

Rutten, Roel; Dessy, Irawati

Conference Paper

KNOWLEDGE CREATION IN TEMPORARY REGIONAL NETWORKS

50th Congress of the European Regional Science Association: "Sustainable Regional Growth and Development in the Creative Knowledge Economy", 19-23 August 2010, Jönköping, Sweden

Provided in Cooperation with:

European Regional Science Association (ERSA)

Suggested Citation: Rutten, Roel; Dessy, Irawati (2010) : KNOWLEDGE CREATION IN TEMPORARY REGIONAL NETWORKS, 50th Congress of the European Regional Science Association: "Sustainable Regional Growth and Development in the Creative Knowledge Economy", 19-23 August 2010, Jönköping, Sweden, European Regional Science Association (ERSA), Louvain-la-Neuve

This Version is available at:

<https://hdl.handle.net/10419/118896>

Standard-Nutzungsbedingungen:

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

Terms of use:

Documents in EconStor may be saved and copied for your personal and scholarly purposes.

You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.

If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.

KNOWLEDGE CREATION IN REGIONAL INNOVATION NETWORKS¹

Dessy Irawati^a and Roel Rutten^b

- a) Newcastle University Business School, CITYWALL, 1st floor – D149, Citygate, St James Boulevard, Newcastle upon Tyne, NE1 4JH United Kingdom, d.irawati@newcastle.ac.uk
- b) Tilburg University, Department of Organization Studies, PO Box 90153, 5000 LE Tilburg, The Netherlands, r.p.j.h.rutten@uvt.nl

Abstract

This paper studies the relation between the organizational characteristics of innovation networks and their knowledge creation outcomes. The paper develops theoretical patterns on the causal mechanism linking these characteristics to knowledge creation and matches them to empirical patterns obtained from twelve regional innovation networks. The findings suggest that a combination of formal and informal organizational characteristics is most conducive to knowledge creation. The findings further suggest that research on knowledge creation in networks should better distinguish between the characteristics of the inter-firm network and the interactions between individuals within the network, who do the actual knowledge creation.

Keywords

Knowledge creation; innovation; organization; networks; pattern matching

JEL classification

D83 L29 L60 O31 O32

Introduction

Organizational knowledge creation is a process of interactive learning between individuals within an organizational context (Amin and Cohendet 2004, Grant 1996, Nonaka and von Krogh 2009). The literature in this field strongly suggests that organizational characteristics have a powerful influence on this process, something that was first explained by Burns and Stalker (1961). They found evidence that ‘organic’ organizations are more conducive to organizational knowledge creation than ‘mechanical’ organizations. Organizational structures that facilitate interactive learning are found to be characterized by shallow hierarchy and decentralized decision-making (Johannessen et al. 1997, Rutten 2003), a combination of formal and informal control (Amin and Cohendet 2004), flexibility and requisite variety (Nonaka and Takeuchi 1994) and shared norms and values between organization members (Amin and Cohendet 2004, Nonaka and Takeuchi 1994). Research into knowledge creation in inter-organizational networks has found that organizational characteristics of these networks should conform to similar principles in order to facilitate learning (Uzzi 1997, Owen-Smith and Powel 2004, Powel, 1998).

¹ The data for this research were collected with the support of STIMULUS, the Program Management of the Eindhoven region Objective 2-program.

This paper contributes to the literature on organizational knowledge creation by empirically examining the relation between the organizational characteristics of regional innovation networks and the knowledge creation outcomes produced by these networks. Based on secondary data, we conducted a qualitative analysis (pattern matching) of twelve regional innovation networks that enabled us to analyze the causal mechanism through which organizational characteristics affect knowledge creation. These twelve networks were created as part of a regional innovation policy effort to conduct product innovation and are composed of mainly manufacturing SMEs from the Dutch high-tech region of Eindhoven. Earlier research on these networks showed that they were successful in furthering innovation in the Eindhoven region (Rutten and Oerlemans 2009). The networks, in fact, were inter-firm innovation projects. The individuals involved formed small inter-firm teams of experts. Though the size of a team could vary over time, it would usually count five to ten members. This sort of innovation networks has become a common organizational form for complex projects such as product development (Bakker 2010, Grabher 2004). In this paper, the concept of networks refers to such small inter-firm teams of experts who work on a common innovation project on a temporary basis.

The literature argues that organizational knowledge creation is a creative process between individuals that requires a high level of social interaction (Nonaka 2009, Tsoukas 2009, Uzzi 1997). Organizational characteristics set the context within which this process takes place. Neither very formal nor very informal organizational contexts are conducive to organizational knowledge creation, as the former may stifle creativity while the latter may render the knowledge creation process unfocused (Amin and Cohendet 2004, Gulati and Puranam 2009, Nohria and Gulati 1997). Therefore, the first causal mechanism that we study in this paper explains the relationship between the level of formalization of the organizational context and the knowledge creation outcomes it yields. The second causal mechanism concerns the effect of network governance on knowledge creation outcomes. Governance mechanisms, such as trust and control, influence the way individuals in networks behave (Dekker 2004, Jones et al. 1997). Shared interests may lead organizations to adopt more informal control mechanisms (Muthusamy and White 2005, Uzzi 1997) but appropriation concerns may have the opposite effect (Dekker 2004, Larson 1992). At this point the literature suggests two things. In the first place that shared interests, and the accompanying informal governance mechanisms, are conducive to inter-organizational knowledge creation (Rutten 2003; Uzzi 1997). Secondly, although informal governance mechanisms, such as trust, are necessary conditions for inter-organizational knowledge creation, formal governance mechanisms, such as contracts, are needed to counter opportunistic behavior (Amin and Cohendet 2004, Klein Woolthuis et al. 2005).

Our sample included twelve innovation regional networks with similar characteristics, except for two variables. Some of the clusters included a ‘dominant partner,’ that had a substantially higher R&D expenditure than the other network members. Furthermore, in some of the networks the partners had worked with one another previously while in other networks they had not. As these conditions may affect the knowledge creation process, we conducted separate analyses for these subgroups. The analyses were conducted through pattern matching, which is a qualitative technique for causal analysis that can be used for small N-studies (Terluin 2001). Our findings suggest that organizational structures with both formal and informal characteristics are most

conducive for communication in networks and result in higher levels of knowledge creation outcomes. This effect was stronger for networks with no dominant partner and in networks where partners have worked with each other previously than in networks with a dominant partner and in networks where partners were new to each other. We further found evidence to suggest that a combination of formal and informal governance mechanisms leads to higher levels of knowledge creation outcomes because it makes network partners more willing to engage in knowledge-sharing behavior. Again, the effect was stronger for networks without a dominant partner compared to networks with a dominant partner. However, whether or not partners had a history of collaboration did not have an effect in our data.

This paper is structured as follows. The next section discusses the relationship between organizational characteristics and organizational knowledge creation and develops two theoretical patterns. The following two sections discuss the data collection and operationalization. The data analysis and the conclusions are discussed in the final two sections.

Organizational characteristics and knowledge creation

Increasingly, organizational knowledge creation is recognized as a social process of communication between individuals (Morgan 2004, Muthusamy and White 2005, Nonaka and von Krogh 2009). This implies that the organizational context in which the knowledge creation takes place has an important role. Early research into the relationship between organizational characteristics and organizational knowledge creation found that flexible organizational structures and bottom up management (organic organizations) are more conducive to organizational knowledge creation than hierarchical organization structures and top-down management (mechanical organizations) (Burns and Stalker 1961). As later research found, this is because tacit knowledge, which is embodied in peoples' minds and embedded in organizational practices and routines (Butler et al. 1998, Muthusamy and White 2005, Nonaka and Takeuchi 1995) is very difficult to exchange in mechanical-like organizational contexts (Amin and Cohendet 2004, Nonaka and Takeuchi 1995, Rutten 2003, Uzzi 1997). However, organizational knowledge creation involves both tacit and codified knowledge and while mechanical contexts are unsuited for the exchange of tacit knowledge, organic contexts are equally unsuited for the exchange of codified knowledge (Amin and Cohendet 2004, Nonaka and von Krogh 2009, Nonaka and Takeuchi 1994). Moreover, in a predominantly organic context, knowledge creation would lack focus and may not contribute to an organization's goals (Nohria and Gulati 1997, Nonaka and Takeuchi 1994). A knowledge creating organization, therefore, has a dual structure that combines elements of both mechanical and organic organization (Amin and Cohendet 2004, Nonaka and Takeuchi 1994). Organizational knowledge creation can only be purposive if it takes places within a context of clearly specified goals and responsibilities, but the process itself must benefit from fuzziness, serendipity and creative chaos (Butler et al. 1998, Grabher 2004, Johannesen et al. 1997, Nonaka and von Krogh 2009, Tsoukas 2009). Under those conditions, organizational knowledge creation is most likely to materialize in outcomes such as new or improved products, skills and competences.

The relationship between organizational characteristics (of networks) and knowledge creation receives generous support in the literature; however, contributions supporting it are often of a theoretical nature (Nonaka and von Krogh 2009). Empirical contributions often focus on the process of knowledge creation itself. This has produced a growing body of qualitative studies into social interaction, which is at the basis of organizational knowledge creation (e.g. Feams et al. 2007, Nonaka and Takeuchi 1994, Tsoukas 2009, Woiceshyn 2000). Although both the conceptualizations of knowledge creation and the empirical approaches chosen to study it vary in this literature, some common elements can be identified. Since knowledge is seen as being socially constructed rather than objective, organizational knowledge creation benefits from social depth of communication, as it allows individuals to develop shared meanings. Social depth of communication follows from usage of 'rich' communication modes, such as face-to-face discussions and group meetings (Morgan 2004). However, also other, less-rich means of communication should be used as they are an efficient means to disseminate codified knowledge (Nonaka and Takeuchi 1994). With regard to the frequency of communication the consensus seems to be that more is better. The present research does not detail the process of knowledge creation; instead, it looks at how organizational characteristics affect this process. That is, it connects organizational characteristics and outcomes of knowledge creation, on the one hand, to the process of knowledge creation, on the other hand. The former are phenomenon on the level of the organization (or network) while the latter is a phenomenon on the level of individuals.

Although knowledge creation in networks essentially adheres to the same organizational principles as knowledge creation in organizations, for the simple fact that networks are a form of organization (Larson, 1992, McFadyen et al. 2009, Powell 1998, Rutten 2003, Uzzi 1997), networks are a special form of organization because they are formed of multiple independent firms (Angel 2002, McFadyen et al. 2009, Powell 1998). With respect to knowledge creation this raises the issues of appropriation. Since knowledge is socially constructed (Morgan 2004) it cannot be owned, which means that all members of the network can benefit from it through intended or unintended spillovers (Breschi and Lissoni 2001). Exchanging firm-specific knowledge to their network partners thus renders firms vulnerable to opportunism and malfeasance (Angel 2002, Dekker 2004, Ozman 2009). Consequently formal and informal safeguards, such as contracts and trust are important mechanisms through which firms attempt to protect themselves against malfeasance and opportunism (Klein Woolthuis et al. 2005, Ozman 2009, Uzzi 1997). The particular configuration of formal and informal safeguards to influence the behavior of network partners constitutes a governance structure and different networks may have different governance structures (Provan and Kenis 2008). In order to research the effect of organizational characteristics on knowledge creation outcomes, we thus have to look at two causal mechanisms. First, a causal mechanism that links the organizational characteristics of a network to the knowledge creation outcomes of the network and, secondly, a causal mechanism that relates the governance structure of a network to its knowledge creation outcomes.

Causal Mechanism I

The level of knowledge creation outcomes, such as new or improved products, skills and competences, of a network is a result of the intensity of the process of knowledge creation between individuals within the network. More frequent communication and usage of rich

communication modes allow individuals to share more knowledge. They will have more and better opportunities to develop shared meanings which, in turn is more likely to materialize in knowledge creation outcomes. However, the communication process in the network must be sustained by a constant inflow of knowledge from the participating organizations. Intensive interaction between individuals in the network may not result into much if they are closed off from the knowledge bases of their respective organizations. The organizational structure that best provides this flow of knowledge is the ‘dual structure.’ Too much emphasis on procedures and a too great a need for the individuals to legitimize their interactions to their respective organizations – that is, a too mechanical structure – will be detrimental to their knowledge creation efforts. For example, they may be forced to communicate more through formal written communication than is healthy for knowledge creation. On the other hand, if there were no formalities to observe – an organic structure – their communication would be in danger of becoming detached from the objectives of their respective organizations. Moreover, unlimited access to the knowledge bases of their respective companies could result in an information overflow which would severely compromise their ability to interpret and analyze this information. The causal mechanism can thus be summarized as follows:

If the network structure under which individuals interact with one another resembles a ‘dual structure’ to a higher degree, then higher levels of access for these individuals to the knowledge bases of the participating firms fuels their knowledge creation process. Subsequently, the higher the intensity of the communication in this knowledge creation process, the more likely it is to materialize into knowledge creation outcomes.

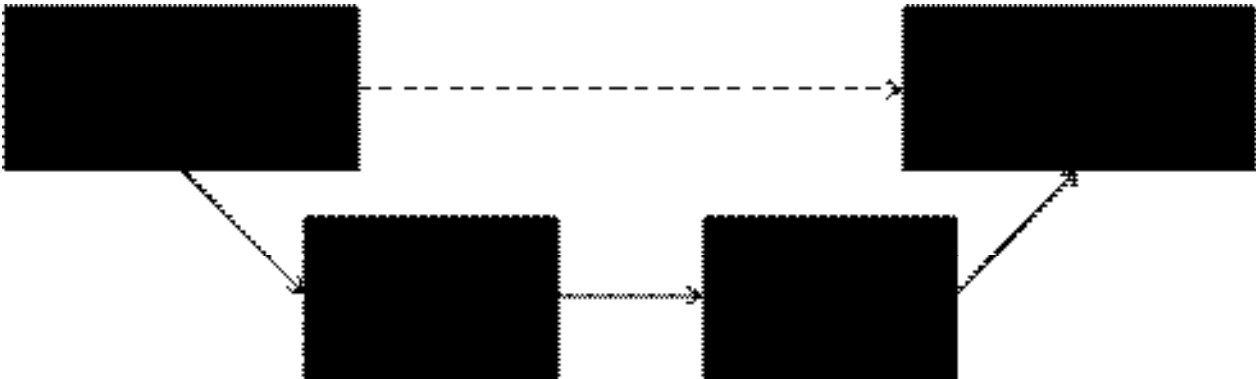


Figure 1: Causal Mechanism I

Causal Mechanism II

In order to effectively conduct complex tasks such as knowledge creation, a network’s governance structure must be neither too strict nor too lenient (Grabher 2004, Klein Woolthuis et al. 2005, Provan and Kenis 2008). Also on this level, too strict a governance structure may stifle creativity while a too lenient governance structure may render knowledge creation unfocused (Rutten 2003). That is, in a situation where both formal contracts and trust safeguard firms against malfeasance, contracts need not be so detailed as to obstruct the intensive communication that is required for knowledge creation (Klein Woolthuis et al. 2005). Also Uzzi (1997) found that trustful relations allow for more ‘fine-grained’ information transfer than those

governed by formal contracts. Additionally, innovation projects often bring with them high levels of interdependence between the companies involved (Grabher 2004). That is, companies are dependent on each other's knowledge to develop the innovation which, in turn, may encourage them to adopt a governance structure that is more conducive to knowledge creation (Larson 1992, Rutten 2003, Powell 1998, Uzzi 1997). In sum, the more a governance structure combines contracts and trust as safeguards against malfeasance and the more network partners are mutually dependent on each other, the more likely it is that this governance structure will contribute to knowledge creation outcomes. This is because it creates a more equal playing field for the individuals in the network who will feel less restrained to engage in a process of knowledge creation. The causal mechanism can thus be explained as follows. The degree in which knowledge creation outcomes on the level of the cluster materialize depends on the degree in which individuals in the cluster are willing to share their knowledge. This willingness increases when the individuals in their day-to-day interactions use both formal and informal control mechanisms to guide their behavior and align their interests (McFadyen et al. 2009, Muthusamy and White 2005). The cluster, which is actually a project team, as we have argued earlier, is separated from the organizations involved. That is, the organizations involved purposefully created the project teams to carry out a specific task (Bakker 2010, Grabher 2004, Hobday 2000, Rutten 2003). In other words, even though conditions with regard to trust and contracts are set on the level of the network (i.e., the cluster), the individuals in the project team may still choose to interact with one another on a formal or informal way. Also on this level we assume that both formal and informal control mechanisms are required for knowledge creation. On this level, an example of informal control is inter-personal trust, while use of formal procedures in communications is an example of formal control. We further argue that the balance of power among the individuals involved as they perceive it, affects their willingness to use both formal and informal control mechanism in their interactions. The more they perceive the balance of power to be equal, the less they will rely on formal control mechanisms and the more room they will leave for informal control mechanisms. Although the actual dependency relations and balance of power is a characteristic of the network, the way that the individuals within the network perceive this balance of power may differ. Consequently, the second causal mechanism can be summarized as follows:

The more the governance structure of a network resembles a 'dual' governance structure, the more the individuals in the network will be inclined to perceive the balance of power among them as equal. This increases the likelihood that they will use both formal and informal control mechanisms in their interactions, which increases their willingness to share knowledge with one another. The more the individuals share knowledge, the more likely it is that this knowledge will materialize in knowledge creation outcomes on the level of the network.

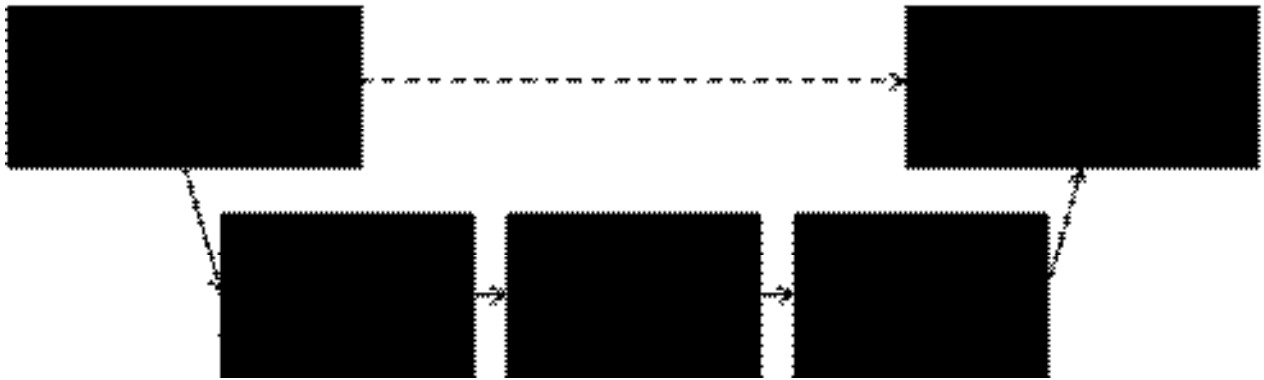


Figure 2: Causal Mechanism II

Data collection

The data for this research were collected for the evaluation of the Eindhoven region cluster scheme in 2005. As part of its regional economic development policy, the Eindhoven region received EU funding to further innovation among its manufacturing SMEs. One of the projects to accomplish that goal was the cluster scheme. Under this scheme manufacturing SMEs from the Eindhoven region could form a temporary network, which was called a cluster, to perform new product development. Some of these clusters would include a large company or a research center as well. The cluster scheme ran from 1994 through 2005 and the evaluation showed that the temporary networks had successfully developed new knowledge and had contributed to network formation of regional SMEs. Both outcomes were found to have a favorable influence on regional innovation (Rutten and Oerlemans 2009). Between 1994 and 2005, 102 clusters had been formed and subsequently dissolved after their project was finished. For the evaluation of the cluster scheme, 41 clusters were selected. The number of companies per cluster varied between two and five. Data were collected by administering questionnaires to the companies involved in these clusters. All the companies involved in the selected clusters were approached and in total 94 companies returned a usable questionnaire. The data were collected using a structured questionnaire with most questions asked in the form of a 5-point Likert scale. The questions related to the organizational characteristics of the cluster, to the process characteristics of the cluster, and to the outcomes that the clusters produced (Rutten and Oerlemans 2009).

To select clusters for the present research, the first priority was to ensure that these clusters did not systematically differ from each other so as to minimize the influence of external variables. We looked at the composition of the clusters, the levels of R&D-expenditure of the cluster partners, the experience that each partner had with working in similar product development networks over the last five years, and at the number of cluster partners they had previously worked with. With regard to the *composition* of the clusters, we only selected clusters that were entirely or predominantly composed of SMEs, where the definition of SMEs is less than 100 FTE employment. Because of its size, a larger partner may dominate a network and thus affect the processes taking place within the network. Next, we looked at R&D expenditure of the various companies to establish if there was a *dominant R&D-partner* in the network. Given that the aim of the clusters was new knowledge creation in order to develop new products, we felt that if one

company had a considerably higher R&D-expenditure than the other cluster partners, it may assume a dominant position. Because the clusters varied considerably on this selection criterion, we had to make two subgroups in our research sample: one with a dominant partner and one without one. We also looked at R&D-expenditure to estimate the level of *cognitive proximity* of the cluster partners. Cognitive proximity is the level of overlap between the knowledge bases of partners. Both very high and very low levels of cognitive distance are detrimental to learning because in the former case partners cannot learn anything new from one another while in the latter case their knowledge bases are so different that they cannot understand each other (Nooteboom et al. 2007). We used the level of R&D expenditure of the cluster partners as proxy for their cognitive proximity, assuming that the relative differences in R&D expenditure reflect the level of cognitive proximity. In one cluster the cognitive proximity was high according to this indicator (but this cluster was later eliminated from our sample because of missing values on other variables) in the other clusters cognitive proximity was moderate or low. Next we looked at the *experience* of companies with similar innovation projects over the last five years. Companies that had fewer than 5 similar projects we argued to have a low level of experience, between 5 and 10 similar project we argued them to have a moderate level of experience, and more than 10 similar projects we regarded as a high level of experience. The cluster score on experience corresponds to the score of the most experienced partner because the whole cluster benefits from this experience. We found no systematic differences between the clusters in our sample. Similarly we scored cluster on the number of partners that had worked with one another previously. We found systematic differences between the clusters and decided to distinguish between cluster where more than 50% of the partners had a history of collaboration and clusters where less than 50% of the partners had worked with one another before.

Table 1: Description of the clusters

Cluster	Composition	Dominant R&D partner	Cognitive proximity	Experience similar projects	Same partners $\geq 50\%$
2	3 SME	No	Low	Low	No
4	4 SME	No	Moderate	Low	Yes
5	4 SME	Yes	Moderate	High	Yes
7	2 SME	No	Moderate	Low	No
9	2 SME; 1 Large	No	Moderate	High	No
11	2 SME; 1 Large	No	Moderate	Moderate	Yes
12	3 SME; 2 n.a.	No	Moderate	Low	Yes
18	2 SME	Yes	Low	Moderate	No
20	2 SME	No	Moderate	Low	Yes
21	2 SME	Yes	Low	Low	No
23	4 SME; 1 Large	Yes	Low	Low	No
24	4 SME	Yes	Low	Low	No

Of the 41 clusters in our population, 29 had to be eliminated because they had missing data on either the control variables or the other variables, or both, which left us with a sample of 12 clusters. The sample is split between clusters with a dominant partner (5) and without a dominant

partner (7), and between clusters where partners have worked with one another previously (5) and clusters where that is not the case (7). The clusters are characterized in Table 1, a more detailed description can be found in Annex 1.

Operationalization

To operationalize the variables, we choose several questions from the questionnaire. The first independent variable – *the level of duality of the organizational structure* – has two components pertaining to formalization and informalization respectively. Formalization indicates the extent to which the goals of the cluster and the obligations of the partners are clear, as this gives direction to the knowledge-creation effort. Two questions measure this component: ‘the level in which the goals of the cluster were clear,’ and ‘the level in which the required contributions of the cluster partners were pre-specified.’ We found that all clusters scored (very) high on the formalization component, which means that whatever variation there may be in the ‘dual structure’ variable, it does not come from formalization. We therefore omitted this component from the analysis. The informalization component we operationalized by using the following question: ‘To what degree did communication within the cluster proceed along formal lines of communication?’ We argue that if the answer to this question is ‘to a (very) low’ degree, then the level of informalization of the cluster is high since, in that case, communication must have occurred through other than formal channels. The first process variable of the first pattern – *access to knowledge of partners* – we could operationalize straightforwardly by using a corresponding question. The *intensity of the communication* we measured by looking at both the communication modes that were used and at the frequency with which they were used. In the questionnaire, respondents could indicate how frequently they used the following communication modes: email, telephone, fax, face-to-face meetings, group meetings and shared documents. The frequency was coded as follows: (1) daily, (2) weekly, (3) every other week, (4) monthly, (5) less, (6) never. The idea behind distinguishing between various modes of communication is that some modes are more suited for the transfer of tacit knowledge, while others are more suited for the transfer of codified knowledge (Daft and Lengel 1986). However, both forms of knowledge must be transferred in order for knowledge creation to occur (Nonaka and Takeuchi 1994). Consequently, we argued that the more a cluster uses all modes of communication and the more frequently it uses them, the higher the intensity of the communication in that cluster. The intensity of the communication thus is the average frequency of use of all communication modes by the cluster partners. The dependent variable – *outcomes of knowledge creation* – is composed of two components that are each measured by a single question: The degree in which an organization improved its technological competences and the degree to which a company expanded its knowledge-base. The cluster score on this variable was calculated as the average of the scores of the companies in a cluster on both questions.

To operationalize the second independent variable – *the level of duality of the governance structure* – we looked at contracts, trust and mutual dependency. Since the clusters were formed as part of an EU funded policy scheme, they all used the same contract. The questionnaire did have a question on the level of trust between the companies in a cluster; however, all clusters reported (very) high levels of trust. Consequently, we had to omit contracts and trust from our analysis since the data showed no variation on these concepts. The level of *mutual dependency* we were able to measure

with the following question: To what degree were the cluster partners dependent on each other’s knowledge and expertise? The *perceived balance of power* within the cluster we were able to measure with a single, corresponding question. This was also the case for the *usage of control mechanisms*. The *willingness to share knowledge* we measured with the following question: To what degree did you share confidential firm-specific knowledge with your cluster partners? The dependent variable in Causal Mechanism II is the same as in the first causal mechanism. (For an overview of the operationalizations, see Annex 2.)

Based on the operationalizations we developed two theoretical patterns. A theoretical pattern reflects the theoretical mechanism linking the dependent variable to the independent variable through a number of causal steps (Terluin 2001). After operationalizing and measuring the variables and causal steps, an empirical pattern can be constructed for each case. Empirical patterns that are identical or very similar to the theoretical pattern support the underlying theory. Since only one aspect of the ‘duality of the organization structure’ could be measured, i.e. the formalization of the communication structure, the first causal mechanism has been developed into the following theoretical pattern. A low level of formalization leads to a high access to the knowledge of partners, which leads to a high intensity of communication. This in turn leads to high knowledge creation outcomes in the form of improved technological competences and an expanded knowledge base. Also for the second causal model, only one aspect of the independent variable (the duality of the governance structure) could be measured, i.e. the mutual dependency of the partners. This leads to the following theoretical pattern. A high mutual dependency leads to an equal balance of power which leads to the use of both formal and informal control mechanisms. This in turn leads to a high willingness to share knowledge which leads to high knowledge creation outcomes. (See, Table 2.)

Table 2: theoretical patterns

Pattern I					
Formalization of Communication Structure	Access to Knowledge of Partners	Intensity of Communication	Knowledge Creation Outcomes		
			Improve Technological competences	Knowledge base Expanded	
low	high	high	high	high	

Pattern II					
Mutual Dependence	Balance of Power	Control Mechanisms	Willingness To Share Knowledge	Knowledge Creation Outcomes	
				Improve Tech. Competences	Knowledge base Expanded
high	equal	formal and social	high	high	high

Data analysis

To obtain a cluster score for a variable we looked at the median score of the companies in that cluster on the variable. The calculations can be found in Annexes 3 and 4 for Patterns I and II respectively. To obtain cluster scores for ‘Intensity of Communication’, however, we calculated

the average score for each company on the usage of the different modes of communication. A cluster score was calculated as the average of the average company scores of the companies in that cluster. (See, Annex 3b.) Each cluster score was given a value (e.g. low, moderate or high) that reflected the meaning of the score in relation to its corresponding Likert-scale. The results are summarized in Tables 3 and 4 for Patterns I and II respectively. The values on the different variables for each cluster constitute an empirical pattern for that cluster. Since we have twelve clusters in our sample, we were able to construct twelve empirical patterns for each theoretical pattern. The empirical patterns are also shown in Tables 3 and 4. We then looked at how the empirical patterns supported the theoretical patterns. If an empirical pattern exactly matched the theoretical pattern, we argued that it gives strong empirical support for the theoretical pattern. If the empirical pattern is not identical but similar to the theoretical pattern, we argued that the empirical pattern offers support for the theoretical pattern. If the observed empirical pattern is different to the theoretical pattern but reflects the causal mechanism, we argued that the empirical pattern offers weak support for the theoretical pattern. In all other cases the empirical pattern offers no support for the theoretical pattern. The outcomes of this pattern matching are also shown in Tables 3 and 4.

Table 3: Matching of Pattern I

cluster	Dominant partner	Same partners	Formalization of communication	Access to knowledge of partners	Intensity of communication	Improve technological competences	Knowledge base expanded	Match
<i>Theoretical pattern →</i>			<i>Low</i>	<i>High</i>	<i>High</i>	<i>High</i>	<i>High</i>	
2	No	No	Low	High	High	High	high	Strong
4	No	Yes	Low	High	High	High	High	Strong
5	Yes	Yes	Low	Moderate	Low	Moderate	Moderate	No
7	No	No	Moderate	Very high	High	High	Moderate	No
9	No	No	Moderate	Moderate	Moderate	Moderate	Moderate	Yes
11	No	Yes	Low	Moderate	High	High	High	Yes
12	No	Yes	Moderate	High	High	High	Very high	Yes
18	Yes	No	Low	High	Moderate	Moderate	Very high	No
20	No	Yes	Moderate	High	Moderate	High	High	Weak
21	Yes	No	Very low	Very high	Low	High	High	No
23	Yes	No	Moderate	Moderate	Moderate	Moderate	Moderate	Yes
24	Yes	No	Low	High	moderate	High	Moderate	Weak

For Pattern I, we found that six of the twelve empirical patterns offer (strong) support for the underlying theoretical pattern, two further empirical patterns offer weak support for the theoretical pattern, while four empirical patterns offer no support. This suggests that data largely corroborate the theory for Pattern I, which states that a ‘dual’ organizational structure is conducive to knowledge creation outcomes as it facilitates knowledge exchange among the

individuals in the network. Although we were only able to measure the level of formalization of the communication structure, we still argue that clusters where the formalization of the communication structure was low (that is, communication was largely informal), had a 'dual' organizational structure since all clusters had specified clear goals for their collaboration effort. Distinguishing between clusters with and without a dominant partner, we found that for three out of five clusters with a dominant partner, the empirical patterns do not match the theoretical pattern. For clusters without a dominant partner, however, we found that for five out of seven clusters the empirical patterns give (strong) support for the underlying theoretical pattern and a further empirical pattern offers weak support. Only one empirical pattern in this group does not match the theoretical pattern. This strongly suggests that network composition matters in a way that it compromises the effectiveness of knowledge creation in networks when a dominant partner is included. Appropriation concerns of the less-intensive R&D firms may reduce their knowledge sharing behavior. Moreover, the dominant R&D firm may be more likely to take the lead in the knowledge creation process, relying more heavily on its own resources rather than acquiring knowledge from its network partners; which reduces the knowledge sharing in the network. Distinguishing next between clusters that have worked with the same partners before and those that have not, we found that for three of the five clusters where partners have worked with each other previously the empirical patterns (strongly) support the theoretical pattern. One further empirical pattern offers weak support for the theoretical pattern and one empirical pattern did not match with the theoretical pattern. Out of the seven clusters where partners have not worked with each other before, three had empirical patterns that (strongly) support the theoretical pattern and a further empirical pattern offers weak support for the theoretical pattern. In three cases the empirical patterns did not match the theoretical pattern. In sum, we found stronger support for the underlying theory in clusters where partners had a history of collaboration than in clusters without such a history. This finding is in line with the literature that suggests that trust is developed through repeated interactions between partners and that trustful relations are very conducive for knowledge creation (Grabher 2004, Klein Woolthuis et al. 2005, Larson 1992, Morgan 2004, Rutten 2003, Uzzi 1997).

Table 4: Matching of Pattern II

Cluster	Dominant partner	Same partners	Mutual dependence	Balance of power	Control mechanisms	Willingness to share knowledge	Improve technological competences	Knowledge base expanded	Match
Theoretical pattern →			<i>High</i>	<i>Equal</i>	<i>Formal and social</i>	<i>High</i>	<i>High</i>	<i>High</i>	
2	No	No	Moderate	Equal nor unequal	Social	Moderate	High	High	No
4	No	Yes	Moderate	Equal nor unequal	Formal and social	Moderate	High	High	Weak
5	Yes	Yes	High	Unequal	Formal and social	Moderate	Moderate	Moderate	No
7	No	No	High	Very equal	Social	Moderate	High	Moderate	Weak
9	No	No	High	Equal	Formal and social	Moderate	Moderate	Moderate	Weak
11	No	Yes	Moderate	Unequal	Social	High	High	High	No
12	No	Yes	Very high	Equal	Social	High	High	Very high	Yes
18	Yes	No	Very high	Equal	Social	Moderate	Moderate	Very high	Weak
20	No	Yes	Very high	Equal nor unequal	Social	Very high	High	High	Yes
21	Yes	No	High	Unequal	Social	Very high	High	High	No
23	Yes	No	High	Equal	Formal	Moderate	Moderate	Moderate	No
24	Yes	No	High	Equal nor unequal	Formal and social	Very high	High	Moderate	Yes

With regard to Pattern II we found that of the 12 empirical patterns, three offer support for the underlying theoretical pattern, a further four empirical patterns offer weak support for the theoretical pattern while four empirical patterns do not match the theoretical pattern. This suggests that our data weakly support the theory for Pattern II, which states that a governance structure that combines both formal and informal elements is conducive to knowledge creation outcomes as it facilitates knowledge sharing behavior among the individuals in the network. As ‘trust’ was high for all clusters in our study, and as all clusters had a contract underlying their collaboration, we argued that the conditions for having a mixed governance structure were met for all clusters with a (very) high level of mutual dependence. Again distinguishing between clusters with and without a dominant partner, we found that for three of the five clusters with a dominant partner, the empirical patterns do not match the theoretical pattern. One empirical pattern offers support for the theoretical pattern and a further empirical pattern offers weak support for the theoretical pattern. For the seven clusters without a dominant partner, two show an empirical pattern that supports the theoretical pattern and a further three empirical patterns

offer weak support for the theoretical pattern. Two empirical patterns do not match the theoretical pattern. These findings cautiously suggest that also for Pattern II cluster composition matters in that not having a dominant partner is more conducive to knowledge creation. Again distinguishing between clusters where partners have a history of collaboration and clusters where that is not the case, we found the following. For two out of the five clusters where partners had worked with each other before the empirical patterns support the theoretical pattern, a further empirical pattern offers weak support for the theoretical pattern while two empirical patterns do not match the theoretical pattern. For clusters where partners had not worked with each other before, the findings are similar. One of the seven empirical patterns in this group supports the theoretical pattern and three empirical patterns offer weak support for the theoretical pattern. Also three empirical patterns do not match the theoretical pattern. This suggests that, for Pattern II, whether or not network partners had a history of collaboration does not have an effect on knowledge creation.

Additional analysis on Pattern II shows that out of the nine clusters with a (very) high level of mutual dependence, six have a (very) high on at least one of the dependent variables. This suggests that there is a relation between mutual dependency and knowledge creation outcomes but that the causal mechanism is different than the one elaborated in Pattern II. Furthermore, of the seven clusters where the control mechanism was more social than formal, five have a (very) high on both dependent variables, and the sixth cluster has a high and a moderate on the dependent variables. This suggests that social control rather than a combination of social and formal control plays a role in facilitating knowledge creation in networks. This suggests that on the level of the individuals who are actually engaged in knowledge exchange in the network, social control is the most effective control mechanism. Duality – the combination of formal and informal governance mechanisms – may, instead, be more important on the level of the network. This is in line with the findings from Uzzi (1997) and Rutten (2003) and it stresses the need to distinguish between networks as organizational configurations, on the one hand, and the process of knowledge creation as it takes place between individuals, on the other hand, when studying knowledge creation in networks.

In sum, we found good support in our data for the theoretical arguments underlying Pattern I and weak support for the theoretical arguments underlying Pattern II. However, in line with theory on knowledge creation in networks, we found that both high levels of mutual dependence (network level) and the usage of social control by the individuals engaged in knowledge creation, are strongly correlated to high levels of knowledge creation outcomes.

Conclusion

The findings of the empirical work in this paper contribute to the literature on organizational knowledge creation in several ways. In the first place, we found that organizational characteristics matter in a way that was predicted by the literature. A dual organizational structure, that gives direction to the knowledge creation effort but at the same time guarantees the individuals involved sufficient freedom to be creative, is most conducive to knowledge creation in networks. It ensures that the individuals involved can have access to the knowledge of the various partner

organizations, which in turn enables an intensive communication between them. This intensive communication is subsequently likely to materialize in knowledge creation outcomes such as improved technological competences and an expanded knowledge base. Secondly, we found some support for the argument that a combination of formal and informal governance is conducive to knowledge creation. However, the actual causal mechanism may be different from the one that we deduced from the literature. We did find a strong correlation between ‘mutual dependence’ and ‘knowledge creation outcomes,’ and between ‘social control’ and ‘knowledge creation outcomes.’ This suggests that a mixed governance structure on the level of the network allows the individuals in the network to adopt social control mechanisms. Social control mechanisms on the level of individuals are conducive to creativity (Feams et al. 2007, Muthusamy and White 2005, Nonaka 1994, Tsoukas 2009) and may thus contribute to knowledge creation and its materializing in knowledge creation outcomes. This train of thought is in agreement with empirical findings from Rutten (2003) and Uzzi (1997). Thirdly, we were able to demonstrate that network composition matters for the knowledge creation in two ways. On the one hand, the inclusion of a dominant R&D partner seems to have a negative effect on knowledge creation, as the junior R&D partners may be less willing or less able to exchange knowledge under this condition. On the other hand, our findings suggest that a history of collaboration favors knowledge exchange between the network partners. However, only Pattern I produced evidence in favor of the history-of-collaboration argument. This may be explained as follows. A history of collaboration is often seen as an indicator of trust (Klein Woolthuis 2005, Uzzi 1997), however, our data showed that trust was high in all of the clusters in our study, regardless of prior relations. In other words, prior relations may not have substantially added to trust, which may explain why we found no effect for prior relations in Pattern II. Finally, our method of data analysis (pattern matching) distinguishes between the level of analysis of the dependent and independent variables (the network) and the level of the causal mechanism (the interaction between the individuals in the network). Our findings suggest that the conditions that are set on the level of the network affect the interaction on the level of the individuals. This suggests that the study of knowledge creation in networks would benefit from accounting more properly for this effect, both in theoretical and empirical research. The majority of studies on knowledge creation in networks seem to either emphasize the network level (e.g. Angel 2002, Larson 1992, Nooteboom et al. 2007, Owen-Smith and Powel 2004) or the level of the individuals within the network (e.g. Feams et al. 2007, Muthusamy and White 2005, Tsoukas 2009). However, our findings suggest that both levels should be accounted for.

Our study also suffers from a number of limitations. In the first place, pattern matching is a qualitative data analysis technique and its strengths become most evident when data are collected on the basis of interviews so that a proper narrative can be constructed of the empirical causal mechanism. Our data, which are secondary data collected for a different purpose, do not allow for such detail. Secondly, the use of secondary data also limited our ability to operationalize the independent variables, since our data did not provide measurements for all indicators of our variables. Moreover, we had to measure the various steps in the causal mechanism from a single question, whereas a combined measure based on several questions is usually more robust. In terms of construct validity and internal validity our study is therefore to some degree compromised. Thirdly, as is the case with all small N-studies, the external validity of our study is

low. The data were collected in a specific context (EU-funded innovation networks in the Eindhoven region), which makes generalization to other contexts potentially problematic.

Avenues for further research, in our view, would include conducting similar case studies in other contexts in order to see if our findings are corroborated. Data collection for such research should be based on interviews in order to enjoy maximum benefit of the pattern matching method of data analysis. Additionally, the theoretical argument regarding the relation between organizational (network) characteristics and knowledge creation should be refined to account for the two relevant levels of analysis: the network level and the level of the interaction between the individuals within the network.

References

- Amin, A. and Cohendet, P. (2004), *Architectures of knowledge: Firms, capabilities and communities*, Oxford: Oxford University Press.
- Angel, D. (2002), Interfirm collaboration and technology development partnerships within US manufacturing industries, *Regional Studies*, Vol.36-4, pp. 333-344.
- Bakker, R. (2010), Taking stock of temporary organizational forms: A systematic review and research agenda, *International Journal of Management Review*, forthcoming.
- Breschi, S. and Lissoni, F. (2001), Localised knowledge spillovers vs. innovative milieu: Knowledge 'tacitness' reconsidered, *Papers in Regional Science*, Vol. 80-3, pp. 255-274.
- Burns, T. and Stalker, G. (1961), *The management of innovation*, Oxford: Oxford University Press.
- Butler, R., Price, D., Coates, R. and Pike, R. (1998), Organizing for innovation: Loose or tight control?, *Long Range Planning*, Vol. 31-5, pp. 775-782.
- Daft, R. and Lengel, R. (1986), Organizational information requirements, media richness and structural design, *Management Science*, Vol. 32-5, pp. 554-571.
- Dekker, H. (2004), Control of inter-organizational relationships: Evidence on appropriation concerns and coordination requirements, *Accounting, Organization and Society*, Vol. 29-1, pp. 27-49.
- Feams, D., Janssens, M., and van Looy, B. (2007), The initiation and evolution of interfirm knowledge transfer in R&D relationships, *Organization Studies*, Vol. 28-11, pp. 1699-1728.
- Grabher, G. (2004), Temporary architectures of learning: Knowledge governance in project ecologies, *Organization Studies*, Vol. 25-9, pp. 1491-1541.
- Grant, R. (1996), Toward a knowledge-based theory of the firm, *Strategic Management Journal*, Vol. 17 – Special Issue: Knowledge and the firm, pp. 109-122.
- Gulati, R. and Puranam, P. (2009), Renewal through reorganization: The value of inconsistencies between formal and informal organization, *Organization Science*, Vol. 20-2, pp. 422-440.
- Hobday, M. (2000), The project-based organization: An ideal form for managing complex product systems?, *Research Policy*, Vol. 29-7/8, pp. 871-893.
- Johannessen, J., Olson, B. and Olaisen, J. (1997), Organizing for innovation, *Long Range Planning*, Vol. 30-1, pp. 96-109.
- Jones, C., Hesterly, W. and Borgatti, S. (1997), A general theory of network governance: Exchange conditions and social mechanisms, *The Academy of Management Review*, Vol. 22-4, pp. 911-945.

- Klein Woolthuis, R., Hillebrand, B. and Nooteboom, B. (2005), Trust, contract and relationship development, *Organization Studies*, Vol. 26-6, pp. 813-840.
- Larson, A. (1992), Network dyads in entrepreneurial settings: A study of the governance of exchange relations, *Administrative Science Quarterly*, Vol. 37-1, pp. 76-104.
- McFadyen, M., Semadeni, M. and Cannella, A. (2009), Value of strong ties to disconnected others: Examining knowledge creation in biomedicine, *Organization Science*, Vol. 20-3, pp. 552-564.
- Morgan, K. (2004), The exaggerated death of geography: Learning, proximity and territorial innovation systems, *Journal of Economic Geography*, Vol. 4-1, pp. 3-21.
- Muthusamy, S. and White, M. (2005), Learning and knowledge transfer in strategic alliances: A social exchange view, *Organization Studies*, Vol. 26-3, pp.415-441.
- Nohria, N. and Gulati, R. (1997), What is the optimum amount of organizational slack? A study of the relationship between slack and innovation in multinational firms, *European Management Journal*, Vol. 15-6, pp. 603-611.
- Nonaka, I. and von Krogh G. (2009), Tacit knowledge and knowledge conversion: Controversy and advancement in organizational knowledge creation theory, *Organization Science*, Vol. 20-3, pp. 635-652.
- Nonaka, I. and Takeuchi, H. (1994), *The knowledge-creating company: How Japanese companies create the dynamics of innovation*, Oxford: Oxford University Press.
- Nooteboom, B., van Haverbeke, W., Duysters, G., Gilsing, V., van den Oord, A. (2007), Optimal cognitive distance and absorptive capacity, *Research Policy*, Vol. 36-7, pp. 1016-1034.
- Owen-Smith, J. and Powell, W. (2004), Knowledge networks as channels and conduits: The effect of spillovers in the Boston biotechnology community, *Organization Science*, Vol. 15-1, pp. 751-21.
- Ozman, M. (2009), Inter-firm networks and innovation: A survey of literature, *Economics of Innovation and New Technology*, Vol. 18-1, pp. 39-67.
- Powell, W. (1998), Learning from collaboration: Knowledge and networks in the biotechnology and pharmaceutical industries, *California Management Review*, Vol. 40-3, pp. 228-240.
- Provan, K. and Kenis, P. (2008), Modes of network governance: Structure, management and effectiveness, *Journal of Public Administration Research and Theory*, Vol. 18-2, pp. 229-252.
- Rutten, R. (2003), *Knowledge and innovation in regional industry: An entrepreneurial coalition*, London: Routledge.
- Rutten, R. and Oerlemans, L. (2009), Temporary inter-organisational collaboration as a driver of regional innovation: An evaluation, *International Journal of Innovation and Regional Development*, Vol. 1-3, pp. 211-234.
- Terluin, I. (2001), *Rural regions in the EU: exploring differences in economic development* – PhD thesis, Groningen: Grafisch Centrum, Rijksuniversiteit Groningen.
- Tsoukas, H. (2009), A dialogical approach to the creation of new knowledge in organizations, *Organization Science*, Vol. 20-6, pp. 941-957.
- Uzzi, B. (1997), Social structure and competition in interfirm networks: The paradox of embeddedness, *Administrative Science Quarterly*, Vol. 42-1, pp. 35-67.
- Woiceshyn, J. (2000), Technology adoption: Organizational learning in oil firms, *Organization Studies*, Vol. 21-6, pp. 1095-1118.

Annex 1: Detailed description of the clusters

Cluster	Company	Number of companies in cluster	Size	R&D expenditure x 1,000 €	Dominant partner	Cognitive proximity	Number of similar projects in last 5 years	Experience of cluster	Same partners in cluster*	
2	2.1	3	SME	100	No	Low	2	Low	33%	
	2.2		SME	15						1
	2.3		SME	n.a.						n.a.
4	4.1	5	SME	17	No	Moderate	0	Low	50%	
	4.2		SME	0						0
	4.3		SME	60						0
	4.4		SME	5						0
5	5.1	4	SME	n.a.	Yes	Moderate	8	High	50%	
	5.2		SME	1,000						2
	5.3		SME	100						25
	5.4		SME	5,000						0
7	7.1	2	SME	75	No	Moderate	1	Low	0%	
	7.2		SME	25						3
9	9.1	3	SME	45	No	Moderate	0	High	33%	
	9.2		Large	n.a.						20
	9.3		SME	25						1
11	11.1	3	SME	50	No	Moderate	0	Moderate	67%	
	11.2		n.a.	n.a.						n.a.
	11.3		SME	100						5
12	12.1	4	SME	415	No	Moderate	4	Low	75%	
	12.2		SME	180						3
	12.3		SME	250						4
18	18.1	2	SME	50	Yes	Low	0	Moderate	0%	
	18.2		SME	200						5
20	20.1	2	SME	20	No	Moderate	3	Low	50%	
	20.2		SME	75						0
21	21.1	2	SME	4	Yes	Low	0	Low	0%	
	21.2		SME	75						0
23	23.1	5	SME	n.a.	Yes	Low	n.a.	Low	20%	
	23.2		n.a.	n.a.						n.a.
	23.3		SME	25						1
	23.4		Large	500						1
	23.5		SME	n.a.						2
24	24.1	4	SME	75	Yes	Low	0	Low	0%	
	24.2		SME	40						0
	24.3		SME	20						0
	24.4		SME	800						0

*) The percentage of partners in a cluster that worked with one another previously.

Annex 2: Operationalizations

Variable	Question	Scale
Level of formalization of communication structure	To what extend did communication within cluster follow formal lines of communication?	1 to a very high degree 2 to a high degree 3 high nor low degree 4 low degree 5 very low degree
Level of access to knowledge of partners	To what extend did you have access to the knowledge of your partners and/or their organizations?	1 to a very high degree 2 to a high degree 3 high nor low degree 4 low degree 5 very low degree
Level of intensity of communication	How often did you make use of the following modes of communication? Email, Telephone, Fax, Face-to-face, Group meetings, Shared documents	1 daily 2 weekly 3 every other week 4 monthly 5 less than monthly 6 never
Level of knowledge creating outcomes: a) improved technological competences	To what extend did your company improve its technological competences as a result of the collaboration within the cluster?	1 to a very high degree 2 to a high degree 3 high nor low degree 4 low degree 5 very low degree
Level of knowledge creating outcomes: b) knowledge base expanded	To what extend did the collaboration within the cluster yield new knowledge for your organization?	1 to a very high degree 2 to a high degree 3 high nor low degree 4 low degree 5 very low degree
Level of mutual dependence	To what extend where the partners in your cluster mutually dependent on each other's knowledge and expertise?	1 to a very high degree 2 to a high degree 3 high nor low degree 4 low degree 5 very low degree
Perceived balance of power	How would you describe the balance of power between you and your partners?	1 very equal 2 equal 3 equal nor unequal 4 unequal 5 very unequal
Usage of control mechanisms	What was the balance between formal and social control within the cluster?	1 more formal than social control 2 as much formal as social control 3 more social than formal control
Level of willingness to share knowledge	To what extend did you bring in confidential company-specific knowledge into the cluster?	1 to a very high degree 2 to a high degree 3 high nor low degree 4 low degree 5 very low degree

Annex 3: From company to cluster scores (Pattern I)*

Cluster	Company	Formalization of communication structure	Access to knowledge of partners	Intensity of communication	Improve technological competences	Knowledge base expanded
2	2.1	4 (4: low)	2 (2: high)	high	1 (2: high)	2 (2: high)
	2.2	5	2		2	2
	2.3	4	2		2	2
4	4.1	3 (4: low)	2 (2: high)	high	2 (2: high)	2 (2: high)
	4.2	5	2		2	2
	4.3	4	3		3	2
	4.4	4	2		2 (3: moderate)	2 (3: moderate)
5	5.1	5 (4: low)	3 (3: moderate)	low	5	2
	5.2	3	3		2	2
	5.3	5	5		5	5
	5.4	4	2		2	2
7	7.1	4 (3: moderate)	2 (1: very high)	high	2 (2: high)	3 (3: moderate)
	7.2	2	1		2	2
9	9.1	5 (3: moderate)	2 (3: moderate)	moderate	2 (3: moderate)	2 (3: moderate)
	9.2	2	4		2	4
	9.3	2	2		5	5
11	11.1	4 (4: low)	3 (3: moderate)	high	2 (2: high)	2 (2: high)
	11.2	4	4		2	2
	11.3	3	2		2	2
12	12.1	2 (3: moderate)	2 (2: high)	high	2 (2: high)	1 (1: very high)
	12.2	4	1		2	1
	12.3	5	2		2	2
18	18.1	5 (4: low)	2 (2: high)	moderate	2 (3: moderate)	2 (1: very high)
	18.2	4	2		3	1
20	20.1	3 (3: moderate)	2 (2: high)	moderate	2 (2: high)	2 (2: high)
	20.2	4	2		2	2
21	21.1	5 (5: very low)	1 (1: very high)	low	2 (2: high)	2 (2: high)
	21.2	5	1		2	2
23	23.1	3 (3: moderate)	1 (3: moderate)	moderate	2 (3: moderate)	(3: moderate)
	23.2	4	4			2
	23.3	4	2		4	3
	23.4	2	3		3	2
	23.5	2	2		4	4
24	24.1	3 (4: low)	2 (2: high)	moderate	2 (2: high)	2 (3: moderate)
	24.2	5	3		2	4
	24.3	4	2		2	1
	24.4	4	2		2	2

*) Cluster scores and labels are in brackets behind the score of the first company in each cluster.

Annex 3b: From company to cluster scores for 'communication'

Cluster	Company	Frequency Email	Frequency Telephone	Frequency Fax	Frequency Face-to-face	Frequency Group meetings	Frequency Shared documents	Average score company	Average score cluster	Intensity of communication
2	2.1		2	2	3		2	2,25	2,58	High
	2.2	1	2	3	2	4	3	2,50		
	2.3		1	4	1	4	5	3,00		
4	4.1	3	1	3	4	5		3,20	2,70	High
	4.2	5	1		1	1		2,00		
	4.3	5	2	2	3	3	3	3,00		
	4.4	5	2	2	2	2		2,60		
5	5.1	3	3	5	5	5		4,20	4,11	Low
	5.2	4	3	4	4	4	4	3,83		
	5.3	5	5	5	5	5		5,00		
	5.4	5	2	2	3	5		3,40		
7	7.1	1	2	1	2	4	1	1,83	1,83	High
	7.2	1	1	1	2	4	2	1,83		
9	9.1	3	3	3	3	4	3	3,17	2,94	Moderate
	9.2	5	3	3	3	3	3	3,33		
	9.3	5	1	1	2	3	2	2,33		
11	11.1	1	1	2	2	4	3	2,17	2,33	High
	11.2	4	1	4	2	2	2	2,50		
	11.3	3	2	2	2	3	2	2,33		
12	12.1	5	1	2	1	2	4	2,50	2,39	High
	12.2	2	1	2	1	3	5	2,33		
	12.3	1	1	5	2	3	2	2,33		
18	18.1	1	2	5	2	2	2	2,33	2,92	Moderate
	18.2	2	2	5	3	4	5	3,50		
20	20.1	1	2	6	3	5	4	3,50	3,15	Moderate
	20.2	2	2	6	2	2		2,80		
21	21.1	2	2	6	5	5		4,00	3,80	Low
	21.2	1	2	6	4	5		3,60		
23	23.1	2	2	5	3	2	5	3,17	3,08	Moderate
	23.2	2	1	2	2	2	2	1,83		
	23.3	3	3	5	5	5	3	4,00		
	23.4	2	2	5	3	4	4	3,33		
	23.5									
24	24.1	5	2	2	2	4	2	2,83	2,92	Moderate
	24.2	5	1	2	1	3	3	2,50		
	24.3	3	3	4	3	4	3	3,33		
	24.4	5	2	2	2	4		3,00		

Annex 4: From company to cluster scores (Pattern II, except dependent variable)*

Cluster	Company	Mutual dependence	Balance of power	Control mechanisms	Willingness to share knowledge
2	2.1	4 (3: moderate)	1 (3: equal nor unequal)	3 (3: social)	2 (3: moderate)
	2.2	2	3	3	5
	2.3	2	4	3	3
4	4.1	3 (3: moderate)	4 (3: equal nor unequal)	2 (2: formal and social)	2 (3: moderate)
	4.2	2	2		
	4.3	2	2	3	4
	4.4	4	3	2	3
5	5.1	2 (2: high)	4 (4: unequal)	3 (2: formal and social)	3 (3: moderate)
	5.2	3	4	1	3
	5.3		5		4
	5.4	2	2	2	2
7	7.1	2 (2: high)	1 (1: very equal)	2 (3: social)	4 (3: moderate)***
	7.2	2	2	3	1
9	9.1	2 (2: high)	2 (2: equal)	2 (2: formal and social)	3 (3: moderate)
	9.2	3	2	1	4
	9.3	2	4	3	2
11	11.1	2 (3: moderate)	2 (4: unequal)	3 (3: social)	2 (2: high)
	11.2	4	4	2	2
	11.3	2	4	3	2
12	12.1	1 (1: very high)	2 (2: equal)	1 (3: social)	1 (2: high)
	12.2	1	2	3	2
	12.3	2	1	3	2
18	18.1	1 (1: very high)	2 (2: equal)	3 (3: social)	2 (3: moderate)
	18.2	2	2		3
20	20.1	2 (1: very high)	3 (3: equal nor unequal)	3 (3: social)	1 (1: very high)
	20.2	1	2	2	2
21	21.1	1 (2: high)	4 (4: unequal)**	3 (3: formal)	1 (1: very high)
	21.2	3	1	3	1
23	23.1	2 (2: high)	2 (2: equal)	1 (1: formal)	4 (3: moderate)
	23.2	2	2	2	5
	23.3	2	2	2	3
	23.4	2	2	2	4
	23.5	3	3	1	2
24	24.1	2 (2: high)	4 (3: equal nor unequal)	3 (2: formal and social)	1 (1: very high)
	24.2	2	2	2	2
	24.3	2	3	2	2
	24.4	3	3	3	1

*) Cluster scores and labels are in brackets behind the score of the first company in each cluster.

**) The dominant R&D-partner perceived relations as equal; the other partner as unequal. The cluster gets scored as having unequal power relations.

***) The smaller firm perceives a very high willingness to share knowledge, the larger firm a low willingness. The cluster gets scored as having a moderate willingness to share knowledge.