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Knowledge in Technology Networks: A case study based institutional approach

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1. How networks think

“Do networks think and if so, how do we know?” can be used as an introductory question for this paper. It takes up the provocative issue of “how institutions think” (raised by Mary Douglas, 1984) and extends it to include the interpretation of clusters and networks as institutions. In this paper we attempt to analyse the extent to which networks can be regarded as institutions. We also try to ascertain the importance of learning and knowledge exchange in networks, both from a theoretical and empirical point of view, and tentatively measure the forms and content of knowledge exchange.

Since Porter’s (1998, 2000) original definition of clusters as “geographic concentrations of interconnected companies, specialized suppliers, service providers, firms in related industries and associated institutions in a particular field that compete but also cooperate”, emphases within cluster analysis have changed considerably. The recent debate has focussed more on how far and in what ways clusters foster knowledge creation and organizational learning, and has placed greater emphasis on the organic-evolutionary dimension of cluster-based industrial agglomerations.

In the following section we will give a short outline of the institutional aspects of networks and their knowledge-specific character (section 2), identify and outline different empirical approaches in identifying the form and content of knowledge exchange. This entails use of the concept of organizational learning, the methodological approach of social network analysis, and of intellectual capital reporting in measuring intangible assets (section 3). The final section contains our conclusions (section 4).

2. Knowledge – in need of institutionalized cooperation

A vast literature concentrating on the combination of clusters, innovation, and regional development now exists. It appears that the process of innovation is favoured by regionally concentrated interaction of (mostly) small firms, mutually exchanging information and creating knowledge in formal and informal ways. It has been emphasized that networking has to be regarded as an important form of innovative activity. This has not only been taken

up by regional scientists but also by various strategic management and industrial dynamics approaches to inter-firm cooperation (Vonortas, 2000). It has also been extended to questions of identifying competences and capabilities in strategic management at different levels of economic interaction (Felin & Foss, 2005).

The question as to what extent these economic interactions are in need of specific guiding and coordinating institutions is a further new element in the cluster debate. Interactions need institutions (such as markets); yet if the focus is on learning and knowledge, markets alone will not suffice for such forms of interaction and additional institutions will be needed (Bünstorf, 2003). Clusters may be regarded as coordinating institutions for knowledge sharing, providing a cognitive framework for transforming information into useful knowledge (Audretsch & Lehmann, 2006, Steiner, 2006).

As clearly foreseen by Adam Smith, a central fact about the modern process of innovation is that it is based on a division of labour. He quickly recognized what is now called the social nature of the innovation process. The social process induced by division of labour produces efficiency gains, from both specialization and professionalization, but it also requires a supporting framework to help connect the component contributions of the different agents. As far as knowledge and skills are concerned, this aspect of connectivity, or technology transfer, cannot be effectively coordinated by conventional markets: we need specific institutional arrangements.

Yet – as has been outlined recently by Helmstädter (2003) – the idea of connectivity transcends the usual problems of the ‘division of labour’ – there are additional and non-trivial problems of ‘knowledge sharing’, which thus far, have not been properly appreciated by the New Institutional Economics.

- The pure transaction cost approach misses fundamentally the essence of knowledge as an economic resource. “The new institutional economics deals with institutions that govern the interactions taking place under the division of labour, but leaves aside the division of knowledge activities that go with it” (Helmstädter, 2003, 14). Once the object of interaction between participating actors is knowledge, the character of interaction changes – the institutional conditions for an efficient division of knowledge are different.
- The main differences reside in the form of interaction and in the impact of interaction. Under the division of labour the transaction of goods and services is paramount, and subject to the rules of competition and to exclusivity of use and consumption. Under knowledge sharing it is knowledge and skills that are paramount, and these are subject to co-operation and the increase of knowledge for all (inclusivity). Whereas the division of labour involves differentiation and separation of method, mode and product, knowledge sharing involves internalization and recontextualization.
- The most important ‘institutional’ consequence is that “cooperation is the basic institution of the process of the division of knowledge” (Helmstädter, 2003, 32). But the degree of cooperation depends again on the type of knowledge use: the area of application has stronger competitive elements whereas knowledge creation and transfer are dominated by non-economic competition (status, acceptance) and cooperation. The interest thus lies here in identifying those institutions that make knowledge sharing efficient.

This institutional approach emphasizes that the growth of knowledge depends on intended and unintended individual processing of experiences, i.e. ‘learning’, while the

interpretation, transfer and use of experiences is influenced by interaction between individuals and between organizations, i.e. 'organizational learning'.

This new understanding of networks as institutions for learning and knowledge exchange leads to further reflections concerning the forms, channels and mechanisms of knowledge exchange. This exchange occurs through interaction, and the structure of the interaction therefore influences the extent of knowledge diffusion (Gay & Dousset, 2005). Here, two explanatory approaches exist, but they tend to oppose each other (Giuliani, 2005, 4). The one attributes knowledge with a highly public nature, so that learning, knowledge sharing and innovation within clusters is externality-driven. The alternative approach points to the necessity to include specific features of the firms and of firm-level learning in order to understand the interaction of firm-level and cluster-level learning. The first approach (whereby Giuliani includes both the economists' perspective on 'localised knowledge spillovers' and the economic geographers' view of clusters and 'collective learning') emphasizes the strong relationship between spatial clustering, knowledge spillovers, and firms' innovative output – 'proximity' and 'territory' lead to a quasi-automatic diffusion of knowledge leading to innovation. The automatic nature of this mechanism is questioned by economic geographers, who regard geographical proximity per se as insufficient, and who emphasize the additional role of social and relational proximity in entailing an interactive and cumulative effort by co-localized firms, which nevertheless results in unstructured and diffuse local interactions. The second approach points to the heterogeneity of firm knowledge base, different firm capabilities, the existence of 'technological leaders' and 'gate keepers' in a local community. These differences have an effect on the mechanisms by which knowledge is transmitted and indicate that knowledge diffusion is not an accidental collective process but is rather structured by the relative distance of firms' knowledge bases (Giuliani & Bell, 2005).

In the following pages we will present summaries of several case studies – all undertaken within the province of Styria/Austria. These provide insight into, and allow comparison of different forms of learning and knowledge generation and diffusion in clusters and networks and in other institutions of knowledge sharing. Each of them represents a specific solution – in different institutional form – to the problem of efficient knowledge exchange and its measurement.

- The first study concentrates on forms of organizational learning. The clusters under scrutiny are regarded as organizations skilled at creating, acquiring and transferring knowledge in diverse but systematic ways. The focus here is on the specific systems and forms of learning at the cluster level.
- The second case uses the tool of social network analysis to differentiate between forms and content of interactions within a network. The main interest here lies in the relative importance and weight of knowledge intensity of the interactions of firms and the subsequent structure of the network.
- A change of perspective is then taken by looking at the specific position of two firms within the network. Both are part of it but – due to their different knowledge orientation and capabilities – have different positions in the network and participate in distinct forms.
- Finally, a further institutional level – a so-called "competence centre", an applied precompetitive sectoral research institution linked with industrial partners and thus forming an additional specific network – is analyzed by means of intellectual capital

reporting. Here the focus is on how different kinds of intellectual capital can be identified and how this capital can be used not only for measuring the knowledge intensity of the network of the competence centre but also for indicating – as relational capital – research driven links to external institutions.

3. How to measure knowledge in networks: summary results and interpretation of empirical approaches

3.1 Organizational learning between firms in specific clusters

3.1.1 Learning systems

Organizational learning – as the outcome of overlapping activities of individual, firm and interfirm learning – requires the presence of specific systems for the transformation and combination of these related spheres. In order to identify forms of learning in clusters and between firms we focussed on two learning systems: participative and informal learning (for a more extensive elaboration see Steiner & Hartmann, 2006).

Informal learning systems may be present at cluster level in the form of informal meetings at conferences or in bars, communities of practice, networks with fellow graduates (old boys' networks), or social networks. Informal meetings (Saxenian, 1996) take place in bars or in the lobby at conferences. Such meetings are mainly focused on the transfer of knowledge on a personal face-to-face basis. Communities of practice (Wenger, 1996) include informal teams which emerge spontaneously. They engage in problem solving, and comprise employees of different firms. Learning takes place in the discussion and fixing of technological problems. 'Old boys' networks' (Saxenian, 1996) are formed by graduates of particular universities. In such networks technological or organisational problems can be discussed freely on an informal basis. Learning arises through the exchange of alternative perspectives. Social networks (Hendry et al., 1995) arise in local sporting clubs and charity organizations (i.e. Rotary Club etc.). In such networks information and knowledge can be exchanged informally and learning takes place in the reflection of work-related problems. Facilitated exchange of experiences (Oess, 1991) takes place in semi-formal meetings which are held in order to discuss particular issues. The efficient exchange of knowledge is enabled through a facilitator, either external, or nominated by the group.

Participative learning systems may be present at cluster level in the form of formal R&D-teams at interfirm level, interfirm teams working on a joint project, participation in benchmarking clubs, or joint preparation of tenders in consortia. Interfirm R&D-teams (Dodgson, 1996) are formed by researchers of universities, R&D-institutions and firms. Within such teams a strong transmission of knowledge from the regional knowledge infrastructure to the participating firms takes place. Interfirm project teams (Pedler et al., 1997) are formed by members of several firms. Within such teams new production programs are launched or new software systems are implemented. Learning arises through the need for continuous problem solving in the course of the project. Benchmarking clubs (Pedler et al., 1997) have been formed by several firms in order to identify good practice for routines at firm level. Learning occurs through the active transfer of good practice between the club members. Consortia (Balling, 1997) collaborate on preparing bids for public or private tenders. Knowledge about particular markets and/or technological problems is exchanged among the firms in the course of the preparation process.

Learning system	Particular forms at cluster level
Informal learning system	<div><div>- informal meetings in bars or at conferences etc.</div><div>- communities of practice</div><div>- „old boys networks“</div><div>- social networks (clubs etc.)</div><div>- facilitated exchange of experiences</div></div>
Participative learning system	<div><div>- interfirm R&D teams</div><div>- interfirm project teams</div><div>- benchmarking clubs</div><div>- participation in consortia</div></div>

Table 1. Particular forms within learning systems
Source: Steiner, M., Hartmann, Ch. (2006), Organizational Learning in Clusters: A Case Study on Material and Immaterial Dimensions of Cooperation, Regional Studies

3.1.2 Results for Styrian clusters

Based on 149 in-depth interviews in the leading firms of five main clusters in Styria the following results were obtained:

	Chemical	IT	Wood	Metal	Auto
Informal meetings in bars or at conferences	80%	90%	74%	46%	67%
Communities of practice	16%	25%	22%	18%	21%
Old boys networks	30%	50%	22%	23%	31%
Social networks	5%	10%	14%	5%	21%
Facilitated exchange of experience	42%	20%	53%	33%	26%
Informal learning systems: summary mean figure	35%	39%	37%	25%	33%

Table 2. Particular forms of informal learning systems in Styrian clusters
Source: Steiner, M., Hartmann, Ch. (2006), Organizational Learning in Clusters: A Case Study on Material and Immaterial Dimensions of Cooperation, Regional Studies

Table 2 shows the relative importance of informal learning systems. The data show the relative importance of each system as an important source of learning and knowledge acquisition outside the enterprise.

	Chemical	IT	Wood	Metal	Auto
Interfirm R&D-teams	50%	55%	41%	41%	50%
Interfirm project teams	21%	70%	50%	50%	67%
Participation in consortia	6%	35%	12%	21%	22%
Benchmarking clubs	17%	40%	54%	47%	53%
Participative learning systems: summary mean figure	23%	50%	39%	40%	48%

Table 3. Particular forms of participative learning systems in Styrian clusters
Source: Steiner, M., Hartmann, Ch., (2006), *Organizational Learning in Clusters: A Case Study on Material and Immaterial Dimensions of Cooperation*, Regional Studies

Table 3 presents the relative importance of the different forms of participative learning system for the five Styrian clusters examined. Also, for participative learning, the data of the four particular forms are aggregated through the generation of the corresponding mean value. The data presented reflect the percentage of firms in each cluster that engage in the respective type of learning system.

The results can be summarized as follows (for details see Steiner & Hartmann, 2006): The learning orientation in Styrian clusters depends as much on the corresponding working cultures within the relevant industries as it does on the existing value chains and the prevailing competitive structure. In the IT and automobile cluster a tradition of joint working and knowledge acquisition through formal and informal teams already exists. This is because the just-in-time production mode in the automobile sector and the necessity of large multidisciplinary interfirm teams in the IT-sector promote new collaborative working styles and attitudes among the corresponding workforce and management. In the chemical cluster such a team-oriented working style is – except with respect to the employment of R&D-teams – virtually unknown. Collaborative learning in interfirm project teams or benchmarking clubs does not fit the business style and culture of this cluster. On the other hand, informal means of knowledge acquisition are of relatively greater importance in this cluster. In the wood, machinery and metal clusters, a team approach towards learning is currently developing both at an organised formal level, and at a rather spontaneous informal level. The size of the clusters in terms of number of member firms seems to have no influence on learning orientation: The IT and the chemical clusters, are both small in terms of numbers of member firms, but still differ strongly in their learning orientation.

3.2 Social network analysis

3.2.1 Data and indicators

Social network analysis is a helpful tool in discussing the structure of networks and allows for the mapping and measuring of the relationships (communication and transaction) between different actors, i.e. the existence, context and portfolio of relations between actors in a regional network. It is a method for exposing the underlying relations between different actors, and for revealing those phenomena which cannot be reduced to the properties of individual actors or firms. Thus, relations have to be interpreted as properties of systems rather than of individual actors.

The analysis here focussed on the mechanical engineering, machinery, and automotive sector forming a well-known cluster in Styria (for a more extensive elaboration see Steiner / Ploder 2008). The starting point was a large system supplier in the automobile sector located in the region. Application of the snowball method led to the identification of firms belonging to different sub-sectors and cultivating related supply-chain and innovation-strategies. This produced a 32-actor-network comprising 18 industrial firms, 5 service firms and 9 R&D institutions.

The selected indicators of the relations cultivated by these agents cover three dimensions of interaction: direct delivery relations, R&D, and technological innovation in a competitive and a pre-competitive context. The following three dimensions of interaction were employed:

(DELIV): The firms were questioned concerning direct delivery relations (goods or services) to clients, suppliers or partners (in the case of synergetic product bundles). The direct delivery of goods and services is not reduced to its material dimensions but is extended to include innovation-related questions in the context of quality and information management or capacity extending investments.

In order to take account of different R&D capabilities and innovation strategies two dimensions of relations with respect to knowledge generating processes were distinguished.

(COMP): Competitive research and development and innovation processes are short and medium term oriented and mostly associated with direct expectations of return or with a direct tender or offer.

(PRE-COMP): The second R&D dimension surveyed concerned the level of interaction in the context of pre-competitive R&D. Pre-competitive research and development aims at extending the product spectrum, as well as at introducing new processes and alternative materials. Pre-competitive research includes fundamental research, which is an activity designed to broaden scientific and technical knowledge not yet linked to industrial or commercial objectives, and industrial research, which is research aimed at developing or improving new or existing products, processes or services.

Applying the basic concepts of social network analysis, the focus was placed on density and centrality. Density is indicated by the ratio of relations actually realized to the total number of maximum possible relations – it yields information on the general structure of the network as a whole.

Centrality is also a core feature identified in network analysis. The concept of centrality provides insight into the specific features of the interaction of the actors in the network and their specific position and/or embeddedness in the network.

3.2.2 Forms and contents of interactions

The focus here lay on identifying the most striking features of the network and the network dimensions as a whole, as well as considering the position of individual actors within the network.

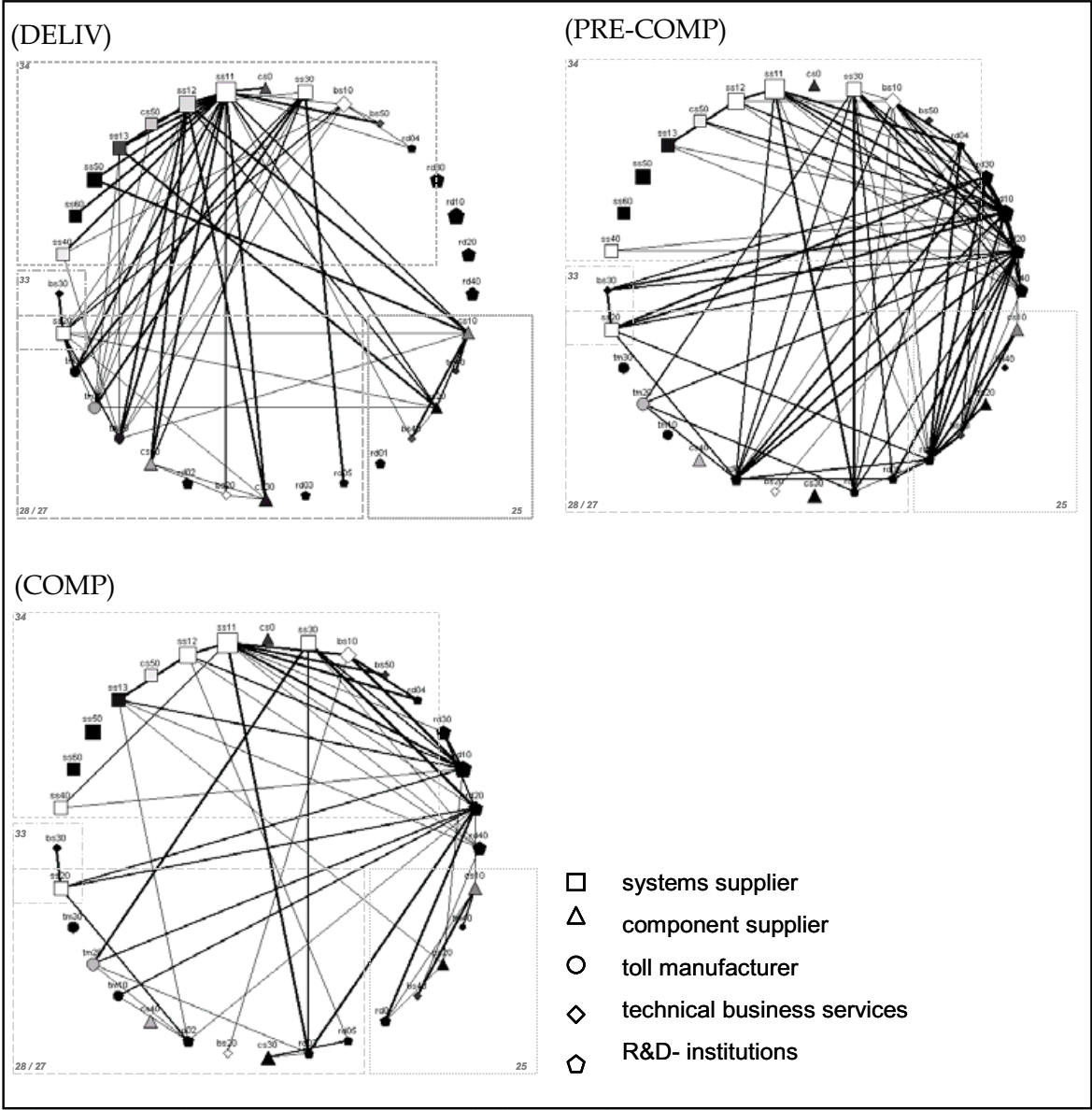


Fig. 1. Comparative presentation of the observed dimension of networking
Source: Steiner, M., Ploder, M. (2008), Structure and Strategy within Heterogeneity: Multiple Dimensions of Regional Networking, Regional Studies

Direct delivery relations have the weakest density. With respect to direct deliveries, most of the firms in the observed network are oriented towards international markets and regional input-output relations have been reduced. This is also reflected by average closeness centrality (even when indirect linkages are considered) which is higher among interactions in the context of competitive R&D and innovation processes than among direct delivery relations, although the densities and number of actors involved (nodes) are comparable. While competitive R&D and innovation processes, especially in the case of domestic system suppliers, are partially similar in density to direct delivery relations, the regional density of the network of pre-competitive R&D is much higher. While R&D institutions are of

negligible significance with respect to direct delivery relations, the network is based to a considerable degree on relations with cooperative R&D institutions. Beyond the coverage of the total network of actors (including all international relations) the network analysis reveals another explanation for the high density of the network dimension of pre-competitive research and development, namely the permanent relations prevailing among the R&D institutions (e.g. semi-public cooperative research institutions and universities). The lower density of the network COMP in comparison to PRE-COMP may be explained by several factors. Competitive R&D and innovation are to a high degree in-house activities, partly owing to time-pressure, but also for reasons of confidentiality. Especially in the case of system suppliers, a considerable amount of competitive research and development and innovation processes involves clients and suppliers outside the region and internationally.

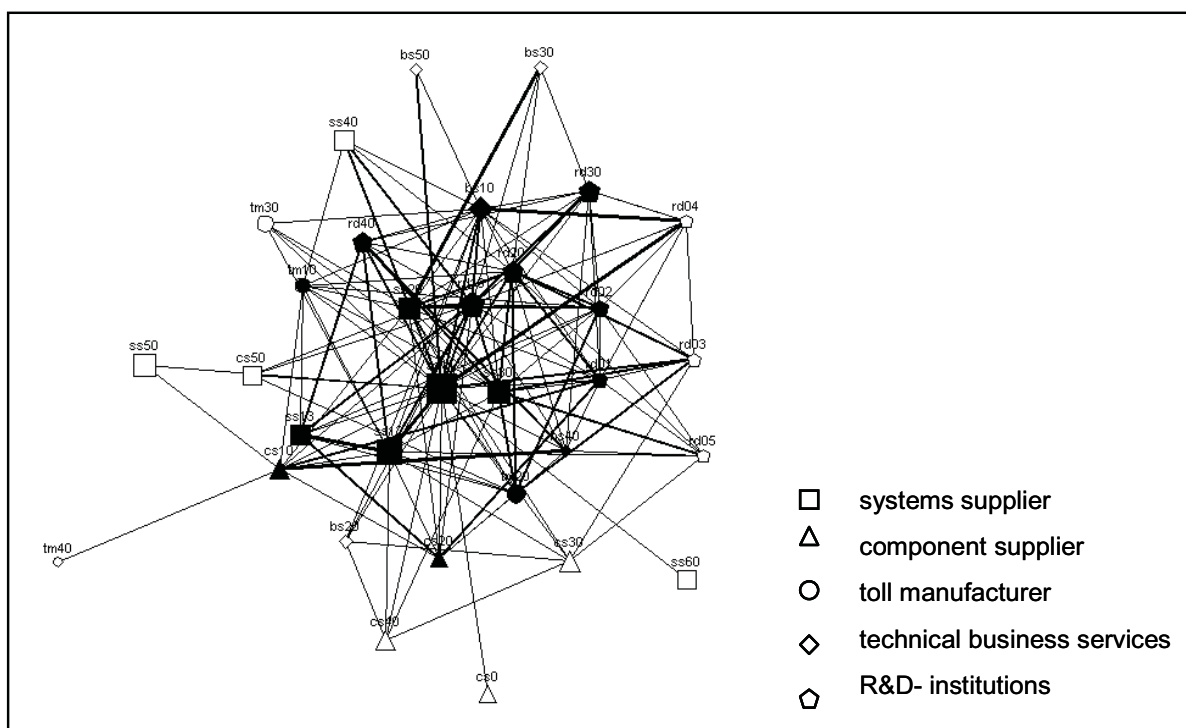


Fig. 2. Network of firms and knowledge generating institutions in Styria

Source: Steiner, M., Ploder, M. (2008), Structure and Strategy within Heterogeneity: Multiple Dimensions of Regional Networking, Regional Studies

Figure 2 gives an overview of all relations recorded and combines the three dimensions discussed above. Without going into the details concerning the different additional indicators of network analysis (for further discussion see Steiner & Ploder, 2008), the following important features can be outlined:

- In its regional dimension the network is strongly based on knowledge intensive relations. The graphical representation of the network relations, its decomposition, as well as the measured densities all reveal that the immaterial dimensions are stronger than the material ones: the highest density was obtained for pre-competitive R&D interactions. While the firms do have extensive supplier relations, these are relatively

weak within the region and within the network. However, their knowledge oriented relations are to a large degree regionally concentrated.

- The interactions are strongly structured: there are distinct leading actors in the network as a whole, both receiving and emitting more flows than others. Position is mainly dependent on size, export orientation, but also on the respective position in the value chain.
- These positions differ according to the type of interaction. Especially in pre-competitive research, local universities and cooperative R&D institutions have an important role and assume gate keeper functions. But firms with higher R&D capacities also take up such a role, indicating the necessity of a well-developed, internal knowledge base.

3.3 Focussing on the microlevel – the relative position of firms in the network

The network reveals very different positions of the agents: Some are at the center, some are at the periphery. Some have very frequent interactions, some are rather isolated in the network. The following two examples – taken from the social network analysis above – provide empirical evidence for complementary linkages of firms in the network to different innovation carriers, both cooperative R&D-institutions and technical engineering services.

3.3.1 ‘High R&D capacity and intensive interaction with knowledge generating institutions’ – case 1

The first firm (ss 20 in the total network) is an independent manufacturer of measuring and analysis devices for science and industry with considerable R&D-capacities. The firm is engaged directly in translating the findings of natural science so as to develop high quality measuring and analysis devices used in the foods and beverages sector, in pharmacy and in medicine.

The firm is vertically highly integrated and is embedded in smaller networks following niche strategies. The partners of the firm in direct delivery (component and toll-manufacturers) and partners in competitive and pre-competitive research and development (key clients, highly specialized business services, universities) are not identical. On the delivery side, the observed firm interacts with component suppliers in the field of die casting, spray casting, plastics processing, electronics, sheet metal forming, manufacturing of high performance glasses.

The firm has a relatively high in-degree centrality in respect of direct deliveries. The out-degree centrality of the firm in the region in the dimension of deliveries is considerably low owing to the high export intensity.

A high share of the turnover is reinvested in R&D -activities, 10% for intramural R&D and an additional 10% of the turnover for extramural R&D. While radical innovations and market novelties mostly emanate from R&D or client-partners, incremental improvements are promoted by internal R&D. R&D and production and marketing of new products are concentrated within the region.

The firm has a relatively high value for betweenness centrality, because it is not located in the core of vehicle manufacturing – the focus of the above analysis – but at the interface with other sectors such as manufacturing of plastic products or measurement techniques. The respective analysis of typical firm strengthens the thesis that the more firms act in market

niches demanding highly specialized cooperation partners, the more they tend to long-term cooperation.

A well established cooperation base includes university partners, and an independent research laboratory (firm bs 30 in the total network). The latter supplies firm ss 20 exclusively with science driven R&D activity and is an important source of innovation. The firm significantly gains from this long-term-partnership with firm bs 30 which is based on social trust and the long-term personal contact of both entrepreneurs. Although firm ss 20 directly and intensively cooperates with universities and other knowledge generating institutions it decided to participate in a cooperative research centre (Polymere Competence Center Leoben – PCCL – see below 3.4.2) in the field of polymers and plastics. The given framework allows intensive cooperation in terms of R&D-projects, but also provides a common framework for the targeted education of young academics and open exchange of information in the sense of communities of practice.

3.3.2 ‘Low R&D-capacity and weak interaction, yet attractive partner’ – case 2

The second firm (cs 10 in the total network) is an affiliate of an international firm group. The firm is active in the field of plastics for the aerospace and automotive industry. The firm works on the basis of work drawings and detailed specifications for both automotive and aerospace clients.

The firm has a relatively low in-degree centrality in respect of direct deliveries because of international sourcing strategies. The out-degree centrality of the firm in the region, in the dimension of deliveries, is considerable low owing to the high export intensity. As a result of the relative immobility of the local labour-force and the small capacity of the regional labour-market most of these firms had the chance to retain key-personnel, competences, and thus the regionally integrative potential of the personnel.

Although the firm has relatively low R&D-capacities, limited absorptive capacities and rather weak contact to university research it has nevertheless been able to establish a contract-based (flexible) partnership to a technical business service firm, and a long-term (but low cost) partnership to the cooperative R&D-institution (PCCL – see below 3.4.2) already introduced in case 1. An technical engineering service (firm bs 40 in the total network) is the major carrier of innovation for firm cs 10 and supports the development and implementation of new products from scratch to market launch.

Firm cs 10 is an active partner of the competence center but no pro-active driver and carrier of new R&D-projects. Nonetheless the partnership is attractive.

The (outward) R&D-efforts are concentrated on the aerospace sector, where 90% of the R&D is carried out by a regional engineering service firm specialized in plastics and polymer technology and in a small part by the competence center already mentioned in the case of firm ss 20.

Both firms considered here (case 1 and case 2) do not cooperate directly in terms of pre-competitive R&D, show different innovation capacities and pursue different individual strategies in R&D-cooperation.

The relatively low current costs of membership, clear rules of interaction and the stable framework of the competence centre seem to be open enough for partners with significantly different innovation capabilities. The set-up provides a flexible framework not only for direct interaction but also for indirect knowledge transfer, in the sense of communities of practice.

Such an institutionalised competence centre – having its own specific network but being integrated in larger informal networks – is the focus of the fourth approach to identifying and measuring knowledge in and between firms.

3.4 Intellectual capital reporting as an approach to measuring intangible assets in networks

3.4.1 Components of intellectual capital

Intellectual capital reports are intended to complement conventional financial reporting. They analyse and assess the intangible assets of organisations in a structured way and thus help to gain additional insight into the internal value of organisations (RICARDA, 2007), as well as their potential for knowledge generation, and knowledge sharing both internally and externally.

While academic interest has to date mainly focussed on intellectual capital reporting in single organisations (i.e. firms, universities, applied research organisations), a recent systematic attempt at applying the concept to knowledge intensive networks and clusters has been made within the RICARDA project¹. The case study presented below is based on the results of this project and provides some insight into the potential and limitations of this approach in dealing with clusters and networks.

Due to their specific character, networks entail certain challenges with respect to the preparation of intellectual capital reports. Since networks, in contrast to organisations, do not possess a clear boundary, categories of intangible assets need to be modified accordingly (RICARDA, 2007). Thus, using the three typical components of intellectual capital, and applying them to knowledge intensive networks, we have the following definitions (Edvinsson & Malone, 1997, adapted):

- Human capital is defined as the knowledge that employees bring and take with them when they join or leave the organisation (firm etc.) belonging to the network. It includes the knowledge, skills, experiences and abilities of people. Some of this knowledge is unique to the individual, some may be generic.
- Structural capital is defined as the pool of knowledge that stays in the network at the end of the working day. It comprises the organisational routines, procedures, systems, cultures, databases, etc. It allows knowledge to be codified to some extent, so that a certain degree of independence with respect to specific individuals results. Some routines may be legally protected and become intellectual property.
- Relational capital is defined as all resources linked to external relationships of the formal network management, such as external R&D-institutions, other clusters or networks, external stakeholders (e.g. regional policy) or non-member firms.

Table 4 provides an additional overview of examples of intangible assets in networks that fit into the three categories introduced above. The first column indicates the dimension of intellectual capital, the second column specifies the related categories of assets, and the last column provides working definitions for empirical work.

¹ RICARDA stands for “Regional Intellectual Capital Reporting – Development and Application of a Methodology for European Regions” and has been carried in the framework of Regions of Knowledge with funding of the European Commission under the 6th Framework Programme.

Dimension of Intellectual Capital	Asset	working definition
Human Capital	Knowledge base	profile of network's member organisations and its employees (in general and those involved in network activities)
	New capabilities and training opportunities	Institutionalised learning capacities for employees of network's member organisations provided by network management
Structural Capital	Interorganisational learning	Learning of network member organisation's employees in joint activities of network member organisations
	Interrelation and partnerships	Interrelations and partnerships between network member organisations
	Common ties, norms and mutual trust ("social capital")	Common ties, norms and mutual trust ("social capital") between network member organisations.
	Common infrastructure and services	Infrastructure and services available for network members only ("club goods")
	Management capacity and institutionalization	Network management's activities and procedures
	Innovation capacity	R&D and innovation activities of network member organisations
Relational Capital	Sound embedding into regional and national innovation system	Links to relevant innovation policy stakeholders outside the network
	Cooperation with other networks, clusters or single organisations	Links to relevant external stakeholders in the field of work of the network

Table 4. Examples for intellectual capital of networks
Source: RICARDA (2007)

3.4.2 Intellectual capital reporting in an Austrian knowledge intensive network

The network

The Polymer Competence Centre Leoben GmbH (PCCL) was founded as a cooperative research company within the framework of the Kplus programme of the Austrian Ministry of Transport, Innovation and Technology and as a competence centre in Polymer Engineering and Science. Since its founding in 2002 it has been based in Leoben (Styria) and operates offices in Graz (Styria) and Wels (Upper Austria) with a management team of 6 (full-time equivalents) and about 80 employees in all. By combining the scientific, engineering and methodological competence of leading polymer research institutions (12 scientific partners) with the technology, application and market-development expertise of the polymer industry and the service sector (40 company partners), the centre links the science-based approach of existing academic institutions with the applied research and product development approach of the polymer industry (Hartmann et al., 2007).

A main mission of PCCL – as part of the general mission of the competence centre programme in linking science and industry – is to carry out a joint research programme to generate new knowledge and know-how in specific areas of polymer engineering and

science, thus enhancing its own R&D competencies and those of its scientific and industrial partners. The application of a science-based methodology to industrial problems and the transfer of research findings, new and available knowledge, promotes the competitiveness of the PCCL and its partners. PCCL also seeks to promote regional development by enhancing the attractiveness of the location for domestic and foreign investors, spin-offs, and start-up companies. The PCCL was a pilot network in the framework of the RICARDA project (Hartmann et al. 2007).

Examples of intangible assets within PCCL

In order to give concrete examples for stocks of intangibles at the level of a knowledge intensive network, selected indicators collected at the PCCL will be presented and discussed in the section below. The discussion follows the structure of human, structural and relational capital introduced above. In addition, the concrete categories are also in accordance with the assets presented in table 4.

Human capital: The measurement of human capital in knowledge intensive networks is usually associated with the existing knowledge base at the time of the assessment and/or with the acquisition of new capabilities and skills by the employees of the network partner organisations. Table 5 represents the scientific and technological knowledge base of the PCCL network for 2006 by taking the number of employees with a university degree.

	employees with university degree	
	full time equivalents	head count
PCCL	52.4%	64.1%
scientific partners	63.3%	68.2%
partner companies	11.9%	15.3%

Table 5. Share of employees with university degree in the network (2006)
Source: Hartmann et al. (2007)

As can be seen, the distribution of this knowledge base is rather asymmetric in the PCCL network. While scientific partners (i.e. universities) have the highest share of academic staff (almost two thirds of their total staff), directly followed by the competence centre itself, the partner companies show much lower rates of personnel with academic training.

Structural capital: Structural capital was measured in the PCCL along several dimensions, but in particular in terms of the innovation output of the whole network. Table 6 provide the results for PCCL’s member firms for the years 2003-2005. In order to operationalise the innovation output, the categorisations of the EU community innovation survey were applied.

	In percent of PCCL company partners		
	2003	2004	2005
introduction of new or significantly improved goods	74%	68%	80%
introduction of new or significantly improved services	56%	69%	65%
introduction of new or significantly improved methods of manufacturing or producing goods or services	70%	74%	79%
introduction of new or significantly improved logistics, delivery or distribution methods for inputs, goods or services	33%	53%	42%
introduction of new or significantly improved supporting activities for your processes, such as maintenance systems or operations for purchasing, accounting, or computing	58%	72%	68%

Table 6. Key innovation indicators of PCCL company partners
Source: Hartmann et al. (2007)

Innovation output – as can be seen – fluctuated for the relevant times-span for all categories under scrutiny; the levels of intensity also differ between some of the categories. While patterns of product and process innovations are somehow alike at a high level innovations in logistics do not seem to play an important role for the member firms of the PCCL network.

Relational capital: The dimension of relational capital has been observed for the PCCL network with a particular focus on co-operations with other networks, clusters or single organisations. As a concrete operationalisation the number of collaborative R&D projects that did not receive funding of the Kplus programme has been under scrutiny (see table 7).

	R&D projects	
	total number	share
Non-Kplus 2005	45	100%
Non-Kplus-projects 2005 performed with partner companies of the (PCCL-) network	14	31.1%
Non-Kplus-projects 2005 performed with external companies	31	68.9%

Table 7. Share of PCCL R&D projects involving external R&D institutions/networks in 2005
Source: Hartmann et al. (2007)

While the first row of table 7 presents the total number of collaborative R&D projects without Kplus funding for the year 2005, the second row shows the number and relative share of those projects carried out with partners in the PCCL network, while the third row contains the number and relative share of those projects undertaken conducted with external partners. As can be seen, the projects that have been performed with external companies account for more than two thirds of the total and can be considered as an indicator of knowledge spillover extending far beyond the original network.

4. Conclusions

The approaches and results presented here show that knowledge and learning in its organizational form is no longer a black box – different methods allow not only for the conceptual definition and the recognition of the importance of organisational learning, but also for its quantification at different levels and in different forms. It can also be shown that knowledge creation and knowledge sharing is in need of specific institutions with different degrees of openness, institutionalization, and exclusivity – extending from rather closed hierarchical forms to more open market-like exchanges.

- Clusters as learning organizations are among the non-market devices by which firms seek to coordinate their activities with other firms and other knowledge-generating institutions. Thus, clusters can be interpreted as subtle and differentiated institutions for co-operation and interactive learning and as such they can be of considerable strategic significance (Steiner & Hartmann, 2006, 504). Yet the results of this approach also show that the forms of learning – within specific clusters – differ according to the technology used, competitive position, and orientation to regional or international markets.
- Patterned coordination does not arise automatically as a result of individual human action, nor does policy automatically create the necessary institutions. The creation of new institutions such as competence centres can be interpreted as a manifestation of institutional alertness on the side of policy makers. They can generate – as the intellectual capital reporting has shown – more knowledge and knowledge diffusion than originally intended: relational capital as an indicator of knowledge spillover is rather strong. Competence centres are primarily a closed club serving their direct partners in industry. But they also extend their knowledge creation function to organizations outside the original institutionalized network.
- The social network analysis applied here reveals that networks are strongly based on knowledge intensive relations. But these relations are no mechanical result of routine-like networking: The firms pursue different sourcing strategies; their activities comprise a portfolio of interactions. The different dimensions of interaction coincide only to a small degree: supplier relations are more or less separated from knowledge intensive ones. There is no automatic parallelism of interactions. This does not exclude automatic spillovers of knowledge connected with supplier relations, but it does illustrate that the higher intensities of knowledge exchange as indicated by the revealed forms of interaction are consciously and selectively chosen, and are not a mere by-product.
- This also implies that knowledge management is a task to be fulfilled at different levels: Firms establish a variety of types of interactions and relationships each of them having different impacts on the knowledge generation and diffusion process. Mariotti and

Delbridge (2001) speak of the necessity for firms – in the face of knowledge ambiguity, of knowledge related barriers, of tacitness and complexity of knowledge – to engage in the management of a portfolio of ties. But individuals and firms alone are, from an economic point of view, not capable of delivering sufficient amounts and varieties of knowledge.

This leads to the final conclusion emphasising the differentiated need of institutionalization of knowledge generation and sharing – clusters, networks and related forms of interfirm cooperation are necessary preconditions for and reveal – as the empirical approaches have shown – different forms of ‘thinking’.

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Advances in Technology, Education and Development

Edited by Wim Kouwenhoven

ISBN 978-953-307-011-7

Hard cover, 474 pages

Publisher InTech

Published online 01, October, 2009

Published in print edition October, 2009

From 3rd to 5th March 2008 the International Association of Technology, Education and Development organised its International Technology, Education and Development Conference in Valencia, Spain. Over a hundred papers were presented by participants from a great variety of countries. Summarising, this book provides a kaleidoscopic view of work that is done, all over the world in (higher) education, characterised by the key words 'Education' and 'Development'. I wish the reader an enlightening experience.

How to reference

In order to correctly reference this scholarly work, feel free to copy and paste the following:

Michael Steiner, Christian Hartmann and Michael Ploder (2009). Knowledge in Technology Networks: A Case Study Based Institutional Approach, Advances in Technology, Education and Development, Wim Kouwenhoven (Ed.), ISBN: 978-953-307-011-7, InTech, Available from:
<http://www.intechopen.com/books/advances-in-technology-education-and-development/knowledge-in-technology-networks-a-case-study-based-institutional-approach>

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