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Structure and Strategy within Heterogeneity: Multiple Dimensions of Regional Networking

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8 ABSTRACT
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10 Clusters are highly differentiated across sectors, regions and countries – both theoretical and
11 empirical approaches therefore have to avoid universalization. Based on recent approaches
12 various forms of network relations and possible contents of interactions of firms connected
13 with knowledge exchange are elaborated. It will be argued that these interactions are
14 distinctively structured, that the diffusion of knowledge is highly selective and strongly
15 dependent on the position of firms within networks and on their absorptive capacity.
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18 By applying network analysis to different dimensions of interactions between firms it is
19 shown that physical linkages within the medium technology cluster under scrutiny are rather
20 weak, that interactions based on different forms of knowledge exchange are denser, and that
21 direct links to the science base seem to be more prominent than long term supplier networks.
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40 Keywords: regional networking, knowledge exchange, institutions, network analysis
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42 JEL: L29, L62, L64, O39
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45 Structure et stratégie dans l'hétérogénéité : Dimensions multiples des réseaux régionaux
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48 Michael Steiner et Michael Ploder
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50 RESUME
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52 Les groupes sont très différenciés entre secteurs, régions et pays ; les approches théoriques et
53 empiriques doivent donc éviter l'universalisation. S'appuyant sur des approches récentes,
54 diverses formes de relations de réseaux et de contenus possibles d'interactions d'entreprises
55 liées à des échanges d'informations sont élaborées. On pourrait objecter que ces interactions
56 sont structurées de manière distinctive, que la diffusion du savoir est très sélective et dépend
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3 fortement de la position des entreprises au sein des réseaux et de leur capacité d'absorption.
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5 En appliquant l'analyse de réseau aux différentes dimensions des interactions entre les
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7 entreprises, il apparaît que les liens physiques au sein du groupe technologique examiné sont
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9 plutôt faibles, que les interactions basées sur différentes formes d'échanges de savoir sont plus
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11 denses et que les liens directs avec la base scientifique semblent plus éminents que les réseaux
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13 de fournisseurs à long terme.
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20 Mots-clés : réseautage régional, échanges de savoir, institutions, analyse de réseau
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23 JEL : L29, L62, L64, O39
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25 26 **Struktur und Strategie innerhalb der Heterogenität: mehrfache Dimensionen der** 27 **regionalen Netzwerke**

28 Michael Steiner and Michael Ploder

29 ABSTRACT

30 Je nach Sektor, Region und Land sind Cluster hochgradig differenziert, weshalb bei
31 den theoretischen und empirischen Ansätzen Verallgemeinerungen vermieden
32 werden müssen. Ausgehend von neueren Ansätzen werden verschiedene Formen
33 von Netzwerkbeziehungen und möglichen Inhalten der Wechselwirkungen zwischen
34 Firmen im Bereich des Wissensaustauschs ausgearbeitet. Es wird argumentiert,
35 dass diese Wechselwirkungen charakteristisch strukturiert sind und dass die
36 Verbreitung von Wissen auf äußerst selektive Weise erfolgt und in hohem Maße von
37 der Position der Firmen innerhalb der Netzwerke sowie von ihrer
38 Absportionskapazität abhängt.
39

40 Durch eine Anwendung der Netzwerkanalyse auf verschiedene Dimensionen der
41 Wechselwirkungen zwischen Firmen wird gezeigt, dass die physischen
42 Verknüpfungen innerhalb des untersuchten Clusters der Mitteltechnologie eher
43 schwach ausfallen, dass die auf verschiedenen Formen von Wissensaustausch
44 beruhenden Wechselwirkungen dichter sind und dass direkte Verbindungen zur
45 Wissenschaftsbasis eine prominentere Rolle zu spielen scheinen als langfristige
46 Liefernetzwerke.
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50 51 Keywords:

52 Regionale Netzwerke

53 Wissensaustausch

54 Institutionen

55 Netzwerkanalyse

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57 JEL: L29, L62, L64, O39
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3 Estructura y estrategia en la heterogeneidad: dimensiones múltiples del sistema regional de
4 redes

5 Michael Steiner and Michael Ploder

6 ABSTRACT

7 Las aglomeraciones están muy diferenciadas en función de sectores, regiones y países, por lo
8 tanto es necesario evitar una universalización tanto a nivel teórico como empírico.
9 Basándonos en recientes planteamientos, elaboramos distintas formas de las relaciones de
10 redes y los posibles contenidos de las interacciones de empresas conectadas con un
11 intercambio de conocimientos. Sostenemos que estas interacciones están estructuradas de un
12 modo característico, que la divulgación de conocimiento es muy selectivo y depende
13 altamente de la posición de empresas en las redes y de su capacidad absorbente.

14 Aplicando los análisis de las redes a diferentes dimensiones de interacciones entre las
15 empresas, mostramos que los vínculos físicos en la aglomeración de tecnologías medias bajo
16 escrutinio son bastante débiles, que las interacciones basadas en las diferentes formas de
17 intercambio de conocimientos son más densas y que los vínculos directos para la base
18 científica parecen ser más importantes que las redes de suministradores a largo plazo.
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23 Keywords:

24 Sistema de redes regionales

25 Intercambio de conocimientos

26 Instituciones

27 Análisis de redes
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30 JEL: L29, L62, L64, O39
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1 Introduction

The debate on clusters, industrial districts and networks of firms has now been around for more than two decades. While earlier contributions to work on industrial agglomerations remain important, the concept of cluster has gained in relevance as a result of a change in the dominant form of production from large scale mass production to flexible specialised producers leading, to the necessity of greater cooperation between firms. The debate has been reinforced by a vast literature (recently e.g. MALMBERG/MASKELL 2002, STORPER and VENABLES 2002, GORDON/McCANN 2005, MALMBERG/POWER 2006) concentrating on the combination of clusters, innovation, and regional development, where innovation is favoured by regionally concentrated interaction of (mostly) small firms mutually exchanging information and creating knowledge in formal and informal ways.

In the search for a common conceptual foundation – or even a unifying theory – and in diverse attempts to find empirical evidence for the role clusters and networks play in a knowledge based economy, several strands of theoretical approaches have been combined: These include analysis of the influence of institutions on human economic behaviour, the role played by knowledge in the creation of wealth, the influence of space and distance for economic decision making, as well as work on the problem of coordinating individual decision making units. Clusters and their networks may now be seen as phenomena that combine the theoretical elements of knowledge, proximity and institutional character.

There has also been a gradual change in perspective regarding the interpretation of clusters, accompanied by a corresponding shift of emphasis in empirical analysis. For example:

- Clusters originally were seen as geographically condensed forms of economic activities and – in the tradition of industrial districts – mostly regarded as material

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3 links between firms and/or sectors within given geographical limits. They were often
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5 based on value chains or supply links of economic activity. The recent renaissance of
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7 interest has focussed more on the immaterial connectivity of clusters emphasizing
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9 technological knowledge spillovers and the different forms of learning occurring
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11 within and through networks (COOKE/MORGAN 1998, CAPELLO/FAGGIAN
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13 2005, STEINER/HARTMANN 2006).

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18 • Networking has come to be regarded as an important form of innovative activity. This
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20 has not only been taken up by regional scientists but also by various strategic
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22 management and industrial dynamics approaches to inter-firm cooperation
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24 (VONORTAS 2000) and extended to questions of identifying competences and
25
26 capabilities in strategic management on different levels of economic interaction
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28 (FELIN/FOSS 2005).
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32 • The question as to what extent these economic interactions are in need of specific
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34 guiding and coordinating institutions is a further new element in the cluster debate.
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36 Interactions need institutions (such as markets); yet if the focus is on learning and
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38 knowledge, markets alone will not suffice for such forms of interaction and additional
39
40 institutions will be needed (BÜNSTORF 2003). Clusters may be regarded as
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42 coordinating institutions for knowledge sharing , providing a cognitive framework for
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44 transforming information into useful knowledge (AUDRETSCH/LEHMANN 2006,
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46 STEINER 2006).
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51 • Diverging opinions about the mechanisms and forms of learning and knowledge
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53 sharing have thus arisen. Questions highly relevant for research are: What is the
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55 geographical extent of clusters, is (geographical) proximity a necessary and/or
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57 sufficient condition for the spread of knowledge (RALLET/TORRE 1998); is
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59 knowledge spill-over in clusters a pre-dominantly regional phenomenon, or are there
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also important extra-regional knowledge linkages (BATHELT et al. 2004); are

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3 technological spillovers more or less automatic, or is the process of knowledge
4 diffusion and the spread of innovation consciously driven and dependent on the
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6 structural characteristics of clusters, on the 'technological leaders' in a region, or on
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10 specific 'gatekeepers' within networks (GIULIANI/BELL 2005).
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15 In terms of empirical analysis, such questions raise several new challenges. In the past,
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17 clusters were often defined in terms of geographical concentration of specific sectors or firms.
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19 More refined versions used regional input-output tables for the identification of concentrated
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21 material linkages and/or bottom-up approaches using firm interviews. The question of
22
23 knowledge cooperation and diffusion was mostly approached using spatial analysis of patent
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25 data and supported by qualitative in-depth interviews and surveys of firms. More recently
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27 attempts have been undertaken – especially on the basis of institutional approaches – to use
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29 network analysis methods. Such a methodology allows for the mapping and measuring of
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31 interactions between different actors; it is hence a helpful instrument in analysing the form
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33 and content of relationships of firms within networks and in revealing the system properties of
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35 economic and social relations.
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44 This paper will employ such network analysis in order to highlight the structure of
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46 knowledge-intensive network relations on the basis of selected interactions between firms in
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48 the machinery sector of Styria, a region within Austria. To gain additional insights
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50 information resulting from regression analysis and from extensive interviews will be included
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52 to support the qualitative analysis of regional cluster dynamics. The aim of the paper therefore
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54 – based on recent contributions concerning the role of clusters in the process of knowledge
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56 generation and knowledge diffusion – is to gain closer insights into various forms of network
57
58 relations and into the possible contents of interactions connected with knowledge exchange.
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3 The paper is structured as follows:
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5 Section 2 gives a focussed outline of the conceptual and theoretical approaches in the recent
6 debate and serves as the basis for the identification of relevant questions and the formulation
7 of tentative hypotheses;
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9 Section 3.1 describes the region under scrutiny – Styria, in Austria, whose recent development
10 has led to the need for new firm strategies;
11

12 Section 3.2 outlines the data and the methodological approach employed;
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14 Section 3.3 will describe the results of the network analysis in combination with regression
15 analysis and a qualitative interpretation based on extensive interviews;
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17 Section 4 gives a final interpretation and offers conclusions based on research results.
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30 **2 Against universalization – yet towards an accepted framework for the analysis and** 31 **function of networks** 32 33

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35 As already foreseen by Marshall, variety exists not only between but also within clusters –
36 there is much unobserved heterogeneity. Ranging from strictly defined ideal types to more
37 agnostic theories of spatial clustering (for a useful survey of competing but also overlapping
38 definitions see Belussi (2006) and Paniccia (2006)) a number of constituting criteria have
39 been suggested: spatial proximity, functional inter-linkage, self-awareness among participants
40 and innovativeness/competitiveness (Malmberg/Power 2006) – criteria which are also
41 contained in Cooke/Huggins' (2001) useful definition: “Geographically proximate firms in
42 vertical and horizontal relationships involving a localized enterprise support structure with
43 shared development vision for business growth, based on competition and cooperation in a
44 specific market field”. To differentiate this notion of clusters from networks we refer to to
45 NOOTEBOOM (2006, 139) for whom the concept of a network is more general. Accordingly
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60 it represents a more general category of inter-firm relations, which does not necessarily entail

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3 local embedding, a shared objective, or a specific market. This leads to the consequence that
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5 while a cluster is a network, the reverse is not necessarily true.
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8 This implies that the major emphasis in cluster and, more generally, network interpretation
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10 has changed from an analysis of forces of agglomeration to forms and contents of
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12 organizational learning and knowledge exchange – the original concentration on clusters as
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14 mere geographic concentrations of sectors and firms has been converted to a search for
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16 institutions for knowledge management and organizational learning, thus more fully
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18 emphasizing cluster dynamics (GERTLER/WOLFE 2006). Growth of the knowledge base
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20 depends on intended and unintended individual processing of experiences, i.e. ‘learning’,
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22 while the interpretation, transfer and use of experiences is influenced by interaction between
23
24 individuals and between organizations (COHEN/LEVINTHAL 1989, ANDERSEN 1995,
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26 HARTMANN 2004). These insights have shifted the earlier emphasis on material links to the
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28 present emphasis on immaterial knowledge flows within clusters and have pointed to the need
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30 for connectivity between different agents for knowledge creation and diffusion to take place.
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32 This then leads to further questions concerning the degree to which clusters are to be regarded
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34 as non-market devices through which firms seek to coordinate their activities with other firms
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36 and knowledge-generating institutions. Ongoing learning processes between firms and within
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38 clusters stress the importance of institutional arrangements for the generation of knowledge
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40 and learning of networks which are not available in the markets (MASKELL/MALMBERG
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42 1999). Since the necessary knowledge may lie outside a firm’s traditional core competence
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44 interfirm alliances and networks are widely recognized as an important organization form of
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46 innovative activity (GAY/DOUSSET 2005).
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58 New forms of evolutionary economic behaviour enter the interpretative framework of
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60 economics emphasizing the role of interaction and coordination processes in the economy that
have to be taken under conditions of bounded rationality and uncertainty (NELSON/WINTER

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3 1982, SIMON 1991, FOSTER/METCALFE 2001). Vast recent research points to networking
4 capabilities as a key factor in innovation and to the fact that the core of innovative capacity
5 resides in the capacity of various agents and agencies to efficiently combine different pieces
6 of knowledge (for a compilation see RONDE/ HUSSLER 2005). This induces firms to
7 establish a variety of types of interactions and relationships, each of them having different
8 impacts on the knowledge generation and diffusion process. MARIOTTI and DELBRIDGE
9 (2001) speak of the necessity for firms – in the face of knowledge ambiguity, knowledge
10 related barriers, tacitness and knowledge complexity – to engage in the management of a
11 portfolio of ties. Organizations therefore are likely to engage in inter-organizational relations
12 that show a variety of types of ties: These can have quite different dimensions and can be
13 defined according to the character of social relations between actors, the regulation of the
14 relationship, frequency of use, length of the relationship and also of course the nature of
15 information exchange (MARIOTTI/ DELBRIDGE 2001, 13). It is also important to
16 distinguish between both content (i.e. the type of relation) and form (i.e. the social structure of
17 relations) as has been outlined by POWELL/SMITH-DOERR (1994). Mariotti and Delbridge
18 also point in this context to the concept of “modular organization” (SANCHEZ/MAHONEY
19 1996), i.e. the decomposition of a complex system into loosely-coupled modules in order to
20 permit the integration of specialist knowledge without the actual transfer of knowledge itself –
21 a concept that can be applied to intra-firm structures as well as inter-firm types of
22 cooperation.
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53 As a consequence, from an economic point of view individuals and firms alone are not
54 capable of delivering sufficient amounts and varieties of knowledge. This has to be seen with
55 respect to questions concerning the adequate level and unit of analysis – one of “the most
56 troublesome issues in the social sciences ...” (FELIN/FOSS 2006, 1). The question whether
57 the individual or social collectives (firms, networks, regions ...) have explanatory primacy is
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3 of course an old debate in economics, sociology and the philosophy of science, and has been
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5 subsumed under the heading of “methodological individualism” versus “methodological
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of course an old debate in economics, sociology and the philosophy of science, and has been subsumed under the heading of “methodological individualism” versus “methodological collectivism” (HAYEK 1945, POPPER 1957, COLEMAN 1964, DOUGLAS 1986). This has in the context of strategic management and organisational analysis, led to the question as to the level at which organisational capabilities need to be defined: Is the organization’s knowledge development path or the level of human interaction the primary source of knowledge and knowledge transfer (ARGOTE/INGRAM 2000); is the concept of firm-level capabilities a kind of explanatory shorthand for underlying individual-level action (FELIN/FOSS 2006, 5) or can additional levels – beyond that of the firm - be found in order to explain organizational capabilities and mechanisms of learning?

Institutional economics has always emphasized the multi-level-character of socio-economic analysis: no entity can ultimately be taken as given. It is neither the individual nor the firm which is the sole ‘agent’ in economic and social life – networks are also potentially useful units. They can be interpreted as institutions in accordance with (HODGSON 1998, 171) for whom “institutions play an essential role in providing a cognitive framework for interpreting sense-data and in providing intellectual habits or routines for transforming information into useful knowledge”. According to MASKELL and MALMBERG (1999) clusters (as ‘locally embedded networks’) facilitate the frequent and proximate relations between economic actors that can contribute to the development of a shared cognitive frame. They can serve to fulfil additional functions such as reducing uncertainty about the experimental knowledge of others and increasing the incentives for medium- and long-term investments in diffusion channels. They can thus serve in effect to integrate the positive externalities of innovation, technological knowledge and development activities. Clusters then become economic clubs, which act as institutions for internalizing the problems of effective knowledge transmission (STEINER 2006). Learning – both as a specific form of acquiring and developing capabilities,

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3 and as a social process of ongoing development embedded in an institutional and socio-
4 cultural (regional) context – has now become, essentially, a communicative process rather
5 than a cognitive performance, requiring new thinking about the nature and forms of the
6 transmission and dissemination of knowledge within a social and organizational context. Such
7 organizations can be firms as well as networks – and the latter can therefore also be regarded
8 as learning organizations capable of developing capabilities. (STEINER/HARTMANN 1999,
9 2006). They become then a ‘mode of governance’ as a form of a Coasian institution and are
10 among the non-market devices by which firms seek to co-ordinate their activities with other
11 firms and other knowledge-generating institutions.
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24 Yet social interaction processes in the form of networks entail a variety of subject matter
25 (HELMSTÄDTER 2003): there are networks of economic transactions and networks of
26 knowledge sharing. The first belong to the process of the division of labour, and deal with the
27 exchange of goods and services, the second, with knowledge. The main differences reside in
28 the form of interaction and in the impact of interaction. Under the division of labour
29 interaction revolves around transaction of goods and services subject to the rules of
30 competition and their redistribution entailing exclusivity. Under knowledge sharing
31 knowledge and skill transfer takes place subject to cooperation and the desire to increase
32 knowledge for all (inclusivity). A further distinction can be drawn. In the former case the
33 processing of goods occurs in specific units; in the latter case internalization and
34 recontextualization dominate.
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50 The most important ‘institutional’ consequence is that “cooperation is the basic institution of
51 the process of the division of knowledge” (HELMSTÄDTER 2003, 32). But the degree of
52 cooperation depends again on the type of knowledge use: application has stronger competitive
53 elements whereas creation and transfer are dominated by non-economic competition (status,
54 acceptance) and mostly cooperation. The interest lies here in the institutions that make
55 knowledge sharing efficient.
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6 The above distinctions lead to further reflection concerning the forms, channels and
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8 mechanisms of knowledge exchange. This exchange occurs through interaction, and the
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10 structure of the interaction therefore influences the extent of knowledge diffusion
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12 (GAY/DOUSSET 2005). Here, two explanatory approaches exist, but they tend to oppose
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14 each other (GIULIANI 2005, 4). The one attributes knowledge with a highly public nature, so
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16 that learning, knowledge sharing and innovation within clusters is externality-driven. The
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18 alternative approach points to the necessity to include specific features of the firms and of
19
20 firm-level learning in order to understand the interaction of firm-level and cluster-level
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22 learning. The first approach (where Giuliani includes both the economists' perspective on
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24 'localised knowledge spillovers' and the economic geographers' view of cluster 'collective
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26 learning') emphasizes the strong relationship between spatial clustering, knowledge
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28 spillovers, and firms' innovative output – 'proximity' and 'territory' lead to a quasi-automatic
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30 diffusion of knowledge leading to innovation. This automatic mechanism is more put into
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32 question by economic geographers, who regard geographical proximity per se as insufficient,
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34 and who emphasize the additional role of social and relational proximity in entailing an
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36 interactive and cumulative effort by co-localized firms, which nevertheless results in
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38 unstructured and diffuse local interactions. The other perspective points to the heterogeneity
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40 of firm knowledge base, different firm capabilities, the existence of 'technological leaders'
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42 and 'gate keepers' in a local community. These differences do have an effect on the
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44 mechanisms by which knowledge is transmitted resulting in the fact that knowledge diffusion
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46 is not an accidental collective process but rather structured by the relative distance of firms'
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48 knowledge bases (GIULIANI and BELL 2005).
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As a consequence of these theoretical approaches and reflections we conclude that cluster theorizing should not attempt universalization –there is not only strong diversity between

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3 clusters but also within them. Clusters are highly differentiated across sectors, regions and
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5 countries. There is also no single model of knowledge transmission, not even within clusters.
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7 Knowledge transfer can not be assumed to be automatic, proximity per se not to be sufficient
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9 to generate learning between firms, while the diffusion of knowledge within clusters is both
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11 highly selective and strongly dependent of the position of firms within networks, on their
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13 knowledge base, and on their absorptive capacity.
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19 These approaches help us to focus our empirical attempt at applying the methods of network
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21 analysis in developing a qualitative analysis of clusters. The insights gained by the above
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23 reflections are formulated below as tentative hypothesis and serve as guiding principles for
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25 our analysis. Thus:
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32 • Networks consist both of material and immaterial links. Material links are
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34 predominantly input-output-linkages in the form of market transactions of deliveries.
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36 Yet immaterial links in the form of various exchanges of knowledge are the essential
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38 element of network activities in the firms involved.
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42 • Networks fulfil different functions and serve different purposes. The interactions
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44 within networks therefore assume different dimensions which do not necessarily
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46 coincide – from the exchange of goods to the sharing of various kinds of knowledge.
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50 • Depending on their resource-base and strategy not all firms participate in equal
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52 intensity in the network and are equally involved in knowledge sharing. Some firms
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54 play a leading role in knowledge generation and diffusion, others assume the function
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56 of technological leader for knowledge transfer, and many others remain in the
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58 background.
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- The interaction of firms includes quite diverse activities and constitutes a sort of portfolio of possible interactions, reflecting a variety of 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 evolve according to the changing needs of the firms involved. They are not closed systems, but rather temporary alliances between firms.

3 Empirical approach:

3.1 New challenges for the region and for established firms in Styria

The region of Styria (one of the nine provinces – ‘Bundesländer’ –of Austria) is of special interest for the investigation of clusters dynamics. Suffering from the problems of a typical ‘old industrial area’ dominated by a large national industry, and being exposed to a new economic situation due to the fall of the Iron Curtain on its border, Styria was confronted with considerable challenges. The 1980s and the beginning of the 1990s were characterized by a low level of growth in regional output, an unbalanced labour market, and structural problems, such as an insufficient rate of firm formation and a low rate of innovation.

In particular, the problems of the steel industry in Upper Styria, turned out to be the major bottleneck for economic development in the time preceding the development of clusters. This region was dominated by large state owned firms that were highly vertically integrated and had lost their headquarter functions in the 1960s and 70s to Vienna. In most cases, planning, R&D and marketing/distribution functions, i.e. those responsible for the monitoring of markets and technology, have been lost. At the end of the 80s large firms were re-privatized

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3 and down-sized. Firms needed to learn to collaborate and to develop the potential to innovate
4 as a strategic resource. It was a situation with a very abrupt – and strongly delayed – change,
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6 from a Fordist way of production to flexible specialisation.
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10 A massive structural change of the regional innovation system in Styria has been observable
11 since the beginning of the 90s, especially in the street related sectors such as the mechanical
12 engineering sector, the machinery, and the automobile sector. High degrees of diversification
13 and broad unspecified clienteles have been reduced to market niches and technological
14 specialization, and higher lot sizes have enabled a higher integration of functions maintaining
15 flexibility by leaving scope for automatisisation. Technological upgrading (including the
16 introduction of quality and measuring standards) also opened doors to a new clientele. Such
17 upgrading has been accompanied by an extension of responsibilities to include tool making
18 and sourcing capabilities, and also by shifting the responsibility for quality and price from
19 clients to suppliers.
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22 Innovation in these sectors was influenced by the availability of specialized knowledge in the
23 field of materials, tooling and processing techniques, or very by the specific problems in the
24 machinery segment. For firms who were already active in R&D a shift from demand-pull
25 driven, to science-push driven R&D seems to be evident.
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27

28 Industrial restructuring of a region and the building of regional innovation capabilities have to
29 be seen as long term processes which require a bottom-up approach (in particular where
30 SMEs' needs are well understood) and cooperation and permanent communication with
31 national policy actors. The successful catching-up process in Styria since the middle of the
32 90s is reflected in the innovation-data in all sectors. A first macroeconomic glance at the
33 region offers the impression of high concentrations of economic- activity in a relatively small
34 range of technology fields and industry. The system's learning capacity has been established
35 in a prudent process of stabilization of expectations as a consequence of the informal
36 interaction of agents, who have been confronted with global challenges and competition on
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3 the one hand, and with a locally stabilizing knowledge infrastructure, human resource base
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5 and immobility of regional agents on the other hand.
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8 The regional government has played a crucial role in promoting cooperation and networks in
9
10 Styria during the last decade. Actually there are four official cluster organizations in Styria (in
11
12 the fields of wood, human technology, automotive industry and sustainable technology).
13
14 Network-orientation also includes policy networks, which help to develop and implement
15
16 regional strategies in the sense of multi-level governance. Those crucial policy actors, who
17
18 accompanied the first steps of multilateral firm co-operation and network development, have
19
20 confirmed that it took a long phase to build up awareness and trust among regional firms,
21
22 which had been faced by regional disintegration in the phase of belated structural change. The
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24 region, and specifically its mechanical engineering and machinery sector, therefore presents
25
26 itself as ideal for a case study on network activities and as means of addressing the questions
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28 outlined above.
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34 35 3.2 Methods and data 36 37 38 39

40 Network analysis is a well established method in the social sciences. Recently, the method has
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42 also been applied for the analysis of production clusters (Krätke 2002), innovative activity
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44 and knowledge exchange (Giuliani 2005), alliance networks (Gay/ Dousset 2005) or R&D
45
46 networks.
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49 Social network analysis is a helpful tool in discussing the structure of networks and allows the
50
51 mapping and measuring of the relationships (communication and transaction) between
52
53 different actors, that is the existence, context and portfolio of relations between actors in a
54
55 regional network. It is a method for exposing the underlying relations between different
56
57 actors, and for revealing those phenomena which cannot be reduced to the properties of
58
59 individual actors or firms. Thus, relations have to be interpreted as properties of systems
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3 rather than of individual actors.
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5 Both, the boundedness of social relations as well as the possibility of drawing relational data
6 from samples, cause selection problems. The boundaries of the core partners of a firm vary
7 from one firm to another. Any definition or measure will tend to be artificial in that it will not
8 allow for all relevant dimensions and features to be captured. Nevertheless, it is necessary to
9 find a compromise between an overarching review of the dimensions of interaction on the one
10 hand and the need to reveal the driving factors in the cluster on the other hand. This paper
11 thus runs along the interface between qualitative regional cluster analysis, quantitative and
12 graphical network analysis, and institution oriented industrial analysis. By combining the
13 quantitative results from network analysis with the outcomes of selective regressions link
14 specific characteristics of firms with their respective position within the network, and by
15 which complementing this with qualitative information based on extensive interviews with the
16 firms, we want to gain insights into the multidimensional behaviour of firms within a given
17 network.
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37 **The empirical database**

38 Principally, two approaches of identifying the sample needed for network analysis can be
39 distinguished, a 'nominalist' on the one hand, and a 'relational' approach on the other hand
40 (ZUCKERMANN 2003, Scott 2000, LAUMANN et al. 1983). In the case of the nominalist
41 approach, a priori criteria for the definition of the relevant set of nodes (actors) are imposed.
42 Here we use the relational approach where the relevant nodes are revealed and judged by the
43 actors questioned themselves.
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53 To find the empirical basis for the network analysis we used the snowballing method of
54 sampling in cluster and network investigation. This corresponds with the relational approach,
55 and is developed by means of the references to actors as revealed by previous respondents
56 (FRANK 1979, SCOTT 2000).¹
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3 The analysis focussed on the mechanical engineering, machinery, and automotive sector
4 forming a well-known cluster in Styria. The starting point was a large system supplier in the
5 automobile sector located in the region. The snowball method led to the identification of firms
6 belonging to different sub-sectors and cultivating related supply-chain and innovation-
7 strategies. Triggered by a citation path of regional suppliers (production or commercialization
8 of goods and services) and of regional partners in the field of research and development
9 (cooperative R&D and related activities and exchange) was followed. Thus the sample was
10 developed stepwise. In this way the data-base for the subsequent network analysis was
11 extended to 23 firms (of which 18 are producer- and five are service-oriented) and nine R&D-
12 institutions. Our network – based on a relational approach using the snowballing method for
13 identification – thus consists of 32 actors, and covers those relations that cross firm (or R&D
14 institution) boundaries. It comprises both heterarchical and hierarchical relations; some of the
15 firms are clearly positioned in a value chain, others have more horizontal relations. The
16 network further comprises firms and R&D institutions within the region – the network
17 analysis therefore describes necessarily, only intraregional relations (extra regional activities –
18 which are an important element – would have to be analysed by other kinds of methods).

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41 The information and data collected are based on extensive qualitative interviews and
42 supported by a quantitative survey concerning specific figures of the firm. The contact
43 persons in the firms have been the general managers (or owners), the heads of the R&D units
44 (as far as existent) and the purchasing agents (as far as existent). In smaller industrial firms
45 most of these functions are held by the owners themselves.

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53 This 32-actor-network does of course not comprise the total cluster. Notwithstanding the
54 generally high willingness to cooperate some firms were not able to reveal all their strategic
55 partners, and some of the Partners indicated (following the idea of the snowballing method)
56 were not willing to participate and to provide the necessary information. The approach
57 nevertheless relies on the assumption that the identified segment of the network is
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3 representative for the whole cluster. This is not to unrealistic given the fact that the leading
4
5 firms and the most important R&D-institutions were included. In addition, the insights gained
6
7 were complemented by shorter interviews with other firms and with regional experts. All
8
9 empirical research was conducted in 2005; the time span covered by the empirical data base
10
11 extends to the period of the last five years, i.e. the answers given by the interviewed persons
12
13 where supposed to describe the recent past and the present situation.
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17 18 **Descriptive indicators** 19

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22 Among the firms, different types can be differentiated in order to show different necessities,
23
24 capacities and patterns of research and development. We thus find original equipment
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26 manufacturers (OEM), systems suppliers, component Suppliers, toll manufacturers and
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28 technical business services.
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- 32
33 • An *original equipment manufacturer* (OEM) sells its products under its own brand name.

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35 An OEM integrates components and modules bought from other suppliers in its own
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37 products which are then sold to the end customers. It is normal for an OEM to bear
38
39 responsibility for the design and development of the final product.
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41

42
43 *Systems Manufacturers* are capable of design, development and manufacturing of complex
44
45 systems. Following a 'black-box' design, this often implies complementary development
46
47 competences to those of OEMs or system integrators. The boundaries between system
48
49 supplier and OEM are in our sample very weak, therefore these categories have been
50
51 pulled together in the following discussion.
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55 • The majority of the suppliers that participate in supply chains in this medium-tech sector
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57 work as *component suppliers*, who manufacture and sometimes design a specific
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59 component or a simple subsystem. Component suppliers are mostly confronted with a
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work drawing.

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3 • *Toll manufacturers* are important partners in the machinery sector. Their success is based
4 on specialization, processing knowledge and additional production capacities. Typical
5 examples can be found in the field of heating, surface treatment, cutting machining or
6 welding.
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9
10 • The *Technical Business Services* observed here operate at very different levels in the
11 sectoral innovation systems.²
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- 13
14 • The investigation also comprised nine public and semi-public *R&D-Institutions* which
15 also have also identified using the snow-ball method. The landscape of public and semi-
16 public R&D-organisations and institutions in Styria was originally dominated by technical
17 universities (rd10, rd20), an applied research organization owned by the regional
18 government (rd 30), and by traditional industrial R&D-institutes (e.g. rd05). In the middle
19 of the nineteen-nineties the Austrian tertiary education system was extended to include
20 polytechnics. These are more oriented towards education than R&D (rd 40), yet developed
21 small-scale cooperation in specific technology fields with local SMEs. At the end of the
22 nineties a new type of R&D organization was established with the intention of building
23 stronger links between science and industry. These so-called Competence Centres are co-
24 funded by the national and regional government and by the private sector. The idea of
25 such cooperative R&D institutions has been accepted very quickly and has allowed for
26 new methods to develop for allocating pre-competitive R&D at the interface between
27 science and industry.
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53 Table 1 reports descriptive statistics for the organizations included in the sample, i.e. the type
54 of organization, the ownership of the organization, the size of the organization, the size of the
55 R&D-unit (as far as existent), the average exporting intensity, and the age of the organization.
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10 Half of the observed firms are not independent but part of different, mostly international, firm
11 groups. The majority of the firms have been situated in the region for more than 10 years.
12 These firms may benefit from the capacity of international firm groups to internalize
13 mechanisms of international integration. The range of observed firms is dominated by
14 medium sized and large firms. This might be caused by the chosen snow-ball sampling
15 approach which starts with a very large system supplier. The R&D capacities of the observed
16 firms varied widely. Nearly the half of the firms has no permanent position for an R&D
17 professional.
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30 **Indicators of interaction**

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35 Both the quantitative indicators presented, as well as additional qualitative indicators
36 revealing may be helpful for the discussion of individual strategies which finally sum up to
37 the structure of the network. They are used selectively to find – via network analysis -
38 structural features of the network of 32 actors. The selected indicators of the relations
39 cultivated by the organizations cover three dimensions of interaction: direct delivery relations,
40 R&D, and technological innovation in a competitive and a pre-competitive context. The
41 following three dimensions of interaction were employed:
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54 (DELIV): The firms were questioned concerning direct delivery relations (goods or services)
55 to clients, suppliers or partners (in the case of synergetic product bundles).³ The direct
56 delivery (DELIV) of goods and services is not reduced to the material dimensions but is
57 extended to include innovation-related questions in the context of quality and information
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3 management or capacity extending investments. Pre-tests undertaken revealed that firms were
4 not willing to quantify the value of the relation in monetary terms. Therefore the questioned
5 organizations were asked to indicate the frequency of direct delivery interaction according to
6 the following scale: 0 = none (no relation), 1 = low (sporadic and infrequent interaction), 2 =
7 medium (frequent interaction), 3 = high (permanent interaction). The valuation of relations by
8 means of the approximate frequency of interaction gives us the possibility to differentiate
9 stronger and weaker relations.
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22 Two further measures in the context of knowledge generation and transfer were discussed
23 with the institutions interviewed. In order to take account of different R&D capabilities and
24 innovation strategies we distinguished between two dimensions of relations with respect to
25 knowledge generating processes. Both dimensions are in line with the common definitions for
26 R&D and innovation.⁴
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33 (COMP): Competitive Research and Development and innovation processes are short and
34 medium term oriented and mostly associated with direct expectations of return or with a direct
35 tender or offer etc., while pre-competitive R&D is long-term oriented, and research and
36 development activities immediately accompany the treatment of a client order or request.
37 While this includes cooperative R&D as well as unidirectional knowledge-transfer, the
38 strategic dimension seems to be only weakly pronounced. In analogy to the case of direct
39 delivery of goods the questioned organizations have been asked to indicate the frequency of
40 interaction according to the following scale: 0 = none (no relation), 1 = low (sporadic and
41 infrequent interaction), 2 = medium (frequent interaction), 3 = high (permanent interaction).
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54 (PRE-COMP): Another dimension surveyed was the level of interaction in the context of pre-
55 competitive R&D. Pre-competitive Research and Development aims at extending the product
56 spectrum, as well as at introducing new processes and alternative materials. Pre-competitive
57 research includes fundamental research, which is an activity designed to broaden scientific
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3 and technical knowledge not yet linked to industrial or commercial objectives, and industrial
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5 research, research aimed at developing or improving new or existing products, processes or
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7 services as far as it is not directly connected with a client tender, an offer or an existing
8
9 business relation. These activities have to be pre-financed by the firm and require an
10
11 additional financial and strategic effort. Pre-competitive R&D does not include routine
12
13 adaptations of existing products and services.⁵ In analogy to the 'competitive-case' relations
14
15 can be cooperative or unidirectional, e.g. in extramural R&D. Once again the organizations
16
17 questioned were asked to indicate the frequency of interaction according to the following
18
19 scale: 0 = none (no relation), 1 = low (sporadic and infrequent interaction), 2 = medium
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21 (frequent interaction), 3 = high (permanent interaction).
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30 **Basic concepts of network analysis used**

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35 The following paragraphs are dedicated to the introduction of the basic concepts of network
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37 analysis. This provides the necessary understanding for subsequent discussion. Following the
38
39 socio-centric approach network density is indicated by the ratio of relations actually realized
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41 to the total number of maximum possible relations. We dichotomized the relations. That is,
42
43 we only differentiate between existence and non-existence of a relation between two actors [0;
44
45 1], and therefore disregard for the moment the intensity of the relations (in our case the
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47 frequency of interaction) to avoid problems relating to measurement of the density of
48
49 weighted graphs (Scott 2000, pp. 73ff.)
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54 In the case of the 32 actor network observed in Styria, the maximum possible number of
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56 relations, where each actor is related directly with all other players is 992.⁶ If there are
57
58 asymmetric relations, i.e. for some relations r_{ij} no reciprocal relation r_{ji} exists, the formula
59
60 for network density is

$$\frac{\sum_{i,j} r_{ij}}{(n(n-1))}$$

where $\sum_{i,j} r_{ij}$ is the number of relations present and n is the total number of observed actors.⁷

The density figure 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 his respective centrality. Using the concept of centrality we gain insights into the specific features of the interaction of the actors in the network and their specific position and/or embeddedness in the network.

While the density focuses on the properties and general structure of the network as a whole, 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, but here the relations are weighted ordinally with in terms of the frequency of interaction. The potential centrality of an actor is determined by a broad range of industry and sector specific factors (Cohen et al 2000), as well as by capacity, and by individual motivation (BAYONA et al. 2001, THETER 2002). A high centrality is positively associated with the number of possibilities of receiving information and generating knowledge.

Diverse measures of centrality can be differentiated and used complementary to each other. Basically it is possible to make the distinction between the synonymous terms of “point centrality”, “local centrality” or “degree centrality” on the one hand, and “graph centrality”, “global centrality” or “closeness centrality” on the other hand (NIEMINEN 1974, FREEMAN 1979, SCOTT 2000).

The terms ‘degree centrality’ on the one hand and ‘closeness centrality’ on the other hand have been accepted widely in the literature and incorporated into software-tools for network analysis. The concept of degree centrality is based on the idea that actors with high centrality in a network maintain a lot of direct relations to other actors. The degree centrality $C_{D(mi)}$

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3 measures the number of direct relations going out from actor i (out-degree) between two
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5 actors i and j . In directed networks a relation can be stated more precisely by the dimensions
6
7 of 'reception' and 'emission'. In-degree centrality therefore captures the centrality of an actor
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9 from the perspective of 'reception', while 'out-degree centrality' measures the centrality of an
10
11 actor from the perspective of 'emission'.⁸
12

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14 Degree-based centrality can be extended beyond direct connections to include those at various
15
16 path distances. In graph theory the shortest distance between two points is called the geodesic.
17
18 The 'global centrality' or 'closeness centrality', defined as the sum of all geodesic distances,
19
20 thus takes into account direct as well as indirect relations to all other actors. *Closeness*
21
22 *centrality* is measured by the inverse of the sum of distances from an actor to all the other
23
24 actors. The closeness centrality $C_{C(mi)}$ can only be calculated in complete networks where each
25
26 actor is in relation with at least one other actor (otherwise the distance would be infinite).
27
28 Isolated actors are thus excluded from the calculation.⁹
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34 Analogous to the degree centrality for a directed network (as in our case) *in-closeness*
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36 *centrality* and *out-closeness centrality* is measured separately, depending on whether the
37
38 distances 'from' or 'to' other nodes are considered.
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41
42 Beyond the measurement of the centrality of actors by means of direct or indirect relations to
43
44 other actors another interpretation of centrality are of interest: The 'betweenness centrality'
45
46 measures the significance of the intermediary role of actors resulting from their position in the
47
48 network. Betweenness centrality is based on the probability that an actor obtains the role of a
49
50 critical gatekeeper (possibly a bottle neck) in the course of indirect exchange between two
51
52 arbitrary actors in the network. Gatekeepers play a critical role because they are in a position
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54 to control exchange (of goods, information etc.) between different agents. The number of
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56 shortest mediate paths (geodesics) is thus set against the number of geodesics crossing the
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58 observed actor.¹⁰
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3 The following discussion of the identified networks is based on the calculation of density and
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5 of diverse measures of centrality but also on additional regression analysis which on the one
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8 hand aims to identify clear correlations between the structural features of the observed actors
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10 and their position in the observed dimensions of networking (DELIV, PRE-COMP and
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12 COMP) on the other:

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15 Type of organization: System Suppliers (SYSTSUP), component suppliers
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17 (COMPSUP), Technical Business Service (TBS), R&D institution (RD_INST)

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20 Part of a firm-group (FIRMGRP)

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22 Age of the firm (LOG_AGE)

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25 Size of the firm: as function of the logarithmic number of employees (LOG_EMPL)

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27 Size of the R&D unit: as a function of the number of R&D employees (RDEMPL)

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30 R&D intensity: as proportion of employees involved in R&D activities
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32 (SHARE_RDEMPL)

33
34 Exporting intensity (EXPORT)

35 36 37 **3.3 Analysis and results**

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40 We begin by focussing on the most striking features of the network and the network
41
42 dimensions as a whole, and consider the position of individual actors in the network in a latter
43
44 discussion.

45 46 47 48 **Structure of the network and network density**

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51 While the current analysis focuses on regional relations it needs to be kept in mind that
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53 interregional and international relations also exist and may be of major priority, as is in fact
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55 the case for direct delivery. Table 2 presents the density measure for the three levels of
56
57 relations between the actors.
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(Insert Table 2 here)

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8 Direct delivery relations have the weakest density. Although the datasets have been
9
10 dichotomized and therefore relations with a very low frequency of interaction have been 'up-
11
12 graded' the density of the network of direct delivery relations is lower than the density of
13
14 knowledge intensive innovation-related interaction. As stated in Section 3.1 and confirmed in
15
16 Table 1 by the figure for exports, most of the firms in the observed network are in the
17
18 dimension of direct deliveries oriented towards international markets. Regional input-output
19
20 relations have been reduced in favour of an orientation towards international markets. This is
21
22 also reflected by average closeness centrality (even when indirect linkages are considered)
23
24 which is higher among interactions in the context of competitive R&D and innovation
25
26 processes than among direct delivery relations, although the densities and number of actors
27
28 involved (nodes) are comparable. While competitive R&D and innovation processes,
29
30 especially in the case of domestic system suppliers, are partially similar in density to direct
31
32 delivery relations, the regional density of the network of pre-competitive R&D is much
33
34 higher. While R&D institutions are of negligible significance in respect of direct delivery
35
36 relations, the network is based to a considerable degree on relations with cooperative R&D
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38 institutions. Beyond the coverage of the total network of actors (including all international
39
40 relations) our network analysis reveals another explanation for the high density of the network
41
42 dimension of pre-competitive research and development, namely the permanent relations
43
44 prevailing among the R&D institutions (e.g. semi-public cooperative research institutions and
45
46 universities). The lower density of the network COMP in comparison to PRE-COMP may be
47
48 explained by several factors. Competitive R&D and innovation are to high degree in-house
49
50 activities owing to time-pressure, but also for reasons of confidentiality. Especially in the case
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52 of system suppliers a considerable amount of competitive research and development and
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54 innovation processes involves clients and suppliers outside the region and internationally. The
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3 relatively high average betweenness centrality conforms to the combinative character of
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5 knowledge in this dimension. Regional network analysis encounters a blind spot as far as
6
7 international relations are concerned since these can not be considered explicitly.¹¹
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11
12 The relational data can be used for a graphical representation of the transaction network of the
13
14 observed organizations. The network diagram is the traditional and basic methodology for
15
16 formalizing network analysis and is still a very helpful means of interpretation and discussion.
17
18 However, clarity suffers the greater the number of actors observed.¹² A quite useful method of
19
20 graphical representation which is implemented in most of the more or less sophisticated
21
22 software packages follows the approach of Kamada-KAWAI's (1989) spring embedding
23
24 algorithm. Taking into account direct as well as indirect relations the shortest path between
25
26 two actors is defined as the geodesic distance between two actors. The concept of path
27
28 distance takes into account mediate relations between actors who are not connected directly.
29
30 Following graph theory the geodesic distance between a pair of nodes is the length of the
31
32 shortest path (path distance) between two actors. In a directed graph or in an asymmetric
33
34 matrix of relations, each relation is only considered in terms of its direction. In our case it is
35
36 again of interest to measure the mean distance, i.e. the average geodesic distance as a measure
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38 of network extension.
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46 The aim of this algorithm is to find a set of coordinates in which, for each pair of nodes, the
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48 Euclidean distance is approximately proportional to the geodesic distance between two nodes.
49
50 Based on the approach of Kamada-Kawai, Figure 1 gives an overview of all relations
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52 recorded. Figure 1 combines the three dimensions already discussed. The diagram in Figure 1
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54 merges all the dimensions of networking, taking into account the valuation of the relations in
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56 terms of their frequency of interaction.
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10 A further interesting dimension of network analysis is the 'coreness' which follows basically
11 the idea of core and periphery. We therefore use the concept of the *k-core* (SEIDMAN 1983,
12 SCOTT 2000). A *k-core* is a sub-graph in which each actor is adjacent to at least k other
13 actors in the sub-graph. That is, for all nodes in the sub-graph the minimum number of the
14 actors' direct relations within the sub-graph is k (in our case eight). The resulting k-core
15 complements the measurement of density, since the latter is incapable of capturing the
16 structural features of the network. The k-core is an area of relatively high cohesion. The
17 symbols for the actors (nodes) correspond to the different types of organizations introduced in
18 Section 3.2. The size of the nodes reflects organisation size. Finally, the length of lines
19 corresponds with the distance between the observed actors. As can easily be seen, we can
20 differentiate between actors who are in the core of the network (coloured black) and actors
21 who are more less on the periphery of the network (coloured white). The diagram makes us
22 aware of the high density of realized relations (calculated in the previous paragraphs). In the
23 k-core of the diagram we can find a group of institutions which seem to interact multilaterally.
24 In the 'core' of the network, we can find R&D institutions, large system suppliers but also toll
25 manufacturers (surface-treatment, heating etc.) which maintain multiple, but weak relations,
26 to a broad range of regional clients.
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52 In the next step, we try to decompose the total network in terms of the three main dimensions
53 of directed exchange. In order to facilitate the visual comparability of the decomposed
54 dimensions of networking we choose circle diagrams. The circle diagram is a very useful
55 method of organizing available data, in that actor can be arranged so as to ensure a minimum
56 overlap among the lines which stand for relations between actors. The position of the actors is
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3 identical in all diagrams. The qualities of network diagrams can be interpreted in a way
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5 analogous to a matrix. Analogous to the definition of asymmetric matrices we also can
6
7 identify unidirectional graphs. Again the weighted relations are taken into account. Analogous
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9 to the diagram in Figure 1 **Error! Reference source not found.** the size of the nodes
10
11 corresponds to the size of the organisation. The shading indicates the export-rate (white:= ~
12
13 100%; black := ~ 0%). Finally the actors are arranged around their core field of economic
14
15 competence following the Nace-Classification. As can clearly seen relations along the
16
17 dimension of direct delivery differ from the relations along the dimensions PRE-COMP or
18
19 COMP. In the network of direct deliveries relations seem to concentrate in the around large
20
21 export-oriented systems suppliers in the Nace 34 sector, manufacturers of motor vehicles and
22
23 vehicle parts, with core competences in the fields of development and assembling. These are
24
25 served by firms in the same sector but also by component and toll manufacturers in the Nace
26
27 27 and 28 sectors responsible for manufacturing of basic metals and fabricated metal products
28
29 (including die casting, forging or surface treatment) with core competences in the field of
30
31 metal processing and material science in its widest sense. Finally the system suppliers in the
32
33 Nace 34 sector are served by finally firms in the Nace 25 sector, the field of manufacture of
34
35 plastic products, which have a relatively broad client base, and reach beyond the NACE 34
36
37 sector. In the networking dimensions PRE-COMP and COMP, R&D institutions are – as
38
39 expected - prominently involved. A considerable amount of small and medium sized firms are
40
41 not integrated in this regional dimension of exchange.
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53 (Insert figure 2 here)
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57 Figure 2 **Error! Reference source not found.** not only supports the density measure but also
58
59 indicates that the observed dimensions of networking only overlap weakly. Taking into
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account the existent relations on the side of direct delivery products and service deliveries on

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2
3 the one hand, and R&D and innovation transfer on the other hand, it is of interest to see which
4
5 share of relations is exclusively business and delivery driven and which share is exclusively
6
7 R&D and knowledge driven.¹³
8
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11
12 (Insert table 3 here)
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- 15
16
17 • If we take into account only relations on the firm level (see perspective A in Table 3)
18
19 16% of the relations between possible partners occur on both dimensions, and are
20
21 business as well as research and development driven. Only 5 % of the relations are
22
23 exclusively research and development driven, but 80 % of the regional relations of the
24
25 network are exclusively driven by direct deliveries or business driven.
26
27
- 28
29 • Perspective B again starts from the perspective of firms but includes relations to R&D-
30
31 institutions. In this case 11% of relations are business as well as research and
32
33 development based. On the regional level, firms seem to cultivate relations with
34
35 different partners in different dimensions. Cases where that the business-partner is the
36
37 core-partner in research and development, or where business partners are related to an
38
39 R&D institution seem to be the exemption. As might be expected, systems suppliers
40
41 with R&D capacities and business services, reveal rather more overlapping between
42
43 business and R&D.
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47
48 The qualitative interviews confirmed the notion that firm motives for coping with
49
50 smaller or larger, stronger or weaker, private or public partners are multilayered and
51
52 depend on a broad range of factors; e.g. competitive conflicts, possible spillovers,
53
54 bargaining power, resources, available time, strategic relevance of the relation etc. The
55
56 strategic dimension of a balanced portfolio of relations, including short term arms-
57
58 length relations on the one hand, and stabile long-term relations on the other, was
59
60 repeatedly made clear. The dichotomous structure of the observed network seems to

1
2
3 be based on a strategic need for balance in the relationship portfolios of the firms
4
5 concerned.

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7
8 • For the sake of completeness we add perspective C. This which corresponds with the
9
10 discussion of the total network and the calculated density measures. If we take into
11
12 account all observed institutions in the regional network (see perspective C in Table 3)
13
14 only 9% of the relations between possible partners occur in both dimensions, and are
15
16 business as well as development driven. 35% of the regional relations of the network
17
18 are exclusively driven by direct deliveries or business driven. A considerable part of
19
20 the revealed relations (57 %) is exclusively based on the R&D side.
21
22
23

24
25 According to the qualitative interviews undertaken with the observed institutions the network
26
27 formation described above seems to correspond to an aggregate of the individual strategies as
28
29 revealed by the interviewed firms. The actors enjoy broad scope in steering their portfolio.
30
31 They can manipulate frequency of interaction, the time of interaction, the choice of the
32
33 partner (MARIOTTO/ DELBRIDGE 2001) and the thematic focus of the relationship
34
35 (specialized or ubiquitous). The choice of partners allows further freedom in that it depends
36
37 on the level of technological spillovers, prevailing technological and economic capacities, and
38
39 on the strategic relevance of the reason for interaction. (ATALLAH 2005). The qualitative
40
41 interviews strengthened the notion that firms seek a portfolio of cooperation partners, and
42
43 consciously combine specialization and flexibility.
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48
49 While larger firms with considerable R&D capacity can utilize international contact in
50
51 research and development activities, smaller low- or medium-tech firms stick to the region
52
53 and regional partners. Smaller firms are rather confronted with a self-enforcing combination
54
55 of low R&D capability on the one hand, and unambitious demand from the client's side.
56
57 Thus, transaction costs are mostly disproportionate to the technological and economic gain
58
59 expected from co-operation on questions of pre-competitive research and development. The
60
low and medium-tech firms partially utilized opportunities to establish long-term contacts to

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3 single public or semi-public R&D institutions which deal with basic technologies –mostly
4 material sciences - in an effort to gain from possible spillovers as a result of activities via
5 appropriate events or informal inquiries. Thus partners in direct delivery and partners in
6 competitive and pre-competitive research and development - as far as existent - are not
7 identical.
8

9
10 Firms with considerable R&D capacity revealed various strategies, depending on their market
11 and co-operation culture. The more these firms act in market niches demanding highly
12 specialized cooperation partners, the more they tend to long-term cooperation involving rather
13 specialized partners.
14

15 As far as natural spillovers are high and competitive conflicts are manageable (e.g. in the case
16 of material sciences) larger firms accepts weaker partners - respectively smaller firms - and
17 are willing to integrate them. Low spillovers and higher market orientation favour a
18 conservative sometimes excluding behaviour of the stronger side. This corresponds with the
19 findings of for partner selection in R&D co operations (ATALLAH 2005).
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40 **Network positions of individual actors (firms, R&D-institutions)**

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44 As mentioned before, our discussion of the position of individual actors is based on
45 complementary qualitative and quantitative sources. Among the diverse measures of centrality
46 regression analyses based on non-parametric regression methods¹⁴ have been employed to
47 identify correlations between structural features of the observed actors and their position in
48 the observed dimensions of networking. The regression analyses tested the ability of the
49 observed characteristics to explain the network-position of the observed actors, supplementary
50 to the results of the qualitative interviews for all dimensions of interaction discussed. In a first
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3 step we tested the correlation of the structural features. We were able to identify significant
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5 positive correlations for the selected explanatory variables.
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8 The correlation values obtained did not exceed acceptable limits for the regression analysis
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10 conducted. The observed correlations basically reflect the specificities of the observed types
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12 of organizations.¹⁵
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6 The results of the regression analysis are summarized in Table 4**Table 4** and are discussed
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8 and complemented by results of qualitative interviews with the observed actors in the
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10 following paragraphs.
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15 In the dimension of direct delivery relations the central role of the leading firms, which have
16
17 been the starting point of the investigation (using the snowball sampling method) is
18
19 reconfirmed by high in-degree centrality.
20
21

- 22 • As might have been expected the regression analysis (see the model-summary in Table
23
24 4) reveals that a high in-degree centrality is positively correlated with a high export
25
26 intensity. The leading system suppliers were confirmed to be strong recipients of
27
28 deliveries (Table 4, Model 1) and are also the largest firms in the observed network.
29
30 Their high in-degree centrality in the observed network can not detract from the fact
31
32 that a considerable part of intermediate products and raw materials is sourced
33
34 internationally.
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38 In the course of the interviews held the observed system suppliers revealed
39
40 considerably different sourcing strategies, which seemed to be influenced by their
41
42 industry and industry specific rules of business. The observed large system suppliers
43
44 of the traditional automobile sector maintain arms length relationships and try to avoid
45
46 total unilateral dependence which could have ruinous consequences in the case of
47
48 market fluctuations. Partially, these system suppliers are obliged with concrete
49
50 recommendations for international suppliers which have been established and
51
52 registered in their sourcing base.
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57 System suppliers who belong to international firm groups and directly source most of
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59 the intermediate products centrally, have rather weak input linkages, as do component
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suppliers who source their raw materials from national wholesale-dealers.

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3 Component suppliers, toll-manufacturers and business-services don't play a significant
4 role as recipients of direct deliveries. The lion's share of intermediate products or raw
5 materials is neither sourced from partners in the observed network nor from other
6 actors in the region.
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12 The dimension of closeness centrality does not deviate significantly from the picture
13 drawn for the degree centrality.
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17 • The dimension of out-degree centralities reflects the converse of the above. The
18 regression analysis very weakly indicates a positive correlation of out-degree
19 centrality in respect of direct deliveries for component-suppliers (Table 4, Model 2).¹⁶
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22
23 The highest out-degree centrality is seen in the case of toll manufacturers (especially
24 surface treatment and heating) and flexible component suppliers with core
25 competences in the fields of die-casting, forging or metal machining and
26 manufacturing of plastics. As can be seen in Table 1, these firms are primarily
27 concentrated in the fields of manufacturing of plastic products, and manufacturing of
28 basic metals and fabricated metal products (including die casting and surface
29 treatment).
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41 The analysis confirms the data amassed from the qualitative interviews: The services
42 of toll manufacturers are sourced locally owing to the transport and logistic costs
43 incurred. Primarily these suppliers mostly act on a regional market. The component
44 suppliers mentioned endeavoured to work in international markets. However, as
45 revealed by all firms interviewed maintaining a certain degree of flexibility and/or a
46 regional client base was regarded as strategically important. The relatively high out-
47 degree centrality can be explained by the fact that such companies offer their goods
48 and services to system suppliers in all technology fields, to, manufacturers of vehicles
49 and vehicle parts but also to manufacturers of precision and measurement instruments.
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Quite low values of out degree centrality can be identified in the case of system

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3 suppliers bound to international firm groups since these exclusively supply their goods
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5 to one leading firm in the network.
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8 Looking at the dimensions of R&D (competitive and pre-competitive) it might be expected
9
10 that R&D-institutions play a considerable role. The regression analysis indicates a high out-
11
12 degree centrality in of R&D-institutions in this network dimension. Again in this context the
13
14 size of the organization is of significance.
15
16

17 Actors with higher in-degree centrality are characterized by higher R&D capacities as a
18
19 function of R&D employees and also by contacts to foreign universities.
20
21

22 The ranking of institutions in respect of closeness centrality does not differ significantly from
23
24 degree centrality. Closeness centrality more or less corresponds to the idea of spillovers.
25
26 Institutions which hold a weak portfolio of relations themselves, but engage in exchange with
27
28 strong nodes (“Stars”) can particularly gain from spillovers. Especially firms which cooperate
29
30 less intensively but are linked to strategic partners, have a better ranking in terms of closeness
31
32 centrality than is the case for degree centrality. This is true for those firms which are not core-
33
34 partners of the leading firms but cooperate intensively with knowledge generating institutions.
35
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- 38 • In section 3.2 we mentioned the new significance of cooperative R&D institutions in
39
40 Styria. Along with the technical universities these cooperative R&D institutions have
41
42 the highest degree centralities in respect of pre-competitive R&D oriented relations. In
43
44 the case of pre- competitive R&D for the technical universities, we can identify a
45
46 relatively high in-degree centrality; in addition, firms with higher R&D capacities
47
48 have higher in-degree-centralities. The latter are system suppliers with R&D
49
50 competences and technical business services. In contrast to the evidence on to direct
51
52 delivery relations, nearly all firms which cultivate more or less regular pre-competitive
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54 R&D oriented relations to other organizations were found to be regionally focussed.
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Especially in the case of pre-competitive R&D cooperative, publicly supported

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3 projects or shareholdings have gained an increasing role during the last decade. In the
4
5 case of cooperative R&D institutions with a small and closed range of partners,
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7 players with notable R&D capacities were found to outsource their pre-competitive
8
9 R&D partially to these co-operative R&D institutions. Cooperative R&D institutions
10
11 in the field of material research are more open to a broader range of (weaker) partners
12
13 benefiting from technology spillovers. The latter, appropriately, have higher degree
14
15 centralities. The latter, appropriately, have higher degree
16
17 centralities.

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19 The prominent role, and high centrality values of universities, can also be explained by
20
21 the existence of continuous low-level exchange (e.g. diploma and doctoral theses) but
22
23 also by long term, informal personal relationships. In agreement with the concept of
24
25 absorptive capacity, firms with low R&D and innovation potentials, where innovation
26
27 mostly has an investment character, were found to have problems building up and
28
29 maintaining adequate relations with knowledge generating organizations. Surprisingly,
30
31 single medium tech component suppliers were seen to maintain continuous
32
33 relationships with knowledge generating institutions particularly when defining,
34
35 setting up and managing single projects. However, they invested in long-term
36
37 partnerships with cooperative R&D institutions giving them the chance to source out
38
39 R&D management on the hand and to gain from possible spillovers on the other.
40
41 Another non-binding form of dealing with pre-competitive and/or anticipative
42
43 knowledge generation lies in the support diploma theses.

44
45 In general firms engaging in cooperative pre-competitive R&D and in knowledge
46
47 generation seemed to be seeking adequate equal partners. Nevertheless, two
48
49 interesting long-term partnerships between small, knowledge intensive technical
50
51 business services and large system or component suppliers were observed. Both were
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53 based on long-term trust and informal exchange.
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3 (Insert table 4 here)
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- 8 • In the case of competitive R&D the universities still have the highest in-degree and
9 out-degree centrality mainly because they are the long-term partner for large firms in
10 the region. The same is true for larger firms with considerable R&D capacity. In the
11 case of competitive R&D and innovation processes on the firm side, the type of
12 organization and its position in the value chain is significant. As already mentioned in
13 Section 3.2, component suppliers are mostly given a work drawing and toll
14 manufacturers are provided with detailed specifications for the handling of
15 components. These work-drawings and tender specifications are explicit enough and
16 don't require further adaptation or knowledge intensive exchange. The burden of
17 liability is not devolved to the suppliers in such cases.
18
19

20 System suppliers, who provide non-standardized products ranked particularly high in
21 degree-centrality with respect to competitive R&D compared to pre-competitive R&D.
22 Cooperative R&D institutions, play a less prominent role than in the case of pre-
23 competitive R&D, where in the latter they interact prominently with universities and
24 their core-partners.
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46 As might be anticipated from Figure 1 consideration of betweenness centrality for the
47 observed institutions reflects more or less the picture found in the case of degree centrality.
48 The R&D-institutions play a considerable role as gatekeepers in the regional network.
49 Nevertheless, critical actors in the form of gatekeepers between two sub-networks, and
50 weakly integrated in the network total, could not be identified. Figure 3 combines the
51 perspectives of degree centrality and betweenness centrality (see Figure 3). The radial
52 position marks the degree centrality¹⁷ and the size of nodes the betweenness centrality. Once
53 again, the symbols used for the actors (nodes) correspond to the type of organization.
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3 In the case of direct deliveries a couple of actors were identified who had a significantly
4
5 higher value for betweenness centrality than for in-degree centrality. These firms were not
6
7 found in the core of vehicle manufacturing but in the interface with other sectors such as
8
9 manufacturing of plastic products or measurement techniques. In the dimension of pre-
10
11 competitive research and development, the universities, together with one cooperative
12
13 research institution in the field of material sciences, have noticeable roles as gatekeepers and
14
15 as considerable knowledge providers. In the case of the universities this can be explained by
16
17 their broad research capacities. The cooperative research institution in question is also an
18
19 important knowledge provider in the case of competitive research, although its concrete and
20
21 frequent contacts in this dimension are less wide spread. The leading systems supplier (with
22
23 considerable R&D capacity) seems to have significant position in the case of competitive
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25 R&D and innovation, reflecting their role in knowledge transfer among selected supply
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27 partners.
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4 Summary and conclusions

The network approach as a 'socio-metric analysis' of the cluster of 32 actors within the machinery sector plus related services and R&D-institutions (identified by means of a snowball sampling method), allowed us to describe both the form and content of their respective interactions. We used this approach for a tentative quantification of the different dimensions of interaction within the network and for establishing the position of the actors within the network. Based on the main economic indicators of the firms and on broad qualitative information obtained through in-depth interviews interactions were differentiated in terms of material-based deliveries (business–interactions), competitive R&D and innovation processes, and pre-competitive R&D.

In summarizing and interpreting the detailed results extensively described in the previous Section we can draw several conclusions:

- 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 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.

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- 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.
 - 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. Once again, 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.
 - The growth of new cooperative R&D institutions (competence centres) is an indication that this kind of network relation is rather new and that the pattern of interaction is becoming temporary in character and depends of the existence of specific kinds of knowledge generating institutions.
 - The pronounced density of regionally concentrated R&D interaction within the network gives support to the concept of networks as institutions for knowledge exchange.

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- In addition to viewing specific persons as generators of knowledge and firms as organizations for R&D we need to include networks and clusters as an additional level of socio-economic analysis.

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Our findings help to underline the following:

The concept of clusters is not universally valid – there is not only strong diversity between clusters (depending on sectoral specificities, regional habits, institutional embeddedness) but also within them. They are also to a large degree overlapping phenomena and hence not closed systems. This opens up the possibility of interpreting clusters not only as entities competing against each other but as variety generating units, variety also within each cluster. This supports the interpretation of LOASBY (1998, 78) who views clusters as a “scientific community” which have both the task of restoring tranquillity, and of “devising intimate connections which exploit the advantages of the increasing subdivision of functions within the economy”.

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Since firms try to establish a variety of types of interaction we can further pursue the idea of HELMSTÄDTER (2003) by distinguishing between the form and impact of these interactions: the exchange of goods obeys the rules of competition, the exchange of knowledge, the rules of cooperation and sharing. In our analysis we found a further distinction: competitive R&D does not lead to such strong numbers and intensities of interaction as pre-competitive research; the latter is dominated by cooperation as the basic institution as process guiding the division of knowledge.

Several methods have identified proximity as a precondition for knowledge. Using network analysis we also found a strong regional dimension for knowledge sharing. As specified

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3 above, density of interaction was all the stronger within a given geographic context the more
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5 the non-competitive elements of R&D dominated. This result is supported by the qualitative
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7 statements supplied by firms: Whereas input-output linkages are only to a small extent
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9 regionally concentrated, the opposite is true for knowledge intensive relations – most of them
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11 occur within regional boundaries.
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17 Regional networks can be regarded as a selective and geographically concentrated form of
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19 cooperation within the larger scales of interaction taking place on a national and international
20
21 level. The different dimensions and the different intensities of interaction support the
22
23 interpretation of networks as strategic interfaces between regional and global activities. The
24
25 various activities within networks constitute a balanced portfolio of relations where actors
26
27 decide for strategic reasons if and how to take part in networks of different quality and
28
29 function.
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36 In such a setting knowledge exchange is structured and not ubiquitous. With our analysis we
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38 hope to have made the heterogeneous nature of such exchange a little more explicit.
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NOTES

¹ The assumption is that the segment of the network that forms the sample is representative for the whole network. Therefore it required us having a deeper knowledge about the parent population and basic relations.

The value-chain of (knowledge) production refers to the sequential set of primary and support activities that are performed to turn inputs into value-added outputs for its external customers.

In our case therefore small trade business, handicraft business or business services like cleaning services, security services etc. which are not substantially integrated in the value chain of (knowledge) production have not been included in the analysis. As far as the value chain of (knowledge) production can be retraced in the region the observed network largely covers the total network of the leading firms. There are evidences for a certain robustness of network measures even under conditions of imperfect data (BORGATTI, CARLEY, KRACKHARDT 2006). Within the defined dimensions of the investigation a nearly complete inventory count can be assumed.

A matching of the characteristics of the observed firms with those of a control group out of the general population (i.e. the total sector) was undertaken to take into account the

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4 representativeness of the chosen sample. The assessment of representativeness has been based
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6 on 15 interviews with relevant firms in the sector which has been carried out in a pre-phase.
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9 For this purpose these 15 firms have been asked for their sourcing and cooperation strategies,
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11 their size and characteristics of their partners in the region and four leading firms finally on
12
13 this basis selected.
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16 ² One firm (BS 1) for instance is a first class technology provider with an export intensity of
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18 above 95% but with a considerable anchorage in the regional innovation system, where
19
20 participation in cooperative competence centres will be accentuated. Another interesting case
21
22 (BS 4) is an export oriented business service firm which is embedded and active in the
23
24 politically-initiated automobile cluster in Styria but lacks a regional key-customer base. BS 3
25
26 is an engineering service firm with industrial customers in the field plastic products and
27
28 composite materials, scientific partners and a pro-active strategy of integration into the
29
30 regional science community. BS 5 is a small service firm in the border region of Slovenia
31
32 which is a supplier to the leading system supplier or BS 1 and has received direct support
33
34 from the leading systems manufacturer during the past years. BS 2 is a small R&D-Service
35
36 which works almost exclusively for a knowledge intensive firm in the field of measuring
37
38 equipment.
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45 ³ The dimension of supply-chain-networks is a function of vertical integration and division of
46
47 labour in an industry. The automobile and aerospace industry are the mascots of empirical
48
49 investigations of supply chain networks and relations. They are special cases because middle
50
51 or high volumes of products with a relatively high number of individual parts are produced by
52
53 specified routines. Regional clients in other areas of the machinery sector with limited batches
54
55 or individual lot orders impose limits on medium and long-time strategic planning, on
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57 automation, or on long-term growth. Given the importance of the systems being subcontracted
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4 by assemblers, there is a clear strategic goal for these firms to work with a smaller number of
5
6 large suppliers.
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9 ⁴ Official Journal C 48 of 13.02.1998, Official Journal C 111 of 08.05.2002 European
10
11 Commission
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13
14 ⁵ We focused on three dimensions of direct exchange between the interviewed firms. Another
15
16 dimension of weak partially undirected relation between regional actors which has been
17
18 addressed in the interviews is informal exchange, in the course of trade fairs, events organized
19
20 by cluster-, business-promotion organizations or business-associations. This dimension of
21
22 interaction can not be operationalized for network analysis, albeit its significance may by no
23
24 means be underestimated as previous research verified (STEINER, HARTMANN 2006).
25
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27

28
29 ⁶ If also the direction of relations is accounted and asymmetric relations exist the number of
30
31 maximum possible relations
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33
$$r_{max} = (n \times (n - 1)) / 2$$
, where n is the total number of actors (possible nodes in the
34
35 network).
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38 ⁷ It seems appropriate to assume that each actor has limited relational capacity. The density of
39
40 a network of relations usually decreases with the number of observed actors; therefore it is not
41
42 possible to compare density measures across networks of different sizes (SCOTT, 2000,
43
44 FRIEDKIN 1981).
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46

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48 ⁸ The degree centrality for actors in directed asymmetric networks is measured in the
49
50 following way: Only the formula for the out degree centrality is presented, which is defined
51
52 analogously to the case of the out-degree of actor i . The distorting effects of the size of the
53
54 network can be neutralized by standardizing with respect to the maximum possible value of n -
55
56 1, where n is again the number of actors.
57

58
$$C'_d(n_i) = od_i / (n - 1)$$

59
60

⁹ The formula for the standardized closeness centrality $C'C(n_i)$ is

$$C'_c(n_i) = \frac{N-1}{\sum_{j=1}^N d(n_i, n_j)} \quad \text{for } i \neq j$$

¹⁰ The betweenness centrality $CB(n_i)$, is defined as

$$C'_B(n_i) = \sum_{j < k}^n \sum_k^n b_{jk}(n_i) \quad b_{jk}(n_i) = g_{jk}(n_i) \frac{1}{g_{jk}}$$

for $i \neq j \neq k$ where

The maximum centrality is dependent on the size of the network. The standardized betweenness centrality is defined by the formula

$$C'_B(n_i) = \frac{2C_B(n_i)}{n^2 - 3n + 2}$$

¹¹ The merging of all dimensions provides a network with a standardized total density of 0.226, which is a remarkably high value. The possible density of the network decreases as one moves from core to periphery. Thus extending the sample using snowballing would result in a lower total network density.

¹² Even in the case of a network of 32 actors with a relatively low density the number of cross-cutting relations causes confusion to a certain degree. This is all the more evident for a network with a density of 0.223.

¹³ To aid clarity we dichotomized and symmetrised the relations here under consideration, This means that the definition of all relations is reduced to the question of whether they are present or not irrespective of frequency and direction of interaction.

¹⁴ The assumption of the independence of statistical observations, which is a prerequisite for standard OLS-estimations cannot be held in the case of social network analysis (SCOTT 2000. The alternatively employed regression algorithm performs in first step a standard multiple regression across corresponding cells of the dependent vector (the observed degree centralities) and independent vectors (selected characteristics of the actors in the network). In a second step the regression is recomputed by random permutations (50 000) storing resultant

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4 values of r-square and all coefficients. Based on this procedure estimates of standard error and
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6 "significance" are computed. The regression analysis was conducted for each degree-
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8 centrality (dependent variable) on the basis of the following explanatory variables:
9
10

- 11 • Dummy variables for the type of organization (business services (TBS), systems
12 suppliers (SYSTSUP), component suppliers (COMPSUP), R&D-Institutions
13 (RD_INST)) and one dummy variable for 'part of a form group' (FIRMGRP)
14
15
- 16 • Metric variables for the age of the institution in the region (LOG_AGE), the size of the
17 organization as a function of the logarithmic number of employees (LOG_EMPL), the
18 size of the R&D-units (RDEMPL), the R&D-Intensity as a proportion of employees
19 involved in R&D-Activities (SHARE_RDEMPL) and finally the export intensity
20 (EXPORT)
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30 The analysis has been conducted in two sequential steps: firstly with a single-step variable
31 selection approach and secondly a stepwise variable selection approach (both based on 50 000
32 permutations).
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37 ¹⁵ Significant results of the correlation analysis are:

- 38 • In respect of the type of organization the characteristic 'system supplier' (SYSTSUP) is
39 positively correlated with the size of the firm (LOG_EMPL) and the exporting intensity
40 (EXPORT).
41
42
- 43 • The characteristic 'R&D-Institution' (RD_INST) is positively correlated with the R&D-
44 Intensity measured by the share of R&D-employees (SHARE_RDEMPL).
45
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- 47 • The size (LOG_EMPL) of the organization is positively correlated with export intensity
48 (EXPORT) and with the size of the R&D-unit (RDEMPL).
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56 The results of the correlation analysis are summarized in detail in the Annex (**Error!**
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59 **Reference source not found.**)
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¹⁶ It has to be remarked, that the final model 2 is only able to explain a relatively small share of the total variance.

¹⁷ The radial scales of the figures are different for ease of presentation.

Degree-centrality focuses on the significance of an actor either on the demand- or supply side.

Betweenness focuses on both sides (in and out). It is thus possible to illustrate six combinations of degree- and betweenness centrality.

We selected the most interesting ones for figure 3. In the case of direct delivery in-degree centrality has been chosen and in the dimensions of research and development the out degree centralities are used.

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ANNEX:

Table 5 Correlation coefficients of degree centralities and structural characteristic of firms –

A comparative view of the observed dimensions of interaction

	RD_INST	TBS	SYST_SUP	COMP_SUP	FIRM_GRP	LOG_AGE	LOG_EMPL	RDEMP_L	SHARE_RDEMP_L	EXPORT	in-degree DELIV	out-degree DELIV	in-degree PRECOMP	out-degree PRECOMP	out-degree COMP
TBS	-0,269														
SYSTSUP	-0,391*	-0,269													
COMPSUP	-0,269	-0,185	-0,269												
FIRM_GRP	0,209	-0,086	0,07	-0,086											
LOG_AGE	0,04	0,028	-0,389*	0,291	-0,531**										
LOG_EMPL	-0,141	-0,256	0,521**	0,06	-0,04	0,091									
RDEMP_L	0,091	0,057	0,131	-0,186	0,174	0,058	0,668**								
SHARE_RDEMP_L	0,77**	0,177	-0,395*	-0,361*	0,306	-0,02	-0,268	0,146							
EXPORT	-0,534**	0,202	0,476*	-0,032	0,125	-0,051	0,463*	0,299	-0,393*						
in-degree DELIV	-0,332*	-0,076	0,531**	0,012	0,229	-0,193	0,677**	0,669**	-0,254	0,647**					
out-degree DELIV	-0,504**	0,022	-0,249	0,413*	-0,414*	0,288	-0,134	-0,295	-0,491*	0,098	-0,08				
in-degree PRECOMP	0,68**	-0,054	-0,095	-0,381*	0,215	0,008	0,303	0,52**	0,656**	-0,035	0,162	-0,527**			
out-degree PRECOMP	0,772**	-0,098	-0,178	-0,34*	0,145	0,12	0,259	0,438*	0,658**	-0,178	0,017	-0,554**	0,962**		
in-degree COMP	0,254	-0,179	0,161	-0,215	0,124	-0,054	0,547**	0,581**	0,195	0,182	0,505**	-0,243	0,695**	0,635**	
out-degree COMP	0,447*	-0,262	0,06	-0,193	0,088	0,023	0,511**	0,636**	0,272	0,031	0,437*	-0,308	0,747**	0,723**	0,853**

Table 1 Descriptive indicators of the observed actors in the network

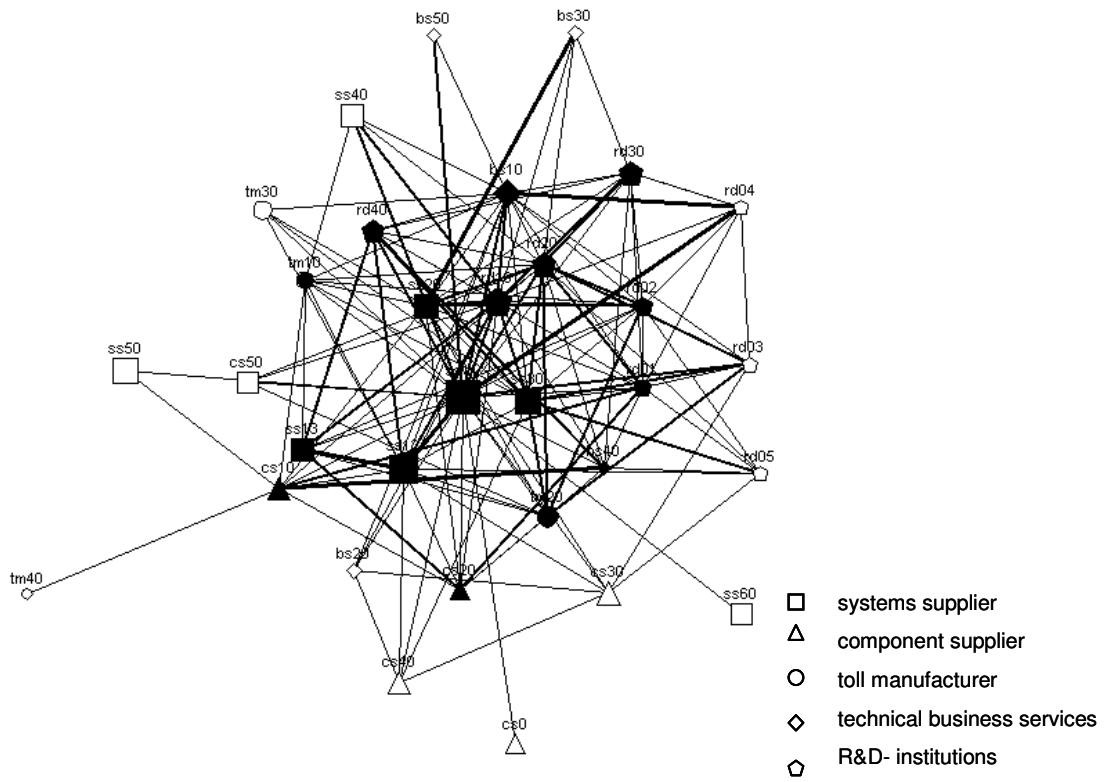
<i>Type of the organization</i>	<i>system suppliers</i>	<i>component suppliers</i>	<i>toll manufacturers</i>	<i>business services</i>	<i>R&D – institutions</i>	<i>Total</i>
<i>N</i>	9	5	4	5	9	32
(%)	28	15.6	12.5	15.6	28.1	100.0
<i>individual firm (N)</i>	4	3	3	3	3	16
<i>part of a firm group (N)</i>	5	2	1	2	6	16
<i>industry</i>						
<i>Manufacturing of rubber and plastic products (25)</i>	0	2	1	0	0	3
<i>Manufacture of basic metals and fabricated products (incl forging, surface treatment and heating) (27, 28)</i>	0	2	3	0	0	5
<i>Manufacture of precision and optical instruments (33)</i>	1	0	0	0	0	1
<i>Manufacturer of motor vehicles, trailers and other trailers (34)</i>	8	1	0	0	0	8
<i>Business Services (74)</i>	0	0	0	5	0	5
<i>R&D (73)</i>	0	0	0	0	6	6
<i>Universities, Educ. (75)</i>	0	0	0	0	3	3
<i>size of the organization (categor.)</i>						
<i>small-sized org. (up to 49 empl.)</i>	0	0	2	4	4	10
<i>medium-sized org. (50 to 249 empl.)</i>	2	3	2	0	1	8
<i>large organization (250 and more empl.)</i>	7	2	0	1	4	14
<i>size of the R&D-unit (categor.)</i>						
<i>no R&D employees (N)</i>	2	5	3	0	0	10
<i>1 to 3 R&D employees (N)</i>	0	0	1	3	0	4
<i>4 to 7 R&D employees (N)</i>	3	0	0	0	2	5
<i>8 to 15 R&D employees (N)</i>	4	0	0	2	7	13
<i>above 15 R&D employees (N)</i>	2	5	3	0	0	10
<i>average exporting intensity (mean in %)</i>	68,67	20,25	27,8	49,8	~	~
<i>age of the organization (categor.)</i>						
<i>1 to 3 years (N)</i>	3	0	1	0	1	5
<i>4 to 7 years (N)</i>	1	2	0	0	2	5
<i>8 to 15 years (N)</i>	1	0	0	2	2	5
<i>above 15 years (N)</i>	4	3	3	3	4	17

Table 2 Density of the observed dimensions of networking and average degree, closeness and betweenness centralities

<i>Relational dimensions</i>	<i>Number of actors involved (nodes)</i>	<i>Density</i>	<i>Average degree centrality</i>	<i>Average closeness centrality</i>	<i>Average betweenness centrality</i>
(DELIV) direct delivery relations	25	0.07	0.07	0.08	0.00
(PRE-COMP) interaction in the context of pre-competitive R&D	23	0.14	0.15	0.27	0.01
(COMP) interaction in the context of competitive R&D and innovation activities	25	0.07	0.08	0.20	0.03
Overall network	32	0.23	0.22	0.46	0.03

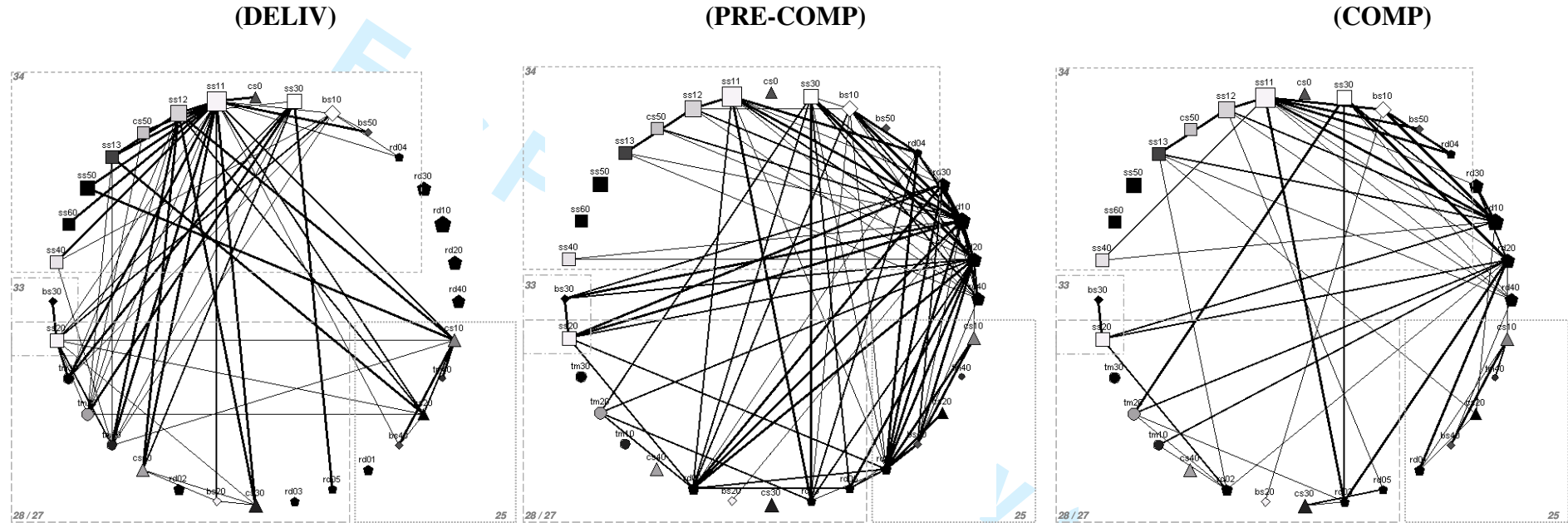
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Figure 1 Network of firms and Knowledge generating institutions in Styria



Review Only

Figure 2 Comparative presentation of the observed dimension of networking



- systems supplier
- △ component supplier
- toll manufacturer
- ◇ technical business services
- ◇ R&D- institutions

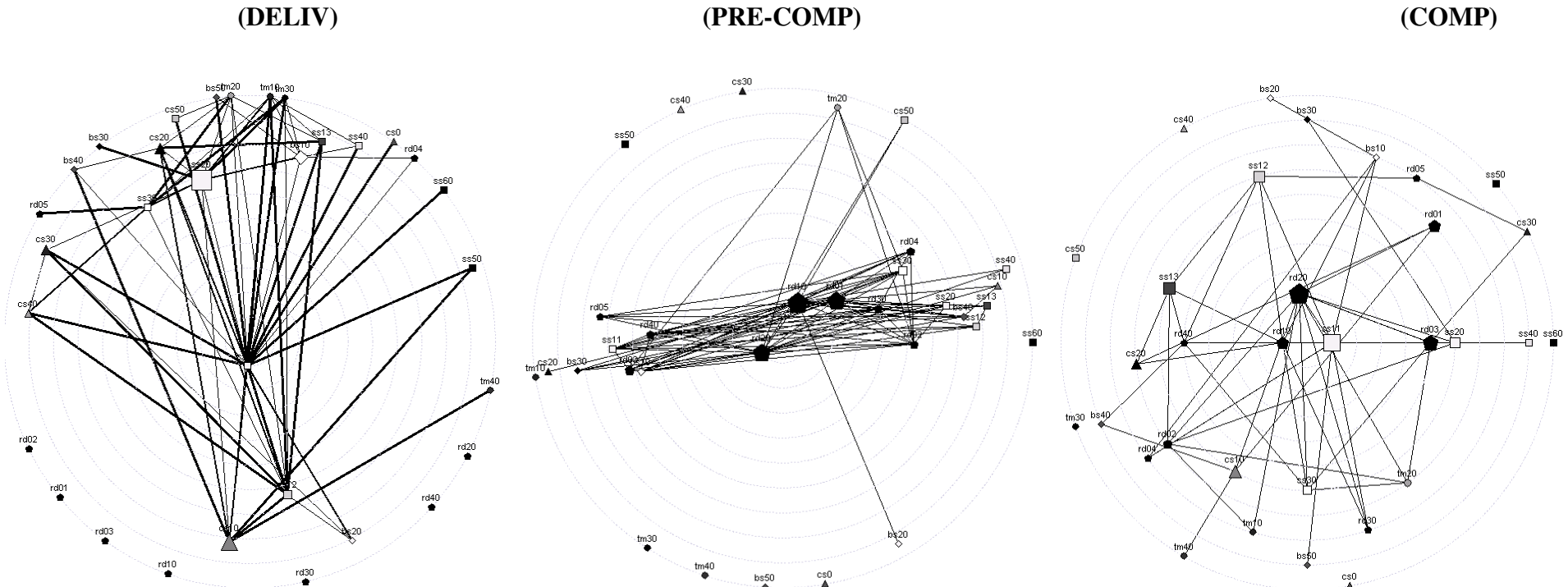
Table 3 Overlapping of the observed dimensions of networking (% of the number of relations)

<i>Perspectives</i>	<i>(in %)</i>	<i>excl. direct - Deliveries (DELIV)</i>	<i>direct Deliveries (DELIV) as well as Interaction in the context of R&D (PRE-COMP or COMP)</i>	<i>excl Interaction in the context of R&D (PRE-COMP or COMP)</i>
<i>perspective A:</i>				
<i>inter-linkages between firms</i>		79.37	15.87	4.76
<i>perspective B:</i>				
<i>interlinkages of firms with other firms in the region and R&D Institutions</i>		40.98	10.66	48.36
<i>perspective C:</i>				
<i>interlinkages in observed total network</i>		34.48	8.97	56.55

**Table 4 Regression coefficients for the correlation between degree centralities and structural characteristic of firms –
A comparative view of the observed dimensions of interaction**

	Interaction by direct deliveries (DELIV)						Interaction in the context of pre-competitive R&D (PRE-COMP)						Interaction in the context of competitive R&D (COMP)						
	Model 1: in-degree centrality			Model 2: out-degree centrality			Model 3: in-degree centrality			Model 4: out-degree centrality			Model 5: in-degree centrality			Model 6: out-degree centrality			
	One-Step Variable Select.		Stepwise Variable Selection	One-Step Var. Select.		Stepwise Variable Selection	One-Step Incl.		Stepwise Variable Selection	One-Step Variable Select.		Stepwise Variable Selection	One-Step Variable Select.		Stepwise Variable Selection	One-Step Incl.		Stepwise Selection	
	R ²	R ²	F	R ²	R ²	F	R ²	R ²	F	R ²	R ²	F	R ²	R ²	F	R ²	R ²	F	
	0.816	0.74	25.8	0.731	0.2	6.8	0.79	0.46	25.8	0.813	0.74	40.2	0.524	0.43	10.7	0.646	0.56	18.3	
	Beta	Sg	Beta	Sg	Beta	Sg	Beta	Beta	Sg	Beta	Sg	Beta	Sg	Beta	Sg	Beta	Beta	Sg	
(Constant)	0.063				0.152					-0.06						0.038			
RD_INST	-0.047				-0.168			0.135	0.205	0.000	0.257	*	0.294	0.000	-0.012		0.084	0.071	0.018
TBS	-0.061				-0.12			-0.018		0.048					-0.061		-0.041		
SYSTSUP	0.073	0.084	0.096		-0.164			-0.051		-0.028					-0.061		-0.018		
COMPSUP	0.086				-0.045	0.08	0.02		-0.05		-0.055				-0.043		-0.003		
FIRMGRP	-0.015				-0.044				-0.029		-0.006				-0.02		-0.034		
LOG_AGE	-0.038				-0.017				-0.024		0.013				-0.028		-0.022		
LOG_EMPL	-0.021				0.027			0.072		0.095	0.086	0.018	0.058	*	0.067	0.000	0.023		
RDEMP	0	*	0	0.029	0			0		0				0		0	0.0	0.001	
SHARE_RDEMP	0				0.001			0.002		0.001				0.001	0.001	0.027	0		
EXPORT	0.001	*	0.001	0.061	0			0.001		0				0		0			

Figure 3 Illustration of degree centrality and betweenness centrality



- systems supplier
- △ component supplier
- toll manufacturer
- ◇ technical business services
- ◊ R&D- institutions

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