STRATEGIC BEHAVIOUR AND KNOWLEDGE MANAGEMENT OF FIRMS: EVIDENCE FROM NETWORK ANALYSIS

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Abstract:

The paper explores forms, channels and mechanisms of interactions and knowledge exchange between firms in networks. It argues that knowledge transfer is by no means automatic, that proximity per se is not sufficient to generate knowledge between firms, that the forms of organized learning differs remarkably between networks, that the diffusion of knowledge within networks is highly selective and strongly dependent of the position of firms within networks and their absorptive capacity.

Some “stylized facts” in support of this perspective will be presented on the basis of a regional network analysis in the case of medium tech clusters in Styria. They can be characterized as more or less individualistic open systems consisting of several overlapping networks. Physical linkages between these networks are rather weak, but intersections based on cooperative R&D and R&D infrastructure, qualification and informal exchanges are evident and seem to dominate. Despite of evident sectoral concentrations direct links to the science base seem to loom larger as binding factors than long term supplier networks. These relationships will be interpreted in terms of their necessity for proximity, their durability but especially their direction of knowledge dependency.

1 Strategy and selectivity within knowledge networks of firms

Growth of the knowledge base 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 (Cohen/Levinthal 1989, Andersen 1995, Hartmann 2004). These insights shifted the emphasis from material links to immaterial knowledge flows within clusters and pointed to the need for connectivity between different agents for knowledge creation and diffusion. This then leads to further questions concerning to what degree clusters are to be regarded as non-market devices by which firms seek to coordinate their activities with other firms and knowledge-generating institutions. Ongoing learning processes between firms and within clusters stress the importance of institutional arrangements for the generation of knowledge and learning networks which are not available in the markets (Maskell/Malmberg 1999). Since the necessary knowledge may lie outside a firm's traditional core competence interfirm alliances and networks are widely recognized as an important organization form of innovative activity (Gay/Dousset 2005).

Vast recent research points at networking capabilities as a key factor to innovate and at the fact that the core of innovative capacity resides in the capacity of efficiently combining different pieces of knowledge by various agents and agencies (for a compilation see Ronde/ Hussler 2005). This induces firms to 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 face of knowledge ambiguity, of knowledge related barriers, of tacitness and complexity of knowledge – to engage in the management of a portfolio of ties. Organizations therefore are likely to engage in inter-organizational relations that show a variety of types of ties: They can have quite different dimensions and can be defined according to the character of social relations between actors, the regulation of the relationship, frequency of use, length of the relationship and also of course the nature of information exchange (Mariotti/ Delbridge 2001, 13). It is also important to distinguish between both content (i.e. the type of relation) and the form (i.e. the social structure of relations) as has been outlined by Powell/Smith-Doerr (1994). Mariotti and Delbridge point in this context also to the concept of "modular organization" (Sanchez/Mahoney 1996): the decomposition of a complex system into loosely-coupled modules permits the integration of specialist knowledge without the actual transfer of knowledge itself – a concept that can be applied to intra-firm structures as well as inter-firm types of cooperation.

These differentiations lead to further reflections on the forms, channels and mechanisms of knowledge exchange. This exchange occurs through interaction, the structure of the interaction therefore influences the extent of knowledge diffusion (Gay/Dousset 2005). Two basic approaches are opposing each other (Giuliani 2005, 4): the one attributes knowledge a high degree of 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 (where Giuliani includes both the economists' perspective on 'localised knowledge spillovers' and the economic geographers' view of cluster 'collective learning') emphasizes the strong relationship between spatial clustering, knowledge spillovers, and firm's innovative output – "proximity" and "territory" lead to a quasi-automatic diffusion of knowledge leading to innovation. This automatic mechanism is more put into question by economic geographers who regard geographical proximity per se as not sufficient and who emphasize the additional role of social and relational proximity entailing an interactive and cumulative effort by co-localized firms yet nevertheless resulting in unstructured and diffuse local interactions. The other perspective points to the heterogeneity of firms' knowledge base, their different capabilities, the existence of 'technological

leaders' and 'gate keepers' in a local community. These differences do have an effect on the mechanisms by which knowledge is transmitted resulting in the fact that knowledge diffusion is not collective but rather structured by the relative distance of firm's knowledge bases (Giuliani and Bell 2005).

As a consequence of these theoretical approaches and reflections we conclude that cluster theorizing has to avoid universalism –there is not only strong diversity between clusters but also within. Clusters are highly differentiated across sectors, regions and countries. There is also no single model of knowledge transmission, also not within clusters. Knowledge transfer can not be assumed to be automatic, proximity per se not to be sufficient to generate learning between firms, the diffusion of knowledge within clusters to be highly selective and strongly dependent of the position of firms within networks and their knowledge base and absorptive capacity.

These approaches help us to focus our empirical attempt of applying methods of network analysis as a way to develop the quality analysis of clusters. The insights gained by the above reflections can be formulated as tentative hypothesis and guiding principles for our analysis:

- Networks consist both of material and immaterial links. Material links are predominantly input-output-linkages in form of market transactions of deliveries. Yet immaterial links in the form of various exchanges of knowledge are the essential element of network activities of the firms involved.

- Networks fulfil different functions and serve different purposes. The interactions within networks therefore assume different dimensions which do not necessarily coincide – from the exchange of goods to the sharing of various kinds of knowledge
- In dependence of their resource-base and strategy not all firms participate in equal intensity in the network and are equally involved in knowledge sharing. There are firms that play leading roles in knowledge generation and diffusion and assume functions of technological leaders for knowledge transfer.
- The interaction of firms includes quite diverse activities and constitutes a sort of portfolio of possible interactions responding to various needs in situations of uncertainty and bounded rationality.
- Knowledge does not spread evenly within networks – there are distinct points of knowledge creation and diffusion depending of the role and position of the firm within the network.
- Knowledge networks are evolving according to the changing needs of the firms involved. They are no closed system but rather temporary alliances between firms.

2 Empirical approach: Network analysis – an outline

Network analysis is a well established method in the social sciences. Recently the method has also been applied for the analysis of production clusters (Krätke 2002), innovative activity and knowledge exchange (Giuliani 2005), alliance networks (Gay/ Dousset 2005) or R&D networks.

Social network analysis is a helpful tool to discuss the structure of networks and allows the mapping and measuring of the relationships (communication and transaction) between different actors, that is the existence, context and portfolio of relations between actors in a regional network. It is a method to expose relations between different actors, phenomena which cannot be reduced to the properties of individual actors or firms themselves. Therefore relations rather have to be interpreted as properties of systems than of individual actors.

The empirical database

To find the empirical basis for the network analysis we used the snowballing method of sampling in cluster and network investigation which correspond with the relational approach and is developed by means of the references to actors which have been revealed by previous respondents (Frank 1979, Scott 2000).[1]

Startingpoint was a large system supplier in the automobile sector located in the region of Styria / Austria. The snowball method led to firms belonging to different sub-sectors of the manufacturing sector and cultivating related supply-chain and innovation-strategies. Following a citation path of regional suppliers (production or commercialization of goods and services) and regional partners in the field of research and development (cooperative R&D and related activities and exchange) of the initial firm the sample has been developed in a first step. In this way the data-base for the following network analysis was extended to 23 firms (of which 18 are producer and 5 are service oriented) and 9 R&D-institutions. The information and data collected are based on extensive qualitative interviews and supported by a quantitative survey concerning specific figures of the firm.

Indicators of interaction

The presented and the additional qualitative indicators revealing individual strategies of innovation may be helpful for the discussion of individual strategies which finally sum up to the structure of the network. They are selectively used to find – via network analysis - structural features of the network of 32 actors. The selected indicators of the relations cultivated by the organizations cover three dimensions of interaction: direct delivery relations, R&D and technological innovation in a competitive and a pre-competitive context.

(DELIV): The firms have been asked for direct delivery relations (goods or services) to clients, suppliers or partners (in the case of synergetic product bundles).[2] The direct delivery of goods and service is not reduced to the material dimensions but extends also to innovation-related questions in the context of quality and information management or capacity extending investments.

(PRE-COMP): Another questioned dimension has been interaction in the context of pre-competitive R&D. Pre-competitive Research and Development aim to the extension of the product spectrum, as well as the introduction of new processes and alternative materials. Pre-competitive research includes fundamental research, which is an activity designed to broaden scientific and technical knowledge not linked to industrial or commercial objectives as well as industrial

[1] The assumption is that the segment of the network that forms the sample is representative for the whole network. Therefore it is inevitable to have a deeper knowledge about the parent population and basic relations. A previously done investigation by sample interviews was able to support this assessment.

[2] The dimension of supply-chain-networks is a function of vertical integration and division of labour in an industry. The automobile but also the aerospace are the mascots of empirical investigations of supply chain networks and relations. Anyhow they are special cases because middle or high volumes of products with a relatively high number of individual parts are produced by specified routines. Regional clients in other areas of the machinery sector and their limited lot or individual piece orders set limits to medium and long-time strategic planning, to automation and long time growth. The traditional machinery sector did not pick up this strategy that extensively. Given the importance of the systems being subcontracted by assemblers, there is a clear strategic goal of these firms toward working with a smaller number of large suppliers.

research, which is research aimed at developing or improving new or existing products, processes or services as far as it is not directly connected with a client tender, an offer or an existing business relation.

(COMP): Competitive Research and Development and innovation processes are short and medium time oriented and mostly associated with direct expectations of return respectively a direct tender or offer etc., while pre-competitive R&D are long-time oriented.

Basic concepts of network analysis used

Following the socio-centric approach the density of a network indicates ratio of actually present relations realized of the total number of potentially maximum possible relations. We dichotomized the relations. That is we only differentiate between existence and non-existence of a relation between two actors [0; 1], and therefore disregard for the moment the intensity of the relations (in our case the frequency of interaction) which have been questioned to avoid problems which accompany the measurement of the density of valued graphs (Scott 2000). The density yields information on the general structure of the network as a whole.

One of the core-features of an actor which can be identified in network analysis is its centrality. Using the concept of centrality (in different forms) we gain insights in the specific features of the interaction of the actors in the network and their specific position respectively embeddedness in the network. While the density focuses on the properties and general structure of the network as a whole, the centrality tries to capture the position of individual actors or groups of actors within the network. This is again based on the relations which have been revealed by the actors, this time the relations are valued ordinally with the frequency of interaction. The potential centrality of an actor is determined by a broad range of industry respectively sector specific factors (Cohen et al 2000), capacity and individual motivation (Bayona et al. 2001, Theter 2002). A high centrality is positively associated with multipe possibilities to get information and generate knowledge.

3 Analysis and results

The discussion starts with an observation of striking features of the network respectively the network dimensions as a whole and will focus on the position of individual actors in the network in a second part.

Structure of the network and network density

The analysis focuses on regional relations holding in the back of the head that interregional and international ones exist and may be of major priority, as it is especially the case for direct delivery relations. Table 1 presents the density measure for the three dimensions of relations between the actors.

Table 1 Density of the observed dimensions of networking

Relational dimensions		***Density***
(DELIV)	direct delivery relations	0,068
(PRE-COMP)	interaction in the context of pre-competitive R&D	0,143
(COMP)	interaction in the context of competitive R&D and	0,074

Direct delivery relations have the weakest density. Although the datasets have been dichotomized and therefore relations with a very low frequency of interaction have been "up-graded" the density of the network of direct delivery relations is lower than the density of knowledge intensive innovation-related interaction. Regional input-output relations have been reduced in favour of an orientation towards international markets.

While competitive R&D and innovation processes especially in the case of domestic system suppliers partially are 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 in respect of direct delivery relations the network is based to a considerable degree on relations to cooperative R&D institutions.

The relational data can be used for a graphical representation of the transaction network of the observed organizations. The network diagram is the traditional and basic methodology for formalizing network analysis and is still a very helpful mean of interpretation and discussion, albeit clarity suffers with an increasing number of actors which are observed.[3] A quite useful method of graphical representation which is implemented in most software packages follows the approach of Kamada-Kawai(1989) spring embedding algorithm.

Figure 1 gives an overview over all relations which have been recorded. Figure 1 combines the three dimensions which already have been discussed. The following diagram merges all dimensions of networking taking into account the valuation of the relations in reference to the frequency of interaction.

[3] Even in the case of a network of 32 actors with a relatively low density the number of cross-cutting relations would cause confusedness to a certain degree, all the more this is evident for a network with a density of 0,223.

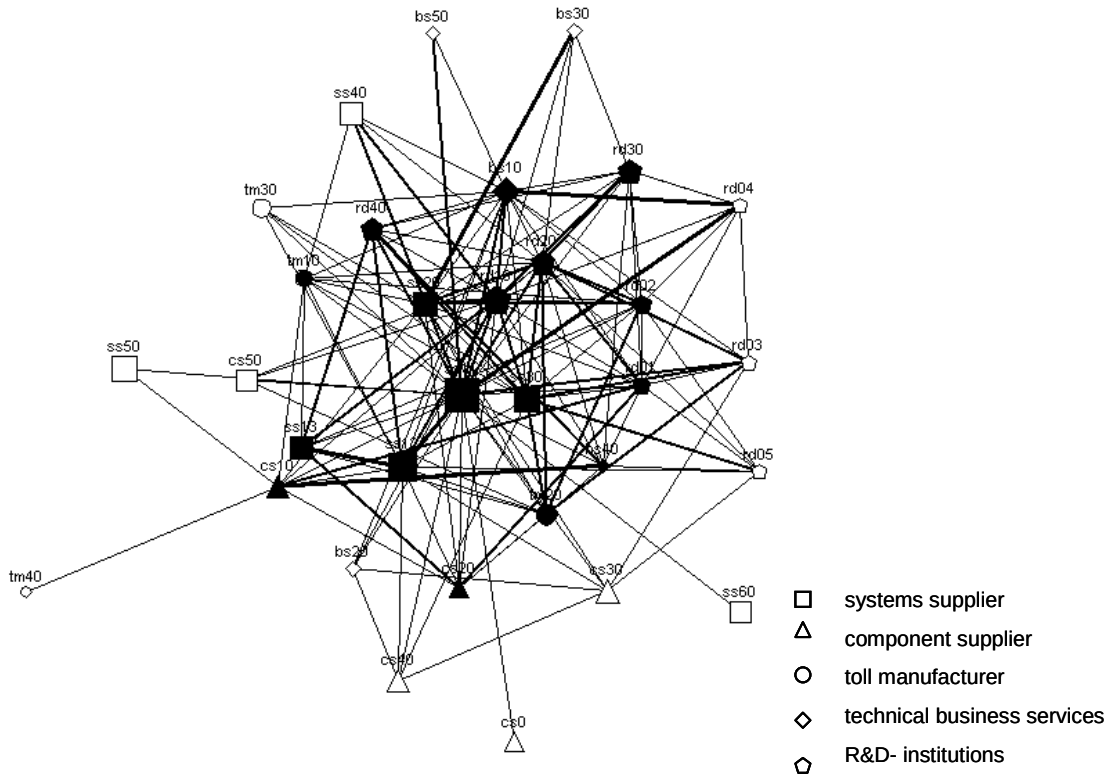

Figure 1 Network of firms and Knowledge generating institutions

A further interesting dimension of network analysis is the 'coreness' which follows basically the idea of core and periphery. We therefore use the concept of the *k-core* (Seidman 1983, Scott 2000). A *k-core* is a sub-graph in which each actor is adjacent to at least k other actors' in the sub-graph. That is, for all nodes in the sub-graph minimum the number of the actors direct relations within the sub-graph is k (in our case eight). The resulting k-core is a complement to the measurement of density, which was not able to reflect structural features of the network. The k-core is an area of relatively high cohesion. The shape of actors (nodes) corresponds with the different types of organizations. The size of the nodes corresponds with the size of the organisation. Finally the length of lines corresponds with the distance between the observed actors. As can be seen at the first glance, we can differentiate between actors which are in the core of the network (black coloured) and actors, which are more less on the periphery of the network (white coloured). The diagram makes aware of the high density of realized relations which has been calculated in the previous paragraphs. In the k-core of the diagram we can find a group of institutions which seem to interact

multilaterally. In the “core” of the network, we can find R&D institutions, large system suppliers but also toll manufacturers (surface-treatment, heating etc.) which hold multiple but weak relations to a broad range of regional clients.

Decomposition of network relations

In the next step, we try to decompose the total network following the three main dimensions of directed exchange. In order to facilitate the visual comparability of the decomposed dimensions of networking we choose another method of visualization. The circle diagram is a very useful method of organizing the available data, by arranging the actors and ensuring a minimum overlap among the lines which stand for relations between actors. The position of the actors is identical in all diagrams. The qualities of network diagrams can be interpreted analogous to the typical form of representation as a matrix. Analogous to the definition of asymmetric matrices we also can identify unidirectional graphs. Again the valued relations are taken into account. Analogous to the diagram in Figure 2 the size of the nodes corresponds with the size of the organisation. The shading indicates the exporting-rate (white:= ~ 100%; black := ~ 0%). Finally the actors are arranged around the core field of economic activity of their competence following the Nace-Classification. As can be seen at the first glance relations in the dimension of direct delivery differ from the relations in the dimensions PRE-COMP or COMP. In the network of direct deliveries relations seem to concentrate in the surroundings of large export-oriented systems suppliers in the Nace 34 sector, manufacture of motorvehicles and vehicle parts, with core competences in the fields of development and assembling which are service firms in the same sector but also from component and toll manufacturers in the Nace 27 and 28 sector manufacturing of basic metals and fabricated metal products (including die casting, forging or surface treatment) with core competences in the field of metal processing and material science in its widest sense and finally from firms in the Nace 25 sector in the field of manufacture of plastic products, which have a relatively broad client base, beyond the NACE 34 sector. In the networking dimensions PRE-COMP and COMP R&D institutions are – as expected - involved prominently. A considerable amount of small and medium sized firms are not integrated in this regional dimensions of exchange.

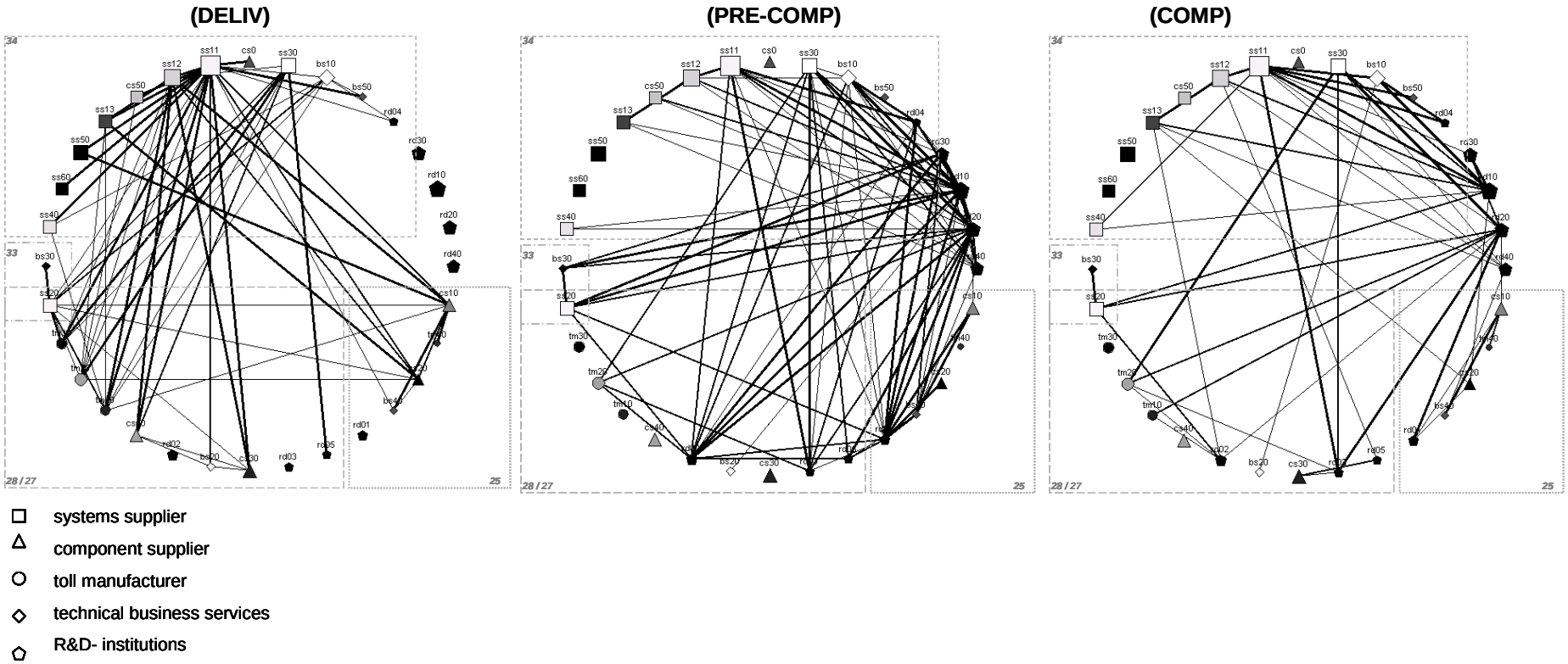

Figure 2 Comparative presentation of the observed dimension of networking

Figure 2 not only supports the density measure but also indicates that the observed dimension of networking only overlap weakly. Taking into account the existent relations on the side of direct delivery products and service deliveries on the one hand and R&D and Innovation-transfer on the other side it is of interest which share of relations is exclusively business and delivery–driven and which share on the other hand is exclusively R&D and Knowledge-driven. [4]

Different networking strategies of firms

According to the qualitative interviews with the observed institutions this pattern seems to be the aggregated reference of the individual strategies which have been revealed by the interviewed firms. The actors have a broad range to steer their portfolio: by the frequency of interaction, the time of interaction, the choice of the partner (Mariotti/ Delbridge 2001) and the thematic focus of the relationship (specialized or ubiquitous). Beyond that the choice of partners depends on the level of technological spill-overs, the technological and economic capacities and the strategic relevance of the cause to interact (Atallah 2005). The qualitative interviews strengthened the notion that firms seek to steer a portfolio of cooperation partners which consciously combine specialization and flexibility.

While larger firms with remarkable R&D-capacities can utilize international contact in research and development activities, smaller low- or medium-tech firms stick to the region and regional partners. Smaller firms are rather confronted with a self-enforcing combination of low capabilities to research and develop on the one hand and unambitious demand from the client's side. Therefore transaction costs mostly are disproportionate to the technological and economic gain of co-operations dealing with questions of pre-competitive research and development. The low and medium-tech firms partially utilized opportunities to establish long-time contacts to single public or semi-public R&D-institutions which deal with basic technologies – mostly material sciences - in their business and try to gain from possible spill-overs from the activities which are transferred per appropriate events or informal inquiries. Therefore partners in direct delivery and partners in competitive and pre-competitive research and development - as far as existent - are not identical.

Firms with remarkable R&D-capacities revealed different strategies in dependence of their market and co-operation culture. The more these firms act in market niches which also demand for highly specialized cooperation partners the more they tend to long-time cooperations with rather specialized partners.

As far as natural spill-overs are high and competitive conflicts are manageable (e.g. in the case of material sciences) larger firms accepts weaker partners - respectively smaller firms - and are willing to integrate them. Low spill-overs and higher market orientation favour a conservative sometimes excluding behaviour of the stronger side. This corresponds with the findings for strategies of partner selection in R&D-cooperations (Atallah 2005).

Spotting a leading firm in the network

The specific firm (ss 20 in the total network) is a highly specialized manufacturer of measuring and analysis devices for science and industry. Its success is based on the direct transportation of findings of natural science in high quality measuring and analysis devices which are able to measure physical or chemical phenomena.

[4] In favour of clarity we dichotomized and symmetrised the relations for this consideration, which means that the definition of all relations is reduced to their existence notwithstanding the frequency and direction of interaction.

The firm is vertically highly integrated and is embedded in smaller networks which are concerted with their 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.

Primarily the firm was a pure converter, producer and specialist in marketing. This division of labour changed since the 1980s. A well established cooperation base allows utilizing university partners but also an independent research laboratory which is supplying to the firm exclusively for science push driven R&D. 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 considerable low because of the high export intensity.

A high share of the turn-over is reinvested in R&D –activities, 10% for intramural R&D and additional 10% of the turn-over for external R&D. The degree centralities in respect of R&D (pre-competitive and competitive) are higher than for the average of the leading firms in the network. The core competences of the firm are based on combinative knowledge on the edge of a high receptivity for findings from basic research, competences in precision engineering and electronics.

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 in the core of vehicle manufacturing but in the interface with other sectors such as manufacturing of plastic products or measurement techniques. The respective firm is a typical example strengthening the thesis that the firms act in market niches demanding highly specialized cooperation partners, the more they tend to long-term cooperation.

4 Tentative conclusions

The network approach as a „sociometric analysis“ of various forms of interactions and its results allow some tentative conclusions:

- The network in its regional dimension is dominated by knowledge intensive relations. Both the graphical representation of the network relations and its decomposition as well as the measured densities reveal that the immaterial dimensions dominate the material ones: the highest density was reached by pre-competitive R&D interactions. The (industrial) firms do have extensive supplier relations but not so much within the region and within the network. Yet their knowledge oriented relations are to a large degree regionally concentrated.

- 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 spill-overs of knowledge connected with supplier relations yet it emphasizes that higher intensities of knowledge exchange as indicated by the revealed forms of interaction are selectively chosen and no by-product.
- The interactions are strongly structured: there are distinct leading actors in the network as a whole both receiving and omitting more flows than others. The position is mainly dependent of size, export orientation, but also of the position in the value chain. Yet again these positions are differentiated according to the type of interaction. Especially in pre-competitive research local universities and cooperative R&D institutions have a dominating role and assume gate keeper functions. But also firms with higher R&D capacities take up such a role indicating the necessity of a developed internal knowledge base.
- This dominating role of the newly founded cooperative R&D institutions (competence centres) might be taken as an indication that this kind of network relation is rather new and that the pattern of interaction has a temporary character and depends of the existence of specific kinds of knowledge generating institutions.
- The pronounced density of regionally concentrated interaction of R&D within the network gives support to the concept of networks as institutions for knowledge exchange themselves.
- Beyond persons who generate knowledge and firms as organizations for R&D we need to include networks and clusters as an additional level of socio-economic analysis in this process.

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