The literature review consists of 7 different parts plus a note on benchmarking[2]; each with its own theme. First, in the present section, a brief overview of the central issues is provided along with a presentation of the actors of the field. Second [2] the drivers and forms of collaborations are reviewed. This part puts a specific focus on collaborations in the field of research and development and on university-industry relations. Next, innovation networks are studied [3] with a special focus on the concepts of the field and empirical studies done on innovations networks. Following in [4], knowledge transfer, sustainable universities and regional models of innovations are reviewed. In the next part [5] the issues of networking is examined with a specific focus on managerial issues and challenges. This leads to a review of the managing the unity/diversity tension of network activities in [6], which is provided in the seventh part. Finally, in the last part [7], a comparative analysis of the US and Japanese innovations systems is provided. Taken together this literature review aims at providing an examination of the state-of-the-art of research on collaboration and networking between actors from research, education and innovation.

[1] SUCCESS is the abbreviation for Searching Unprecedented Cooperation on Climate and Energy research to ensure Sustainability

[2] References and quotes from the introduction refers to the appendix and are all presented in squared braces **[ ]** with the relevant number and if necessary, followed by page number after **:**. All other references are to be located in the different texts in the appendix.

The energy sector is, as other modern technology sectors, characterized by the presence of a large number of actors from various disciplinary sub-fields. Even though some of these technologies are mature and the actors and organizations are both experienced and powerful, a large number of them are still in their formative stage, struggling to improve the technologies and to finance and manage the projects. The technologies of the field span a range of various disciplines. In the one end of the spectrum we find areas such as wind energy, wave energy, hydrogen energy, and sun cells (photovoltaic cells), which represent upcoming and rapidly growing technologies, just as areas such as bio fuel cell and bio gas in general. But also more mature technologies are to be taken account of in the field of energy and climate research; actors that deal with safe and clean development of already known technologies such as nuclear fuel and coal. These actors argue to be sustainable alternatives to existing energy sources because they do not emit greenhouse gases. Still, these energy forms vary a lot in respect to commercialization potential, safety issues and the consumption of other resource, such as water, in the development and production process. Additionally, the time period in which they might gain success vary tremendously; whereas wind energy is already seen as an relevant alternative to traditional power production, the production of clean coal is still only a prospective successor.

In addition to these technological players a number of other actors take part in the field of climate and energy research. They aim to develop new ways of limiting the CO^2 emission from various energy forms or deal with the required adaption of the distribution net to the new energy forms. Others work with the challenges of handling and storing the new forms of energy or they focus on adjusting machineries and motors. These elements of research and development are all vital to the field as new energy forms and production modes may not fit well with the existing distribution-net or options of storage. As shown the number of actors is large and they span many subfields and research areas. Thus, even though the field of climate and energy research has a common and very comprehensible recon d'être; that is, to handle the grave challenges of climate change, it is a field of great diversity.

To be innovative in this field a range of technologies must be brought together and numerous actors with different disciplinary background need to work in a joint manner. To illustrate this diverse character of the process of innovation scholars have suggested that innovations are largely systemic in nature. The basic

idea is that firms rarely innovate alone, rather the innovation process rely heavily on external sources of knowledge. The systemic perspective has been applied to many different fields and shows how innovation activities are closely related to activities in the wider framework in which it is embedded [4:9]. The systemic nature has been delineated on the basis of technological, industrial or sectorial characteristics and, as outlined by Markhorst [4], this has lead to the formation of constructs such as Regional Innovation Systems (Cooke *et al,* 1997; Asheim and Isaksen, 2002) or National Systems of Innovation (Freeman 1987; Lundvall, 1992; Nelson, 1993). Scholars working with these perspectives do define the systems in different ways and do include various issues in their analysis, but in general the systemic perspective denotes a framework for analysing the organizations and institutions as well as the relations between them. The Systems of Innovation perspectives encompass the determinants of the innovation process and it describes the important factors that influence the development, diffusion and use of innovations. These influential factors may be economic, social, political, organizational, or institutional in character (Edquist, 2003). As pointed to by Markhorst [4] the systemic perspective is often used as a framework that generates the empirical foundation for innovation policymaking (Doloreux and Parto, 2005). The innovation system perspective has gained ground due to a number of strengths such as its ability to highlight the importance of knowledge and learning in the innovation process, to underline the holistic and interdisciplinary character of innovation and to highlight interdependence and non-linearity of the innovation process (see Edquist, 2003:184 for an overview).

This put focus on the transcendent nature of innovations. Scholars studying the modularity of product design (e.g. Sanchez and Mahoney, 2003) claim that modularity is not only a characteristic of product design, but is also a characteristic of the organizations designing and producing them. This argument about modularity in production transferring to the organization as well has been questioned by scholars pointing to the fact that sometimes technological modularity even requires a more tight and integrated management. Chesbrough and Kusunoki (2001) question the linear relationship between product modularity and organizational modularity; that is an organizational form where actors are linked together in loosely coupled networks [5] often denoted as virtual organizations (Teece and Chesbrough 1996). These organizations are more flexible and responsive to changes in the marketplace, but they might not always

be the best option for organizing complex technological processes. Chesbrough and Kusunoki (2001) argue that because 'technology change causes the environment to change so frequently, technology-intensive settings provide researchers with abundant opportunities to observe the effects of change over a relatively short period of time. Technology provides and indeed requires, explicitly dynamic approaches to managing knowledge' (Chesbrough and Kusonoki 2001: 202). Still, not all organizations react rapidly to technological changes and end up managing the knowledge processes in ways that match previous technological development stages and not the present. This is what Chesbrough and Kusonoki denote the 'modularity trap'; that is, a situation where virtual organizations lack the expertise of an integrated system that can respond to new technologies that rearrange the boundaries of existing technologies. Their single-minded focus on specific technologies becomes a significant liability.

The bottom line is that sometimes the virtual organization that arrange activities in interaction between firms or even in the market place are ended more 'virtuous' (Teece and Chesbrough, 1996) compared to firms that arrange and manage all activities within the firm, but in order to design and decide on the best way of organizing technological research and development activities one must study carefully the developmental stage of the technology and the knowledge that is to be managed.

Models of collaboration

As shown by Moreira Ottahi and Bou [3] the organizational form chosen is in fact often formed by the need for knowledge that may lie outside the core competencies of the firm. This search for knowledge may result in the formation of inter-organizational networks. As they state: 'Interorganizational networks, through a manifold of ties and relations ships, may lead to various benefits regarding information diffusion, resource sharing, access to specialized assets and interorganizational learning' [3:11]. These inter organizational networks link actors from many different fields. This is also the case in the present project, the SUCCESS project. In the collaborations studied actors from numerous organizations such as university departments, public research units, private firms, government institutions, funding organizations, or technological transfer organizations are included. This variety can be illustrated by different models

such as the Triple helix model developed in 1994 by Etzkowitz and Leydesdorff with the intention of crossing the boundaries between institutional analysis of knowledge infrastructure and evolutionary analysis of the knowledge base of an economy [3:11]. Its core question was: *"how can co-evolution between the layers of institutional arrangements and evolutionary functions be conceptualised in relation to the division of innovative labour among both institutions and functions?"* (Leydesdorff and Meyer, 2006, p.1441). This heuristic model of university – industry – government relations are considered as evolving networks, whose interactions change the relevant environments for R&D (Leydesdorff, 2000; Leydesdorff and Meyer, 2006).

This model states that the relationship among the three institutional spheres - university, industry and government - is central to innovation in the knowledge-based society (Etzkowitz and Mello, 2004). It refers to a spiral model of innovation that captures multiple reciprocal relationships among institutional settings (public, private and academic) at different stages in the capitalization of knowledge. The triple helix denotes the university-industry-government relationship as one of relatively equal, yet interdependent, institutional spheres which overlap and take the role of the other. These three institutional spheres are increasingly working together, with a spiral pattern of linkages emerging at various stages of the innovation process, to form the so-called 'triple helix'.

Another model [3:13,14] is used to determine innovation networks by how its three components are influenced by the type of **proximity** among the actors. According to Graf (2006), innovation networks are formed by three core elements: a scientific pole (formed by universities and independent research centres), technical pole (composed by technical laboratories in organisations, cooperative research centres and pilot plants) and market pole (formed by organisations, professionals and practitioners). These poles, together with intermediaries (which are the resources - such as electronic systems, telephones, journals, research grant, etc. - that facilitates the interactions), are embedded in a framework of institutions formed by the government or by the system of actors themselves. The functioning of these innovative systems is based on information and knowledge exchange among actors. The success of it depends on the specific type of proximity among actors. Proximity is not exclusively related to geographical closeness. There are five types of proximity (Graf, 2006):

- **Cognitive proximity:** is related to the fact that organisations usually search for new knowledge in close proximity to their existing knowledge-base.
- **Organisational proximity:** actors are closer if they belong to the same relational framework or share common knowledge and capacities.
- **Social proximity:** refers to social relations among actors when trust is involved.
- **Institutional proximity:** is associated with the institutional framework.
- **Geographical proximity:** refers to the spatial distance between economic actors.

Due to the variety in actors as well as technological background the collaborations studied in the SUCCESS project are very heterogeneous in nature. This heterogeneity makes studies of how the collaborations are managed and organised highly interesting and the experiences form these collaborative projects constitutes a solid basis for analysing how different project models may best be organized and managed. To understand why projects are organized the way they are we need to study why firms collaborate.

Why collaborate?

Collaboration in R&D is discussed in the literature on strategy and innovation as a key strategy for knowledge based firms to secure a competitive advantage by controlling complementary knowledge flows into the innovation process. In one of the background paper by Knudsen [2] it is formulated as follows: “Research collaboration has a number of advantages in relation to this end. The higher speed of collaborative knowledge production, the opportunity to match complementary knowledge and an increased commercialization potential are just a few beneficial characteristics of university-.industry collaboration. However, the utilization of these potential benefits is contingent on a current development of the governance models and internal structures of the integrated networks that connect universities and industry partners.” [2:3]

For the SUCCESS pilot study, R&D collaboration is the key driver for collaborating in different local, regional and international networks. The collaborations differ considerable in size, members and time span, but all

combines different types of research organizations, public research organizations, private firms and universities in researching toward front-end knowledge on sustainable energy projects. This is primarily done in order to enhance the performance in the knowledge triangle of innovation, education and research.

Recently the research on collaboration in R&D has moved on beyond the traditional focus on private companies as a consequence of the fact, that key players in R&D today interact with public research institutions and universities as well as private firms. However, as most of the empirical and theoretical studies of research collaboration by tradition are related to collaboration between private firms, we will start by listing up the key findings from this research.

Motives for collaboration:

The rise in the interest in collaboration in the field of R&D is first of all a result of the growth in the knowledge-based economy and intense global competition. These general drivers behind motivation to collaborate [2, 3, 5] need to be specified in order to produce useable knowledge on how and why collaboration in R&D occur. A very visible hindrance in private companies – but one also to some degree in operation in relation to public research organizations, is the organizational boundaries. The very fact that opening the boundaries of the R&D unit in a firm to others, to outsiders, in order to collaborate contradict the very often high level security surrounding the key knowledge of the firm as well as policies to secure IPR's. So in relation to a traditional understanding of innovation, collaboration has to be valued in relation to the overall strategy of the firm, meaning that collaboration normally has to be about definable or codified types of knowledge.

This was more or less the basic logic of inter-firm collaboration in innovation until recently when this view was challenged from the perspective of **open innovation** [2:11]. Open innovation centres around the idea of willingness by the firm to use a wide range of resources, external as well as internal in the process of innovation. The paradigm of open innovation has become very important in order to understand the recent growth in R&D collaboration, between firms as well as between firms and public research organizations and universities. Open innovation makes it much easier to set up systems of collaboration, because the approach is no longer exclusively on exchange of well-defined or codified units of knowledge but the opposite, on expectations of future new knowledge and

knowledge resources. Open innovation implies a much more positive attitude toward collaborating on integrated knowledge production and exchange over a longer time span and existing boundaries has to permit the new level of integration in the knowledge production. Drivers in the collaboration will be the acknowledgment by partners of new demands to R&D if the firms or the universities will keep their competitive advantages. “As knowledge creation and innovation are becoming increasingly multidisciplinary, an amount and combination of scientific skills and intellectual capabilities that normally exceed the capabilities of a single firm is often needed to generate research breakthroughs” [2:15]

Barriers to collaboration:

The increasing demand for collaboration in R&D makes it necessary to take a closer look into the different roles of knowledge exchange or transfer in the collaboration. The transfer can be knowledge in the role of complementary assets or as sharing in novel ways [4:9], demanding knowledge mobility as well as stability in the collaboration network.

A barrier very often mentioned in collaborations is the interest by especially private firms to protect their core knowledge from outsiders. The use of legal constructions such as contracts can solve some of the problem, but even the most specified and detailed contract will never be able to cover all dimensions in the search of new knowledge in a field. Related to this barrier a more general one is how strategic routines in the organization is geared toward the kind of dynamic changes and adoptions necessary to absorb, create and exchange new knowledge in a collaboration. These capabilities have individual as well as organizational dimensions. The concept of ‘absorptive capacity’ by Cohen and Levinthal (1990) discuss explicit these barriers in the organization. Organizations without absorptive capacity will have a reduced ability to recognize, absorb and assimilate new (outside) knowledge. Private firms and public organizations may differ in how they organize their ability to absorb new knowledge. However, a common challenge is the question of how to formulate a strategy toward openness to outside collaboration and accordingly, organize internally to support the strategy. From network theory, we learn [5] that the ability of an organization to learn and absorb knowledge depends very much on how the boundaries of the organization function and especially what specific kind of network relation is at stake. We can

distinguish between a network based on weak ties (open to the surrounding) or strong ties (closed to the outside) (Granovetter 1973, [5:10]). Furthermore, we know that the necessary trust in network collaboration is a product of continuity and experience of the relationship.

An important distinction when we want to understand the operation of different network based collaborations is between exploitation and exploration in knowledge creation (March 1991). In collaborations between different organizational units, companies and universities, the balance between interests in exploiting existing knowledge or explore new knowledge can take many forms and become itself a barrier to the collaboration. The latent conflict between short run exploitation and long run concerns to explore can take the form of a conflict between visible gains to individual knowledge at the prize of the growth of collective knowledge. Often these conflicts or dilemmas will be a hindrance to a full-scale involvement in collaborating with partners. Network collaborations with weak ties and partners with different levels of knowledge will tend to exploit the knowledge resources in the collaboration while collaborations characterised by strong ties tend to be oriented toward exploration and the exchange of complementary knowledge.

It has often been assumed that a basic motive for collaboration in R&D is the interest of participating organizations to learn from others, to exploit the knowledge from partners through organizational learning processes. A recent study by Grant and Baden-Fuller (2004) has questioned this motivation for collaborating by demonstrating, that most often collaborative alliances are based on a strategy to access knowledge from other partners rather than to acquire and incorporate in own organization processes of learning. Following this argument, collaboration motivation takes the form of a strategy of search for complementary knowledge by partners.

Managing collaboration

It is a necessity for a successful collaboration that the boundaries of the participating organizations can be managed in order to allow in and outflow of knowledge exchange. Here is the role of the gatekeeper extremely important, as the gatekeeper in relation to the internal structure of the organization perform the role of transforming the organizational structures to open up boundaries. In the relationship to other partners in the collaboration, the brokers (Burt, 2005), [5:18]

in the network has the role of combining the different notes in the network and thereby help establish and maintain the relations between the partners, making bridges.

It is possible to list some major mechanisms that play a central role in the success of collaborating between different organizations [2:25]. First are the functions, which are how the organization manages the tasks necessary to the transfer knowledge in the collaboration. Secondly, we have the tools needed to manage the organization internally in order to help the day-to-day practice of collaborating. Thirdly, the control and management processes in the organization need to be focused on alliance management and last, support from external experts as lawyers have to be in place. Even if these conditions are taken into account there are a number of R&D managerial issues to be aware of, first to motivate the employees who will participate to share knowledge even if it against their convictions by communication the collaboration strategy, and secondly to support teamwork and autonomously work organization and a spirit of innovation.

Networks as organisational forms

Networks as organisational forms are opening the boundaries of organisations. Networking is a type of organising across organisations, whether there are joint organisations as special units in a collaboration relation or not. Even though most network literature stress the openness of networks, as there are always new open access to more organisations or people, some of the literature on strategic alliances (Grant & Baden-Fuller 2004) and on "whole networks" (Provant et al. 2007) prefer to focus on partnerships, coalitions, cooperative arrangement as a closed but interorganisational form.

Networks consist of relationships between units, and some relations may be transitive and refer to new units with other types of knowledge [5]. In this process there is a focus on: what is the purpose, but also how is this managed and related to the usual organisation structure? The focus is shifting from the active firm in the passive environment, to an active interacting environment, which are also networking [5]. The increasing interest in networks is tied to the necessity for all firms and universities to create external relations and collaborations for getting access to competence, as in the complex knowledge society innovative firms do not have all knowledge and R&D capability in-house. They have to look for other

resources outside, for overlap with other innovation projects, and for new knowledge to include in the further development [3, 5].

There are two dimensions of networking: The first dimension of access/ complementarity/ openness embrace a number of characteristics. First, it involves strategic access to resources outside the subculture and the strong ties. Second, it yields access to people and resources with a different background and other types of resources – as diversity management requires. Third, it involves surpassing the boundaries to create open doors and to keep options open, in which new opportunities and entrepreneurship are created. This is essential for getting access to complementarity, and creating bridges to other types of organisations, recruitment and researchers with other profiles.

The second dimension of control/ constraints/ cohesion/ closing include a number of other characteristics and much more like a collaboration or strategic alliance [4,6] Control is a social form of exchange based on cohesion of nodes and a joint interest to use the personal relations as a social form of control. The cohesion and glue of the network in collaborations create constraints in terms of mutual obligations, and moving external relations to internal. In a strictly economic perspective, the network can represent a constraint for options. On the other hand it is also 'closing of commitments' and choice of collaboration partners, which stops the search procedure. This part of the network theory is related to the partnerships and collaboration, but often the purpose is tied to the access to new knowledge and resources.

Collaborations are formed as inter-organisational relations, which may resemble cross-department projects in matrix organisations. This is easy to perceive as accessing new knowledge outside, but the collaboration over time, where knowledge is exchanged many times, and involving collaboration between researchers, also need management and control. The network organisation is a phenomenon, where the contacts of the individual (or firms as actors) are linked from one context to the other, and thus getting access via others to knowledge from environments, where there is no direct contact. This form of getting access, is either called the "strength of weak ties" ([5], Granovetter 1973), or communication across structural holes, i.e. getting access to environments that are not known before, to open new contacts as to avoid getting only predictable or redundant information from the usual collaborators.

Innovation literature is stressing the need for diversity for radical innovation. The access to new knowledge outside you specialisation, as a supplement to specialisation [2,3]. At the same time, most research on learning and communication stresses the problems of communicating complex knowledge with people outside your own community of practice [2.5], as the nearness and closeness makes communication about not only the knowledge but also of the aspects 'not yet known' much easier, if people have been working together before. We have some paradoxes here, as we want complementarity but with friends [6].

The networking beyond the isomorphous tight networks is especially in relation to innovation and research seen as imperative for getting access to new research and researchers while they are doing new research, as the document research in databases and articles are based on research a number of years ago. The idea of creating collaborations for the benefit of both organisation, and based on complementarities in a division of labour is fundamental in research projects, but very difficult to handle in practice. Trust and confidence in network relations seem to be much easier in homogeneous groups, and here the need is to go beyond these groups also to diversity in competence, which is not necessarily beneficial for trust building. Some of the paradoxes are therefore, that whereas most of the networking literature is focusing on the strategic need for weak ties, or cross structural holes relations, the researchers indicate the need for trust and experience with other researchers. They emphasise the need for tight relations, but based on diversity on professional profiles for complementary knowledge [5.6].

We know that matrix organisations, with many cross departmental projects have difficulties in defining clear management structures. In cross-organisational collaborations this is worse, as there are several managers at the same level involved. Power is a part of the organising, as the hierarchical power of managers in each organisation is challenged. These collaborations or strategic alliances have to define some kind of management structure to deal with different interests. This may be part of a joint venture, i.e. a form, where the collaboration result in building a new joint organisation with a manager, or it may be regulations and rules to settle the loosely coupled collaboration and defined steering committee or manager [3,4,5]. The focus is on obtaining control and power, but also to keep all the actors active even when they are formally out of control of the manager. Management rules have to be developed, especially if the scope of the collaboration is increasing beyond a few partners who work on the same and

know each other. The up scaling is complicated, as trust based informal management is challenged, and some kind of professional management organisation has to be accepted in the inter-organisational space.

The need for trust and confidence in collaborative partners especially on issues of core competence and innovation is evident. But we have very litlle evidence on how confidence is built up. We have evidence that collaboration is not a given for everyone, but something you have to learn the skills [Knudsen, 2]. But this also means that the network mechanisms are used to scan, get recommmedations, and assessing collaborating partners in open networks. Serious collaboration where engaged interdependency is developed are based on earlier experiences, on who could contribute and were working well on the collaborative skills as well.

Managerial Dilemmas:

When studying the issue of management in large and diverse collaborations it becomes clear that there is not one single managerial model that fits all. Still a number of factors determine which managerial model that support a given project the best.

A core finding from the literature reviews of this project is that the decisions and action taken on the management issues of collaboration is often based on a number of dilemmas. As pointed to by Saz-Carranza the governance of inter-organizational networks is an inherently difficult task [6]. First of all there is the unity/diversity tension. This relates to the fact that in fragmented settings, such as networks, it is difficult to generate common institutions and maintain the desired diversity at the same time. Saz-Carraza [6] shows that in situations where ‘two (or more) organizations depend on the other’s resources they will take advantage of their complementarity only if they are capable of using in concert the resources that they bring together. In other words, diversity provides the resources and unity ensures the capacity to use them’. This represents the core of the paradox of unity and diversity in a network context. The degree of unity and diversity of course, will vary within a continuum of circumstances, but there must always be a minimum of diversity resulting from the autonomy of the organizations and a minimum of unity resulting from adherence to the network.

This leads to another widespread dilemma; that is, the dilemma of autonomy and control in the research setting. It reflects the researchers need for autonomy in the work processes and the network manager's pursuit of control over the work processes. This managerial dilemma pertinent to internal R&D management becomes even more outspoken when research is done in collaboration across firm boundaries.

Research is a process of creativity and researchers are most often motivated by a high degree of autonomy and freedom of choice in the work processes. This does often conflict with the corporate wish for managerial control of the R&D activities. In this context control can be defined as the exercise of authority through a hierarchical structure that limits or channels behavior (Weber, 1946). In inter-organizational R&D we witness both an autonomy-control tension at the functional level (researchers ask for autonomy, managers need control) and the inter-firm level (one partner demands autonomy, another partner ask for insights and control, and vice versa).

Autonomy can be granted in different ways and by different managerial behavior. The first mode is a non-directive leadership style that will lead to the empowering of employees by giving them responsibility and increasing the intrinsic rewards of the task (Trevelyan, 2001). Releasing employees from managerial control and asking them to participate in decision making is by no doubt a good way of granting autonomy. A second way of leaving the employees with a high degree of autonomy is by refraining to involve in the work processes. This behavior may give the employee a high degree on autonomy, but at the same time, it may also lead to situations where employees are isolated and left without support or guidance (Trevelyan, 2001). This situation is not beneficial and the need for autonomy must be balanced. Even though there is—by definition—no clear solutions to organizational dilemmas, the autonomy-control dilemma may be easier understood and thus handled if we separate what we could call the 'strategic autonomy', namely the freedom to set one's own research agenda, from the 'operational autonomy' (Bailyn, 1985). Operational autonomy is the freedom that a research has, once a problem has been set, to attack it by means determined by himself within the limits of given resource constraints. This is important to include in the analyses done in the present empirical setting of large-scale collaborations. In a collaborative project, there might be limits to the level of strategic autonomy as the overall research agenda is set jointly or by the manager

of the collaboration, still, it is vital to ensure that operational autonomy is not damaged.

Saz-Carranza [6] proposes that identifying the dimensions along which the coordinating units unite the network and support diversity is a central task in the governance of networks, independently of what will be the optimum balance between unity and diversity for each network type. Even the least diverse of networks must cope with the diversity introduced by uniting autonomous entities with diverse organizational characteristics, and must unite members along some dimension. Achieving the successful mix, what ever it looks like, must be the aim of the governance of the whole network.

Another central dilemma to the kind of collaborative projects we deal with in this study relates to the finding the right level of openness between partners in the collaborative process. It is widely acknowledged that innovation networks help a partner to gain new knowledge at a higher speed and thus be more innovative. Yet, scholars as for example Laursen and Salter (2006) has shown that even though openness in the R&D process does enhance innovation it does so at an decreasing rate, meaning that beyond some limit increased search for knowledge through external sources will become negative. It seems that the tendency to ask for more openness in some phases of the R&D process or at specific times is faced with a quest for more closeness or protection at other times. This can be framed as the knowledge-sharing/knowledge-expropriation dilemma. What is referred to is a tension occurring when a focal partner firm has to adopt a variety of practices to facilitate the transfer of knowledge in the collaborative project, but in doing so may increase the likelihood that knowledge which is beyond the scope of the collaboration, and difficult to legally protect, is expropriated by the other partner (Heiman and Nickerson, 2004:401). Thus a need for protection is engendered. This situation resembles the ‘paradox of openness’ describing the concurring needs of many knowledge intensive firms to be both open to many external knowledge sources and to put up the shutters to protect their knowledge in order to appropriate the value of it (Laursen and Salter, 2006). These are seemingly contradictory actions, but none the less a prevalent situation in many collaborating organizations.

To handle this dilemma of being open *and* protective at the same time, managers need to adopt specific knowledge management practices, designed to handle the need for ‘openness’ or open channels between the partners in a very

deliberate way. For example, managers must be clear on whether to design communication channels that are high in bandwidth or not. Communication bandwidth refers to the degree of intensity in the communication. By way of example, high bandwidth means that interaction between a focal firm and its partner need to facilitate a high degree of rich context, high effect and high transparency in the communication. This can be attained by providing opportunities for physical demonstrations, immediate redundancy and rephrasing the information in own context, high clarity in the information, rich contextual clues, high interactivity and clear emphasis (Heiman and Nickerson, 2002). High bandwidth is needed if knowledge is highly tacit and problem solving is complex, whereas low bandwidth is sufficient if knowledge is easily codified. This finding is closely related to the work of social network scholars [5], who have revealed that complex and highly codified knowledge is hard to transfer (Szulanski, 2000) and that this kind of knowledge need to be frequently compared to the 'template' from which is replicated (Nelson and Winter, 1982) in order to be successfully received. This means that close interaction is needed between the partners.

That limits to openness do exist is apparent; a given organization would not have any knowledge to build on in the future if all channels were constantly open. What is important in the context of this somewhat dilemmatic situation is to remember that higher degree of openness may be beneficial in more that one way. An open attitude towards external knowledge sources may as well promote a better employment of the internal resources of the organization for example by facilitating a higher degree of internal knowledge sharing between the researchers of the sub group, e.g. university department. A by-product of collaborative activities may thus be that employees of the subunits of the focal firm are being better acquainted and therefore becomes able to exchange knowledge to a higher degree.

As referred to by Saz-Carranza [6] it is important to distinguish between management *of* and management *in* networks. By focusing on these to levels and connecting the responsibilities the right managerial level (either in or of the network), many managerial challenges may be easier handled, by separating the managerial decisions taken on a day to day basis from the overall design decisions. As stated by Knudsen [2], "The R&D manager must delineate ways to manage R&D more effectively by empowering teams to work autonomously, aid the formation of collaborative networks and gather experience and expertise on

collaboration to help further collaborative processes… One of the core tasks of the R&D manager is to stimulate a climate of creativity and intrapreneurship, in which highly motivated and self managed employees work towards unambiguous goals. This is, however, not an easy task". The contributions following in this report aim to illuminate both the tensions and the solutions in the field of collaboration in the knowledge triangle of innovation, education and research.