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The Regional Embeddedness of Small Manufacturing and Service Firms: Regional Networking as Knowledge Source for Innovation?

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Abstract

Information and knowledge are important prerequisites for innovation activity in firms. One important means of acquiring complementary knowledge are innovation networks. Depending on their absorptive capacity and knowledge base, firms develop different abilities to access and utilise external knowledge. These abilities might also be linked to firm size. Although size as such is not a decisive criterion for distinguishing between the innovative performance of firms, it can at least be used to classify firms according to common structural characteristics. It is the objective of this paper to analyse whether the size of a firm significantly affects its innovative behaviour and co-operation pattern and whether there are differences between manufacturing firms and business-related service firms. Using data from a regional innovation survey carried out in Germany, we come to the conclusion that for structural firm characteristics, innovation strategies, information use and innovation networking size matters. Small manufacturing and service firms mainly behave similar and are more regionally oriented in their market reach and knowledge acquisition than large firms. Especially small firms in intermediate and rural areas strongly depend on regionally available knowledge sources and are therefore discriminated compared to large firms which make a more frequent use of knowledge and information sources from outside the region.

1. Introduction

Although concepts like innovative milieux and industrial districts emphasise the importance of small firms, and empirical studies in industrial economics have associated these firms with flexibility, efficiency, and innovative activity (Acs/Audretsch 1990; Pavitt et al. 1987; Rothwell 1989), there is no clear evidence for a relationship between size and innovativeness of a firm. It is often argued that size is not a decisive criterion for the performance of a firm (Sengenberger/Pyke 1992: 11), but the organisational and institutional context in which they operate. The decentralisation of entrepreneurial functions, the creation of smaller production units, outsourcing and other strategies for improving the core competencies of companies lead to an increase in the number of smaller manufacturing and service firms and to the assumption that small firms adjust more efficiently to market volatilities (Camagni/Capello 1997). The dichotomy between small and large firms is surely a simplification, but it makes clear that the influence of regional framework conditions for firm innovation varies according to the firm's absorptive capacity, its access to intra-company assets and inter-company networks. On the other hand, several empirical studies find evidence for a closer local integration of small firms (Backhaus/Seidel 1998; Koschatzky 1997; Sternberg 1998). Within the vicinity of their location they are better able to reduce co-operation risks and to monitor possible violation of contracts than over greater spatial distances. It can therefore be assumed that small firms more strongly rely on knowledge sources avail-

able in their region and are therefore more dependent on the quality of regional information and co-operation partners for the realisation of innovations than larger firms.

Based on this hypothesis, the objective of this paper is to find answers to the question whether the size of a firm significantly affects its innovative behaviour and co-operation pattern and whether there are differences between manufacturing firms, often object of empirical testing, and business-related service firms, for which only a few innovation studies already exist. The paper is structured as follows: In the following section a short overview on recent debates about the roles small and large firms play in the innovation process and their ability to handle external and internal knowledge will be given. Section three then describes the methodology and the data source which were used for empirically testing the research questions raised in this paper. It also includes the segmentation between small and larger firms and describes the two size categories which form the basis of the empirical analysis. This will be performed in section four for manufacturing and business-related service firms. Conclusions from the empirical analysis with respect to the objective of this paper and regional innovation policy will be drawn in section five.

2. Small and Large Firms in the Innovation Process

The debate whether small or large firms are more innovative and whether size is a useful criterion to distinguish between the differences in the intensity and the kind of innovative activity of firms is not a recent phenomenon, but can be traced back to the pioneering work of Schumpeter. While he first emphasised the risky behaviour of pioneer entrepreneurs for improving the supply of innovative solutions (Schumpeter 1911), he later argued that large firms can devote more resources to systematic research and development and are more innovative than small firms due to scale advantages (Schumpeter 1942). Freeman summarised these two hypotheses in the model of entrepreneurial innovation (Mark I) and the model of large-firm managed innovation (Mark II) (Freeman 1982: 212-213). Both hypotheses became the starting point for numerous theoretical and empirical studies and reflect the still existing influence of Schumpeter in innovation economics.

An important aspect of studies analysing innovation processes in firms (e.g. Nelson/Winter 1982) deals with the relationship between firm size and innovative activity. One common result of these studies carried out during the 1970s and 1980s was that innovation intensity increases with size up to a turning point and then decreases again with increasing firm size, shaping an inverted "U". Although variations in the results of these studies concerning the trend and turning point of the inverted U-curve can be observed depending on the data used for the analysis, the innovation indicators and the

firm units, the general pattern was believed to be stable (see Frisch 1993 for a summary of different input- and output-oriented studies).

Based on the empirical evidence in several North American and European regions, small firms and the role they played for job creation and economic development were put into the limelight during the 1980s. Not only in the United States, where between 1969 and 1976 two-thirds of all new jobs were created by new firms and firms up to 20 employees (Birch 1987), but also in many other countries and regions small firms contributed to regional and employment growth (Aydalot 1986; Camagni 1991; Keeble 1997; Piore/Sabel 1984; Pyke et al. 1990; Sengenberger/Pyke 1992). Besides these specific regional examples, the decentralisation of entrepreneurial functions, the creation of smaller production units, outsourcing and other strategies for improving the core competencies of companies led to an increase in the number of smaller firms during the 1980s and to the assumption that small firms adjust more efficiently to market volatilities. Evidence for the importance of small firms was provided by the SPRU innovations database according to which small firms were not only responsible for more innovation than their share of R&D expenditures would imply, but also for a larger share of innovations than could be expected from their share of employment (Pavitt et al. 1987; Tether et al. 1997: 21).

Not surprisingly, in the late 1980s and early 1990s the contribution of small firms to innovation was subject of several publications of which Acs's and Audretsch's empirical study was one of the most significant (Acs/Audretsch 1990). Their analysis opened the floor for a more differentiated view about the relationship between firm size and innovation. Although they found some evidence that small firms are more innovative than large firms, one of their major conclusion is that innovativeness mainly depends on the industry. In industries composed predominantly of large firms, the increase in innovative activity emanates from the smaller firms because their survival depends on innovation (Acs/Audretsch 1990: 50). Pointing to Scherer who concluded that "no single firm size is uniquely conductive to technological progress. There is room for firms of all sizes" (Scherer 1980: 418), both authors summarised their findings by stating that "it would be erroneous to conclude that the small firm is more innovative than the large firm" (Acs/Audretsch 1990: 54). To be more detailed, they found out that the innovation rates of small and large firms depend on the degree of capital intensity in a way that in capital-intensive, advertising-intensive, concentrated and highly unionised industries larger firms are more innovative than smaller ones, although the innovative activity tends to decrease as the level of concentration in an industry increases. On the other hand, in highly innovative industries composed predominantly of large firms, the innovative advantage is held by the smaller firms (Acs/Audretsch 1990: 57-59).

Taking these and other results as a starting-point for further research, behaviouristical aspects of firm innovation (based on Nelson and Winter's fundamental ideas) as well as

a revision of earlier empirical findings became predominant topics in recent years. By reclassifying firms originally listed as small to large, data from the SPRU database now suggest that "...the relationship between innovative intensity and enterprise size in the manufacturing sector (tends) to be not u-shaped but j-shaped, with only the largest enterprises introducing a disproportionately large share of the innovations" (Tether et al. 1997: 31). Using as well the SPRU database and pointing to the limitations of his analysis, Tether (1998:742) came in another study to the conclusion that by using the average value of an innovation, measured by revenues, "... the interpretation that small firms are more innovative (or more efficient innovators) than large firms because they have introduced a larger number of innovations relative to their employment is unsound." There is also no evidence for an extremely rapid growth among the small firms included in the database between 1975 and 1983.

All the results presented so far lead to the conclusion that it is not mere size by which innovative activity of firms can be distinguished, but by several firm internal aspects as well as by the organisation of the innovation process itself. Similar to the fact that the innovation does not exist, there is also no optimal firm size for innovation, as Frisch (1993: 283) concludes in his study. The preparedness to innovative depends, among others, on the degree of the risk aversion of a firm which itself is depending on the structure and behaviour of the management (Barkham et al. 1996: 73). These ideas are linked to the concept of the absorptive capacity of a firm which, in short, describes the ability to exploit, evaluate and utilise external knowledge for innovation (Cohen/Levinthal 1990). The larger the knowledge base of a firm, be it small or large, to which internal and external communication structures, R&D, production experiences and the learning capacity of the firm staff contribute, and the higher their competencies in integrating the knowledge into the organisation (Le Bars et al. 1998: 316), the better will be its ability to absorb new knowledge and to innovate. In this respect, the so-called "gatekeeper" achieves an important interface function. Firms centralising the access to external information and knowledge and its distribution might run into problems, especially under the conditions of rapid and uncertain technical change (Cohen/Levinthal 1990: 132). Linking more members of a firm to innovation relevant knowledge reduces the risk of not being able to monitor relevant technical information and to translate it into a language which can be understood by the individual members of the firm.

Recent research work in the fields of knowledge and network economics goes beyond the more general concept of the absorptive capacity of an organisation and stresses the importance of systematic learning and the need for interacting in the innovation process (Coombs/Hull 1998; Cowan/Foray 1997; Cimoli/Dosi 1996; Nonaka/Takeuchi 1995; Spender 1996). It is argued there that knowledge can only be acquired by systematic learning and forgetting. Learning within a firm can take place at different levels (Reid/Garnsey 1998) of which the learning processes induced by interactions (net-

works) between users and producers, competitors, other firms and research institutes are one of the most powerful driving forces for innovative activity (Lundvall 1988). To a certain extent, networking can compensate for lacking internal knowledge and resources, but without the ability to manage network relations and to integrate the transferred knowledge into the firm's production and managerial activity, firms would not be able to benefit from learning effects (Koschatzky 1999). Networking, learning and knowledge accumulation are therefore a cumulative process by which firms might run into path dependence. Those firms which do not interact with others are in the long run not able to utilise and accumulate external knowledge and lose their ability to handle external knowledge and information exchange. Firms which are integrated in a set of network relations continuously improve their learning capabilities and their knowledge base and also their ability to utilise new knowledge (Capello 1999).

Depending on the kind of the exchanged knowledge, spatial and cultural proximity is a more or less important prerequisite for the exchange process. It is argued that codified knowledge can be transferred over long distances at low costs so that spatial proximity between transmitter and receiver is not necessary, while tacit knowledge exchange requires interpersonal contacts, verbal and non-verbal communication and is therefore sensible to an increasing spatial and cultural distance between the interaction partners (Arnold/Thuriaux 1997; Foray/Lundvall 1996; see also Saviotti 1998). It is not only distance as such that influences knowledge exchange, but also the sum of distances to the different partners a firm is interacting with. Firms which can minimise these distances should have an advantage over those firms which can either not realise the transfer of (tacit) knowledge due to distance problems or at higher costs only. A minimising strategy is to locate at those locations where a large selection of possible knowledge sources could be expected. This is especially the case in agglomerations which can be characterised by the availability of localised knowledge and generic assets (Storper 1995; Storper 1997). On the other hand, agglomerations might not necessarily imply a mutually beneficial innovative environment for all industries, because cumulative causation processes based on the pre-existing economic structure of that region pre-determine the location of modern economic activities (Coe/Townsend 1998: 389). Because of the functional relationship between the different types of regions, also non-core regions are able to generate own growth conditions and to provide a favourable innovation climate (Scott 1995; Storper 1997: 77). Nevertheless, there is empirical evidence that firms adapt to their regional environment by applying different innovation strategies. For example, in regions where the supply of skilled labour is limited, labour is substituted by capital (Meyer-Krahmer 1985).[1] It can therefore be concluded that the regional environment in which a firm is embedded has at least some

[1] See also Keeble (1997: 289) who concludes "...that firms in peripheral regions may actively try to compensate for and overcome environmental handicaps by pro-active engagement in research and development to an even greater degree than their counterparts in core regions."

impact on its access to information and knowledge and on its ability for collective learning (Keeble/Wilkinson 1999; Lawson/Lorenz 1999), especially when the firm is small and unable to manage complex networking relations (Klein Woolthuis et al. 1998) and the spatial range of networks is mainly confined to the region itself.

Although within both small and large firms the ability to exploit internal and external knowledge for innovation might be developed differently, larger firms have - in general – a stronger resource base with respect to human capital, capital and economic power and can make better use of national and international knowledge sources than small firms. This can be shown in empirical networking studies according to which larger firms are engaged in more diverse and spatially distant networking relations than smaller firms (Backhaus/Seidel 1998; Sternberg 1998). Often this pattern is closely linked with the market reach of firms: generally small firms realise a higher share of turnover in local and regional markets while the propensity for larger firms to be engaged in international business relations is higher than for smaller firms.

In the recent literature on industrial innovation one major research question is not whether small or large firms are more innovative, but which role these firms play in the innovation process. The growth in the number of small firms during the 1980s is nowadays not seen to have been an independent process, but attributed to the decentralisation strategies of large firms which contributed to small firm growth (Camagni/Capello 1997; Sengenberger/Pyke 1992). The outsourcing of entrepreneurial functions increased the flexibility of larger firms by being able to react more quickly to changing market conditions. Small firms are a major source for new products and processes, but due to their limited financial resources they are often confined to the first creative phase of the innovation process. On the other hand, large firms are more engaged in gradual technological change, imitation and diffusion by adopting incomplete innovations of small firms and bringing them to the market (Frisch 1993: 285). They are more strongly engaged in incremental innovation and carry out more process-oriented research and development than smaller firms (Cohen 1995: 205). Mass production enables larger firms to realise learning effects, but also leads to path dependence in a way that these firms are usually bound to a technological trajectory which impedes flexible technological change.

Including the results of a recent empirical study about the relationship between product innovation, process innovation and size (Fritsch/Meschede 1998: 18-19), the question whether the intensity and the kind of innovative activity of firms differ according to size can be answered as follows:

- There is ample evidence that small firms are not per se more innovative than larger firms, although small firms that perform R&D tend to be more innovative than large firms and also generate a higher number of innovations per unit of R&D input.

- The amount of firms that do not innovate or that were not engaged in R&D is relatively high among small firms and declines with size. As a matter of fact, large firms are more innovative with respect to the share of firms with R&D.
- An optimal firm size for innovation does not exist.
- Innovation varies between firms, between sectors and between markets.
- Innovation activity depends on the risk aversion of firms, their absorptive capacity, knowledge base, their competencies in organising innovation processes, their learning abilities and information channels and their access to and handling ability of external knowledge.
- Small and large firms play different roles in the innovation process.
- Small firms are the engine of new technological developments, but are often unable to finish innovations because of limited resources.
- R&D activity in large firms is more directed towards incremental innovation and process developments, since the budget for process R&D rises somewhat stronger with size than the one for product R&D.

These results emphasise the different roles firms play in the innovation process. It is not mere size by which a distinction can be made between the different activities and behaviours of firms, but according to the studies presented in this section similar characteristics of firms group around firm size in the spectrum from small to large. Size will therefore be used as a substitute for structural characteristics of firms and for classifying firms according to their different attributes.

So far, most of the empirical studies dealing with firm size and innovation made statements for the manufacturing sector only. Here one important result already reported is that innovative activity depends on the industrial sector. The question arises whether this finding can also be transferred to the service sector in a way that evidence for similarities and differences in the innovative activity within the service sectors and between manufacturing industry and services can be found. Research on innovations in services, especially in business-related services, started only quite recently (Bellini 1998; Licht et al. 1996; Miles et al. 1994; Strambach 1995; Wood 1995). Since a comparable amount of studies which were carried out for the manufacturing industry does not exist for the service sector, it seems worthwhile to compare at least some innovation and networking characteristics of manufacturing and business-related service firms.

For both manufacturing and service firms covered by the German regional innovation survey, the following research questions should serve as the guidelines for the empirical analysis:

(1) By which structural characteristics do small and large firms differ?

(2) Which innovation strategies are applied in each group?

(3) What external information sources are used by small and large firms and how is the distribution of this information within the firm being organised?

(4) Which knowledge sources are used for innovation by the firms and what is the spatial range of innovation networking? Can differences in information and knowledge acquisition and the spatial range of networking be found for small and large firms between different types of regions?

(5) What are the major obstacles for innovation and how do firms assess the region in which they are located?

(6) Are there similarities between small manufacturing and small service firms in their innovation behaviour, or do firms from both sectors differ significantly in innovation, irrespective of size?

(7) Which conclusions can be drawn for regional innovation policy with respect to small firms innovation and regional supply supporting factors?

3. Data and Methodology

The data used for this analysis originate from a regional innovation survey, carried out among mainly small and medium-sized manufacturing and business-related service firms in several German and European regions during 1995 and 1998.[2] For this paper, data from Baden, i.e. the western part of Baden-Württemberg, and from south-east Lower Saxony, comprising the cities of Hannover, Braunschweig and Göttingen, are used (for details see Backhaus and Seidel, 1997; Koschatzky and Traxel, 1997; Koschatzky, 1997). The regions under review cover a representative breakdown of German regions, ranging from the automobile regions in eastern Lower Saxony, the service oriented Expo 2000 urban region of Hannover and the technology region Baden. The industrial branch spectrum of the survey ranges from NACE codes 15 to 36. In services, computer and related activities (NACE 72), architectural and engineering activities/technical consultancy and technical testing and analysis (NACE 74.2 and 74.3), legal activities, accounting, tax consultancy (NACE 74.11 and 74.12), and market research, business and management consultancy, and advertising (NACE 74.13, 74.14, 74.4) were included. Within the regions a differentiation was made between

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2 These data originate from the European Regional Innovation Survey (ERIS), jointly carried out by the Fraunhofer Institute for Systems and Innovation Research Karlsruhe, the Department of Economic Geography at Hannover University, the Chair for Economic Policy at the Technical University Bergakademie Freiberg, and the Department of Economic and Social Geography at University of Cologne, with financial support of Deutsche Forschungsgemeinschaft (DFG).

three types of functional regions, i.e. central, urban regions (e.g. Hannover, Karlsruhe), intermediate regions (e.g. Freiburg, Göttingen), and rural regions (e.g. the Black Forest region Schwarzwald-Baar-Heuberg), in accordance with the official German planning region classification of 1991.

Usually in classifying small, medium-sized and large firms, 500 employees serve as a threshold for segmenting SMEs from large firms. In some studies, large firms are defined by a minimum of 2,000 employees. With respect to the size distribution of the sample and the firm characteristics for which size is used as substitute, a different approach was applied in this study. First of all, only firms which recorded at least some innovative activity and related interactions were included in the analysis. Average size of manufacturing firms of 265 employees (median 97 employees) and of service firms of 44 employees (median 3 employees) made it not only necessary to apply different definitions of small and large for both samples, but also to define small and large according to the structural characteristics of the sample firms.

In order to divide the sample in size classes according to firms' structural characteristics, their co-operation behaviour and their expected future development[3], a homogeneity analysis has been performed. With the aid of plot outputs, this type of analysis aims at presenting relationships between categorical variables in few dimensions which thus allows to describe structures or patterns in variable relationships that are difficult to detect otherwise.[4] In order to do so, homogeneity analysis is based on optimal scaling and assigns scores to categories which account for as much association between the variables as possible. Consequently, the output indicates similar variable categories and may serve as a basis for characterising and classifying the sample (cf. Figure 1).

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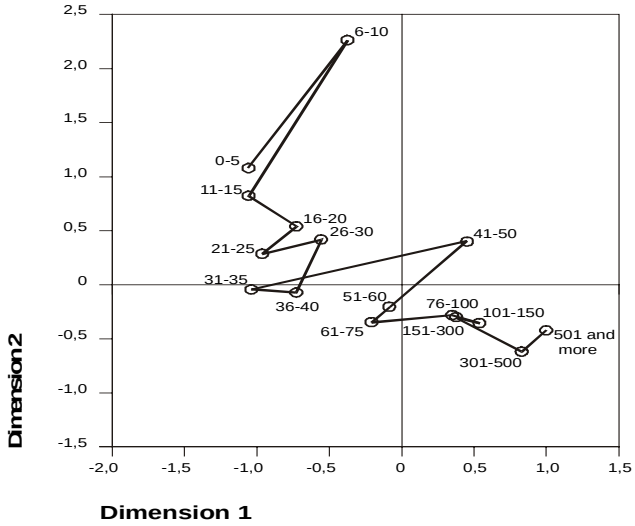
3 These variables include the number of employees with university degree, companies' co-operations with other economic actors, their sector of activity as well as their expected changes in R&D activities and in number of employees.

4 Thus, homogeneity analysis can be described as principal component analysis for nominal data.

Figure 1: Homogeneity analysis for classifying small and large manufacturing firms



Our aim in this first step of the analysis was to investigate if different size classes according to the chosen structural characteristics could be differentiated. Therefore, the variable input also included the number of employees. For manufacturing firms, the size variable discriminated well on both dimensions of the analysis, i.e. this sample consists of 398 firms of which 173 are defined as ***small manufacturing firms with up to 40 employees*** and 225 as ***large manufacturing firms with more than 76 employees***. Resulting from a respective homogeneity analysis, the service sample comprises 174 firms, of which 95 are ***small service firms with up to 3 employees*** and 79 defined as ***large service firms with more than 21 employees***. Tables 1 and 2 give an indication about the size distribution among industries and type of location. *SF stands for small firm and LF for large firm.* Although the term "large firm" is used in this paper, it has to be clearly stated that our large firms are still small compared to the definition of "large" used in other innovation studies and that the definition of small and large differs between manufacturing and service firms.

Table 1: Distribution of small and large manufacturing firms according to industries and type of region

Industry (share of firms in %)	**Total**		**Central**		**Intermediate**		**Rural**	
	SF (n=173)	LF (n=225)	SF (n=50)	LF (n=65)	SF (n=73)	LF (n=115)	SF (n=50)	LF (n=45)
Food	2.3	5.3	2.0	9.2	4.1	5.2	0.0	0.0
Textile	2.9	5.3	0.0	0.0	2.7	8.7	6.0	4.4
Wood	19.1	13.8	14.0	10.8	24.7	15.7	16.0	13.3
Plastics	15.0	17.3	22.0	26.2	16.4	16.5	6.0	6.7
Metal	13.9	11.1	16.0	7.7	8.2	11.3	20.0	15.6
Machinery	24.9	28.4	26.0	21.5	24.7	29.6	24.0	35.6
Electronics	22.0	18.7	20.0	24.6	19.2	13.0	28.0	24.4
χ^2	0.301		0.404		0.381		0.890	

While for manufacturing firms the industrial mix between small and large firms is statistically insignificant (according to χ^2 test) and therefore branch effects on firm behaviour can mostly be neglected (although the industrial mix between the three types of region varies significantly), the industrial composition between small and large service firms differs significantly. Especially the consultancy sector is dominated by small firms, contrary to engineering services where many more large firms can be found. Although this would demand sector specific analyses, the sample size is too small for a sectoral and regional breakdown for each of the variables. We therefore abstained from this analytical step.

Table 2: Distribution of small and large service firms according to industries and type of region

Industry [(1)] (share of firms in %)	**Total**		**Central**		**Intermediate**		**Rural**	
	SF (n=95)	LF (n=79)	SF (n=47)	LF (n=40)	SF (n=31)	LF (n=29)	SF (n=17)	LF (n=10)
Computer	26.3	22.8	27.7	22.5	22.6	27.6	29.4	10.0
Accounting	6.3	11.4	2.1	10.0	6.5	6.9	17.6	30.0
Consultancy	36.8	11.4	40.4	12.5	35.5	10.3	29.4	10.0
Engineering	30.5	54.4	29.8	55.0	35.5	55.2	23.5	50.0
χ^2	0.000		0.007		0.138		0.273	

[(1)] **Computer:** Computer and related activities; **Accounting:** Legal activities, accounting, book-keeping and auditing activities, tax consultancy; **Consultancy:** Market research, business and management consultancy activities, advertising; **Engineering:** Architectural and engineering activities and related technical consultancy, technical testing and analysis

The empirical analysis in the following section is based on cross-tabulations and χ^2 test for distinguishing the information, knowledge exchange and networking behaviour between small and large firms. It should be noted that although χ^2 significance is given in most tables, especially for services in rural areas the significance level should not be overinterpreted because of low frequencies. Descriptive statistics like cross-tabulations and χ^2 tests were thought to be more appropriate for the objective of this paper than multivariate statistics. Among the different independent variables reflecting firm characteristics, regional characteristics and networking activity included for example in regression models, networking usually does not contribute much to the total model (Koschatzky 1998). Consciously abstaining from the analysis of complex correlations, we therefore decided to use descriptive statistics for being able to describe the networking pattern in more detail. As a kind of synthesis of the results, we included pertinent categories in further homogeneity analyses for both size groups in order to "map" the most important knowledge acquisition and networking characteristics of small and large manufacturing and service firms. This analysis complements bivariate χ^2 tests by illustrating associations between the most important variable categories.

4. Empirical Analysis

Although the regional innovation survey covered both manufacturing and service firms, the questionnaires for each sample were not identical so that the variables used to characterise manufacturing firms are not always available for services. According to the research questions raised in section two, the empirical analysis will cover the following aspects:

- structural firm characteristics
- innovative activity
- information exchange
- knowledge exchange by networking
- assessment of the region.

4.1 Structural characteristics

The *industry structure* and distribution among types of region of both samples were already presented in Tables 1 and 2. The *spatial turnover distribution* of small and large firms gives some indication about their regional and international market orientation. It can be seen from Table 3 that small manufacturing as well as service firms realise most of their turnover in market transactions taking place within Germany, while large firms show a higher orientation towards international clients. This is especially the case for large manufacturing firms which reach an export share of nearly a third in their total turnover. Large service firms, on the other hand, are as twice as much export oriented than small service firms, but realise only 15.4 % of their turnover by foreign contracts. In general, service firms show a higher degree of regional integration than manufacturing firms, i.e. 56.5 % of the turnover of small service firms and 41.8 % of large service firms originates from regional clients, while the respective shares for manufacturing firms are 34.3 % and 29.5 %. This makes service firms, and among them especially the small ones, highly dependent on regional markets and their economic development. On the other hand, the figures also clearly illustrate that proximity to clients seem to be a vital precondition for at least the majority of business-related service firms. Due to their ubiquitous character, especially legal activities, accounting and tax consultancy are mainly demanded over short physical distances (Koschatzky 1997: 15). It has to be seen whether these market relations correspond with the networking activities of (small) service firms.

Table 3: Spatial distribution of turnover of manufacturing and service firms

Origin of turnover (turnover shares in %)	Manufacturing		Services	
	SF (n=161)	LF (n=189)	SF (n=81)	LF (n=67)
Within federal state	34.3	29.5	56.5	41.8
Within Germany	47.0	38.5	37.1	42.8
Abroad	18.7	32.0	6.4	15.4

The *share of highly qualified personnel* (with university or technical college degree) is an indicator for the knowledge-intensity and absorptive capacity of a firm. According to Table 4, significant differences exist between small and large manufacturing firms. In general, over a quarter of small firms does not employ highly qualified personnel at all (27.7 %). Between the different types of region, the highest share of firms which do not have staff members with university or technical college degree can be found in intermediate regions (34.2 %). On the other hand, small firms also employ the highest share of highly qualified personnel. 23.7 % of the firms, in central regions even 32.0 % reach a share of 15 % and above of this group, while large firms dominate in the size classes up to 10 %.

Table 4: Share of highly qualified personnel in total employment of small and large manufacturing firms according to type of region

(share of firms in %)

Employment Classes	Total		Central		Intermediate		Rural	
	SF (n=173)	LF (n=225)	SF (n=50)	LF (n=65)	SF (n=73)	LF (n=115)	SF (n=50)	LF (n=45)
nil	27.7	4.0	18.0	4.6	34.2	4.3	28.0	2.2
≤ 5%	12.1	43.1	16.0	33.8	9.6	47.0	12.0	46.7
≤ 10%	26.6	31.1	20.0	33.8	28.8	30.4	30.0	28.9
≤ 15%	9.8	7.1	14.0	7.7	8.2	6.1	8.0	8.9
> 15%	23.7	14.7	32.0	20.0	19.2	12.2	22.0	13.3
χ^2	0.000		0.012		0.000		0.000	

This distribution is only insofar surprising as it reflects the share of highly qualified people among the staff of a firm. When it comes to absolute figures, large firms employ many more qualified workers than small firms. Statistically significant at the 1 % level, 65.4 % of large firms have more than 7 qualified workers (35.6 % even more than 21), while 4.6 % of the small firms reach a similar absolute figure. This makes clear that the relative knowledge base of small firms is larger than that of large firms, but the absolute knowledge capacity is higher in large firms. The high relative share of the small firms can be explained by the filter used for this empirical analysis. As already pointed out, only those firms were selected which were engaged in innovative activity. Compared to small firms in general, this might result in a bias towards the small, knowledge-intensive and innovative firm.

Unfortunately, the same question was not asked in the service questionnaire. Therefore the client structure of small and large service firms should serve as a structural characteristic. Table 5 reveals that both in the total sample (significant at the 1 % level) as well as for firms located in central regions (5 % level) small and large service firms distinguish by their client structure. 12.7 % of large firms, but only 2.1 % of small firms realise at least 50 % of their turnover from contracts with clients from the public

sector. On the other hand, no large firm of the sample was dependent on private households, compared to 5.3 % of the small firms (in central regions even 8.5 %) which achieved a private households turnover share of more than 50 %. As a matter of fact, small service firms had the majority of clients among private enterprises, while large business-related service firms were also regarded as relevant contractors by the public sector. Small service firms are therefore more dependent on private enterprises as clients, while large service firms have a more diversified client base. Although statistically insignificant for the other two types of region, this client pattern can be found there as well.

Table 5: Client base of small and large service firms according to type of region

(share of firms in %)

Clients (share of turnover)	**Total**		**Central**		**Intermediate**		**Rural**	
	SF (n=95)	LF (n=79)	SF (n=47)	LF (n=40)	SF (n=31)	LF (n=29)	SF (n=17)	LF (n=10)
> 50% public sector	2.1	12.7	0.0	7.5	6.5	20.7	0.0	10.0
> 50% private enterprises	88.4	78.5	89.4	85.0	87.1	75.9	88.2	60.0
> 50% private households	5.3	0.0	8.5	0.0	3.2	0.0	0.0	0.0
no information	4.2	8.9	2.1	7.5	3.2	3.4	11.8	30.0
χ^2	0.004		0.040		0.328		0.176	

4.2 Innovative activity

In the survey, manufacturing firms were asked about their own innovation activities, while service firms were considered to play an important knowledge contributing function for manufacturing firms (Koschatzky 1999; Muller/Zenker 1998). Therefore they were not only asked to evaluate their own innovative activity, but their *contribution to industrial innovations* as well. 72.6 % of the small and 69.6 % of the large business-related service firms supported innovations at their industrial clients. This kind of activity does not seem to depend on firm size. Size differences, although statistically insignificant, can be found with respect to the kind of innovations which had been supported. Large firms were more engaged in process innovation (44.3 % resp. 34.7 % of the small firms), compared to a higher engagement of small firms in market development (30.5 % resp. 21.5 % of the large firms). This can be explained by differences in average employment figures among the four service industries. Engineering services, which might be closely related to process innovation, are in general much larger (median 26 employees) than consultancy/market research (median 3 employees). According to the service firms, their main function was the supply of knowledge to

industrial clients: 65.3 % of the small and 63.3 % of the large firms mentioned knowledge supply as most important function. Cost reduction, flexibility gains and the reduction in capacity bottlenecks were given the next ranks. In this contribution to manufacturing innovation, small and large service firms do not discriminate.

Between small and large manufacturing firms, differences do exist in the kind of own innovative activity. Innovations in large firms seem to be more complex with respect to the engagement both in product and process innovation than in small firms. While 30.6 % of the small firms did carry out product innovation only, the respective figure amounts to 11.6 % for the large firms. More than 84 % of them reported a combination of product and process innovation. This was the case for 63.0 % of the small manufacturing firms. Between the small and large service firms, no such distinction is possible. The slight differences which can be seen in Table 6 are statistically insignificant. It might be the case that the definition about what a service innovation comprises (although supplied in the questionnaire) is not as precise as the definitions for manufacturing innovation, so that therefore no clear distinctions can be made between small and large service firms. At least the fact that large manufacturing firms are more strongly engaged in process innovation, as already pointed out in section 2, can be indirectly confirmed by our analysis.

Table 6: Kind of innovative activity of small and large firms

Manufacturing firms **Service Firms**

Kind of activity [1] (share of firms in %)	SF (n=173)	LF (n=225)	**Kind of activity** [2] (share of firms in %)	SF (n=95)	LF (n=79)	χ^2
only product innovation	30.6	11.6	new service	61.1	63.3	0.762
only process innovation	6.4	4.0	improved service	56.8	62.0	0.489
both product and process innovation	63.0	84.4	new/improved processes for service	67.0	60.8	0.392
Total	100.0	100.0				
χ^2	0.000					

[1] Measured according to the devotion of R&D expenditures

[2] Share of firms which implemented this kind of innovation

The amount of research and development (R&D) activity is generally measured by the input factors "share of R&D expenditures in total turnover" or "share of R&D personnel in total employment" (Pfirrmann 1994). For manufacturing small and large firms, the share of R&D personnel as a human capital input factor to innovation reveals the same pattern as the one for highly qualified personnel (cf. Table 7). Small firms have as well a higher share of no R&D personnel as higher shares in the class of 8.1 % R&D employees and above than large firms. This is statistically significant for the total sample and for all three types of region, i.e. also in rural areas. Relatively strong in the size classes up to 8 % R&D employment share, in absolute terms large firms employ much more persons who are engaged in R&D activities than small firms (also statistically significant). The same holds true for the service firms, although the differences be-

tween small and large firms are statistically less significant. This outcome of the empirical analysis supports the diversified pattern of innovation activities in small compared to large firms. With respect to their size, small (innovative) firms (manufacturing and service firms) devote more financial and human capital resources to R&D than large firms. In absolute terms, however, large firms comprise a higher R&D potential than small firms.

Table 7: R&D intensity of small and large firms

(share of firms in %)

Share of R&D personnel in manufacturing firms

Share as % of personnel	Total		Central		Intermediate		Rural	
	SF (n=173)	LF (n=225)	SF (n=50)	LF (n=65)	SF (n=73)	LF (n=115)	SF (n=50)	LF (n=45)
nil	11.6	8.0	12.0	7.7	11.0	8.7	12.0	6.7
≤ 3%	8.7	39.6	10.0	33.8	8.2	41.7	8.0	42.2
3 – 8%	41.6	32.0	32.0	33.8	43.8	32.2	48.0	28.9
> 8.1%	38.2	20.4	46.0	24.6	37.0	17.4	32.0	22.2
χ^2	0.000		0.011		0.000		0.002	

Share of innovation expenditures in service firms

Share as % of turnover	Total		Central		Intermediate		Rural	
	SF (n=95)	LF (n=79)	SF (n=47)	LF (n=40)	SF (n=31)	LF (n=29)	SF (n=17)	LF (n=10)
≤ 3.5 %	22.1	30.4	27.7	27.5	19.4	37.9	11.8	20.0
3.5 – 8 %	29.5	41.8	27.7	42.5	32.3	41.4	29.4	40.0
> 8 %	48.4	27.8	44.7	30.0	48.4	20.7	58.8	40.0
χ^2	0.022		0.271		0.066		0.628	

For manufacturing firms, information are additionally available for the *regularity of R&D*, which might be interpreted as a routine reflecting path dependence (Dosi 1982). 19.7 % of the small firms and 28.9 % of the large are permanently engaged in research work, aiming at the creation of new technical and organisational solutions. This stronger orientation of large firms towards research is statistically significant at the 5 % level. Development, which reflects the continuous improvement of products and processes, is carried out by most of the firms (cf. Table 8). Only 3.5 % of the small firms (and 0.4 % of the large) did not perform development work at all. Permanent development processes seem to be a common characteristic of large firms: 80.4 % of them are permanently engaged in development. For more than 40 % of the small firms, development is an occasional option, so here routine development activity is less frequent. As a matter of fact, routines are less prevailing in small than in large firms, as well as in development and in research work. As postulated in the literature, large firms seem to follow trajectories, which are defined by systematic and continuous R&D activities.

Table 8: Continuity of development of small and large manufacturing firms and according to type of region

Continuity (share of firms in %)	Total		Central		Intermediate		Rural	
	SF (n=173)	LF (n=225)	SF (n=50)	LF (n=65)	SF (n=73)	LF (n=115)	SF (n=50)	LF (n=45)
never	3.5	0.4	4.0	0.0	0.0	0.9	8.0	0.0
occasionally	41.6	19.1	42.0	21.5	43.8	16.5	38.0	22.2
permanently	54.9	80.4	54.0	78.5	56.2	82.6	54.0	77.8
χ^2	0.000		0.011		0.000		0.023	

According to the concept of the absorptive capacity of a firm, firms must face different *obstacles in the innovation process*. These might be related to size in a way that small firms could have more severe problems in organising innovation processes. Nevertheless, for the small firms of the sample the relative knowledge base was found to be larger than that of the large firms. Tables 9 and 10 list the major innovation obstacles the firms reported in the survey.

Table 9: Obstacles to innovation for small and large manufacturing firms

Assessment of obstacles (share of firms in %)	Lack of R&D personnel		Lack of production personnel		Lack of marketing personnel		Organisation of innovation		Co-operation with research		Access to external knowledge	
	SF (n=163)	LF (n=215)	SF (n=163)	LF (n=214)	SF (n=164)	LF (n=213)	SF (n=95)	LF (n=91)	SF (n=164)	LF (n=212)	SF (n=164)	LF (n=213)
no	59.5	53.0	56.4	66.4	36.6	50.7	62.1	41.8	61.6	69.8	54.3	65.3
medium	29.4	40.0	32.5	29.0	48.2	36.2	31.6	49.5	29.3	25.5	34.8	31.5
great	11.0	7.0	11.0	4.7	15.2	13.1	6.3	8.8	9.1	4.7	11.0	3.3
χ^2	0.068		0.032		0.022		0.021		0.125		0.005	

As can be seen from the χ^2 significance values, for most of the obstacles significant distinctions can be made between small and large firms, but a clear pattern relating innovation obstacles to size groups could not be found. For small firms, the recruitment of personnel, especially for production and marketing, seems to be a slightly greater problem than for large firms. On the other hand, the availability of R&D personnel is less a problem in small firms than in the larger ones. This difference in the problem assessment might be explained by the fact that small firms usually employ only a few persons engaged in R&D, so that they face less problems in hiring respective people because of the small absolute amount of vacancies. In production and marketing, where also small firms have a higher absolute demand, wage competition might favour large firms. It is interesting to note that (statistically significant at the 5 % level) small firms seem to have much less problems in organising the innovation process. For 62.1 % of the small firms which answered this question this is not seen as a problem. Whether this self assessment is realistic cannot be answered by the figures. The greater problems for large firms might depend on the more complex innovation processes

there in which product and process innovation are more closely related than in the small firms (cf. Table 6). The co-operation with research institutes is not a major obstacle to innovation, and small and large firms differ only slightly in their assessment (statistically insignificant). Stronger differences can be found in assessing the access opportunities to external knowledge. Small firms have a slight disadvantage over large firms, be it because of limited search capabilities or because of limited knowledge processing facilities. This aspect will be raised again later on.

Table 10: Obstacles to innovation for small and large service firms

Assessment of obstacles (share of firms in %)	**Lack of qualified personnel**		**Lack of financial capital**		**Organisation of innovation**		**Innovation risk hardly assessable**		**Internal openness for innovation**		**Co-operation with research**	
	SF (n=95)	LF (n=79)	SF (n=95)	LF (n=79)	SF (n=95)	LF (n=79)	SF (n=95)	LF (n=79)	SF (n=94)	LF (n=79)	SF (n=94)	LF (n=78)
no	42.1	32.9	30.5	43.0	57.9	36.7	41.1	35.4	77.7	60.8	69.1	67.9
medium	27.4	45.6	29.5	34.2	33.7	49.4	35.8	45.6	17.0	31.6	17.0	24.4
great	30.5	21.5	40.0	22.8	8.4	13.9	23.2	19.0	5.3	7.6	13.8	7.7
χ^2	0.043		0.046		0.020		0.421		0.050		0.274	

As for the manufacturing firms, also small service firms have fewer problems in organising the innovation process than large firms. Their internal openness for innovation is also greater than in their larger counterparts, probably because of more fluent organisation structures and less routine behaviour. Access to capital and qualified personnel is a more serious problem in small service firms, so that these results support the common picture of small firms with respect to these topics. Neither small nor large firms have great problems in co-operating with research institutes. In general, manufacturing and service firms do not differ greatly in their assessment of innovation obstacles. This seems not to be a question of industry, but of size.

4.3 Information exchange

Information is an essential basis for knowledge. They are the relevant medium for knowledge creation and knowledge formalisation. Information consist of a flow of news which can be fractionised into single parts ("bits"), be added to the knowledge base and by this alter it (Nonaka 1994: 14-15). For the innovativeness of a firm it is crucial to have access to recent information and knowledge and to channel information flows within the firm in an efficient manner. In section 2 it was argued that a decentralised information handling favours creativity and innovation. The *kind of co-ordination activities for innovation* gives an indication about how the gatekeeper function is organised. As can be seen from Table 11, innovation activities in small manufacturing firms are predominantly centrally co-ordinated (94.7 % of all small firms), while in nearly 40 % of the large firms a decentralised co-ordination strategy is applied. This behaviour is almost independent of the kind of the regional environment.

Only in rural areas of the sample more large firms favour a centralised co-ordination (71.1 % compared to an average of 62.7 %). It might be attributed to differences in the regional industrial mix according to which the machinery industry is overrepresented in the rural areas (35.6 % of the large firms vs. 28.4 % on average), while the plastics industry is underrepresented (6.7 % compared to 17.3 % on average). The different gatekeeping activity in small and large firms might have influenced the more negative assessment of small firms concerning their access to external knowledge. When information transfer and related activities are monopolised, the knowledge base and innovative potential of a firm highly depend on the absorptive capacity of the gatekeeper. In cases where this capacity is low it could have negative effects on the learning and knowledge building abilities of the firm. Due to their size, small manufacturing firms suffer more on inefficient centralised gatekeeping than large manufacturing firms which have, according to the figures in Table 11, also other options in organising information processing processes.

Table 11: Structure of information and innovation co-ordination in small and large manufacturing firms according to type of region

Type of co-ordination (shares in %)	**Total**		**Central**		**Intermediate**		**Rural**	
	SF (n=173)	LF (n=225)	SF (n=50)	LF (n=65)	SF (n=73)	LF (n=115)	SF (n=50)	LF (n=45)
corporate co-ordination	3.6	22.2	2.0	21.5	6.9	27.8	0.0	8.9
decentralised co-ordination	1.8	15.1	2.0	18.5	1.4	11.3	2.1	20.0
centralised co-ordination	94.7	62.7	95.9	60.0	91.7	60.9	97.9	71.1
χ^2	0.000		0.000		0.000		0.001	

It is not only important for innovation by whom information is distributed and how, but also which information sources are used. In this respect the following table should answer the question whether there are clear differences between small and large firms in accessing *external information sources*. For manufacturing firms, a distinction is possible between information relevant for product innovation and for process innovation (cf. Table 12). The two most important information sources for product innovation are customers and exhibitions. While with customers learning by using processes and related information flows play the major role, it is a selective and autonomous information search when information is picked up at exhibitions. For these two sources, small and large firms act in a similar way. Major differences can be found with respect to competitors, suppliers and research institutes. All three sources are much more rated to be important by large firms. In the case of competitors this might have something to do with trust and diversification. Large firms with a broader product spectrum and a lesser dependence on only a few strategic products have more freedom in entering in information exchange with competitors than small firms. The knowledge base and absorp-

tive capacity of a firm is related to its ability in co-operating with research institutes (Rosenberg 1990; Hicks 1995). In our sample many more large firms rate research institutes to be an important information source than small firms (significant at the 1 % level). Technical services are the last important information source, both for small and large firms. With respect to process information, the order of the different information sources varies compared to product innovation, and also the distinctions between small and large firms are more pronounced. Literature seems to be an important stimulus for process innovation, and much more for the large firms. Here firms are able to search and select by their own and are not dependent on other partners. The second most information source are exhibitions, fairly equally rated by small and large firms. The first interactive information flow, that with suppliers, ranks at position three. Here, as well as in accessing information from competitors, research institutes and technical services, large firms assess these sources significantly more often to be important than small firms. These differences have their reason in the fact that small firms are less engaged in process innovation than large firms and do therefore not make use of all these information sources. It can be concluded from the table that the information spectrum of large firms is more diversified than that of small firms, because more large firms rated the given sources as to be important.

Table 12: Importance of external information sources for small and large manufacturing firms

Information source [1] (in %)	**Product Innovation**					**Process Innovation**				
	SF		LF		χ^2	SF		LF		χ^2
	(n=173)	Rank	(n=225)	Rank		(n=173)	Rank	(n=225)	Rank	
Customers	90.2	1	91.1	1	0.749	37.0	4	40.4	5	0.484
Exhibitions	72.3	2	75.1	2	0.520	56.1	2	64.0	2	0.109
Literature	69.4	3	69.3	4	0.995	59.0	1	72.4	1	0.005
Competitors	59.0	4	71.1	3	0.011	34.7	5	46.2	4	0.020
Suppliers	44.5	5	56.0	5	0.023	45.7	3	63.1	3	0.001
Research	20.8	6	36.9	6	0.001	21.4	7	36.9	6	0.001
Services [2]	19.7	7	22.7	7	0.467	22.5	6	35.6	7	0.005

[1] Rated important and very important for innovation (multiple answers allowed)
[2] Engineering and planning bureaux

The information search behaviour between small and large service firms does not differ significantly. Literature and exhibitions, both self-selective sources, rank first and second among small and large firms (cf. Table 13). A slight distinction can be found for research institutes, which were more often mentioned by large firms to be an important information source. For these firms, personal contacts as an access to the decentralised information supply in these institutions are much more important than for small firms. 60.8 % of the large, but only 43.2 % of the small firms found personal contacts to research institutes for acquiring business information to be important or very important.

Table 13: Importance of external information sources for small and large service firms

(share of firms in %)

Information Source [1]	SF (n=95)	Rank	LF (n=79)	Rank	χ^2
Literature	75.8	1	74.7	1	0.866
Exhibitions	60.0	2	70.9	2	0.134
Clients	57.9	3	62.0	4	0.580
Other services	55.8	4	67.1	3	0.128
Competitors	49.5	5	53.2	5	0.628
Other firms	42.1	6	46.6	6	0.532
Research	22.1	7	34.2	7	0.076

[1] Difference to 100 %: source does not matter

Summarising client and other firms based information as vertical information networking, and competitors, other services and research based information as horizontal information networking, the *spatial range* of accessing "vertical" sources does not differ significantly between small and large service firms (cf. Table 14). There is also no distinction within the three different types of region so that with respect to one of the research questions raised at the beginning of this paper it can be concluded for this type of external relations that they are not sensible to spatial proximity and therefore not strongly affected by the regional environment of the firm. They also do not follow the market reach of the service firms (cf. Table 3) which was more strongly oriented towards the region. This might be due to the fact that the "region", in this case defined by the federal state in which the firm is located, is a client base, but a less important information pool compared to the rest of the country. Also in the spatial distribution of "horizontal" information sources small and large service firms reveal a quite similar behaviour. The only exception are firms which are located in central regions. Although it should be expected that firms would find enough relevant information within their metropolitan area, especially large service firms do not make intensive use of the information offer, but prefer German and foreign information sources. Branch differences can be eliminated as a possible explanation, because the industrial structure between the total service sample and that for central regions is fairly equal (cf. Table 2). Nevertheless, the generally low sample size in the regional breakdown should prevent from overinterpretation of this finding.

Table 14: Spatial range of information networks of small and large service firms

Spatial Range (share of firms in %)	Vertical[1]		Horizontal[2]			
			Total		Central Regions	
	SF (n=95)	LF (n=79)	SF (n=95)	LF (n=79)	SF (n=47)	LF (n=40)
same federal state	13.7	16.5	18.9	17.7	19.1	7.5
within Germany	47.4	50.6	48.4	51.9	53.2	52.5
beyond German borders	11.6	10.1	9.5	16.5	8.5	27.5
not relevant	27.4	22.8	23.2	13.9	19.1	12.5
χ^2	0.860		0.291		0.065	

(1) information exchange with clients and other firms
(2) information exchange with competitors, other services and research institutes

4.4 Knowledge exchange by networking

While information networking does not demand close relations, innovation networks are of a different kind. They can be defined as a loose, informal and recombinable institutional arrangement, by which the firms seek to reduce uncertainty, to realise learning processes, to gain access to complementary knowledge and to transfer know-how and knowledge between the different partners of a network (DeBresson/Amesse 1991; Koschatzky 1998; Powell 1990). This knowledge transfer function makes innovation networks so important for both small and large firms. Especially for small firms external linkages play an important role in accessing complementary knowledge (Laranja 1998). Usually, a distinction is made between vertical networks, integrated in the value chain of customers and suppliers, and horizontal networks with other firms and research institutes. The degree of freedom to search partners is larger in horizontal networking than in vertical networks which are much more production based. Networks are not only a knowledge source, but demand competencies to manage and handle networking relations. Firms without a proper network management will be unable to make sufficient use of the network advantages and will lose trust of their network partners (Ritter 1998; Koschatzky/Zenker 1999).

The manufacturing firms of the sample were asked with which partners they co-operate in innovation processes beyond the usual business relations. These relationships were grouped into vertical co-operations (with customers and suppliers), horizontal co-operations (with other firms and research institutes) and co-operations with service companies as a special case of knowledge support. *Vertical innovation networks* were rated to be most important by the firms. 71.7 % of the small and 78.2 % of the large firms found this type of relationship to be of great importance for innovation support (cf. Table 15). For the total sample as well as for the three types of region, small and large firms do not discriminate. Due to its production based character, vertical innova-

tion networking mostly reflects already existing business relations which are exploited for innovation purposes. Since they fulfil a viable function for the firm, the collaborative activity does not differ significantly between small and large firms and is also independent of the type of region.[5] Also the spatial range of these networks does not vary significantly between the two types of firms. Large firms show a slightly higher interregional orientation, while small firms co-operate a little bit more with partners from the same federal state. This pattern is also not affected by the type of region in which a firm is located.

Table 15: Importance and spatial range of vertical networking by small and large manufacturing firms according to type of region

(share of firms in %)

Importance/ Spatial range	Total		Central		Intermediate		Rural	
	SF (n=173)	LF (n=225)	SF (n=50)	LF (n=65)	SF (n=73)	LF (n=115)	SF (n=50)	LF (n=45)
no co-operation	27.2	20.9	30.0	18.5	23.3	23.5	30.0	17.8
less important	1.2	0.9	0.0	1.5	2.7	0.9	0.0	0.0
very important	71.7	78.2	70.0	80.0	74.0	75.7	70.0	82.2
χ^2	0.323		0.253		0.608		0.165	
regional [(1)]	40.5	35.6	36.0	30.8	38.4	38.3	48.0	35.6
interregional [(1)]	40.5	42.2	40.0	41.5	43.8	45.2	36.0	35.6
χ^2 [(2)]	0.317		0.554		0.990		0.220	
χ^2 [(3)]	0.724		0.868		0.853		0.964	

(1) Firms which stated to have regional resp. interregional co-operations
(2) for regional networking: within the same federal state
(3) for interregional networking: outside the federal state

Not only in intensity and the spatial range of vertical networking, but also in the kind of collaborative activity no significant differences occur between small and large firms (cf. Figure 2). For both small and large firms, the major purposes of vertical networks are the realisation of joint projects, a collaboration which is usually based on contracts and therefore formally arranged, and informal loose contacts for several purposes. More informally organised are the exchange of experience as well. Co-operation in pilot applications ranks fourth. It can thus be seen that vertical networks are not only a collaborative arrangement for informal information and knowledge exchange, but also used for joint research, development and application in which mutual learning processes can be realised.

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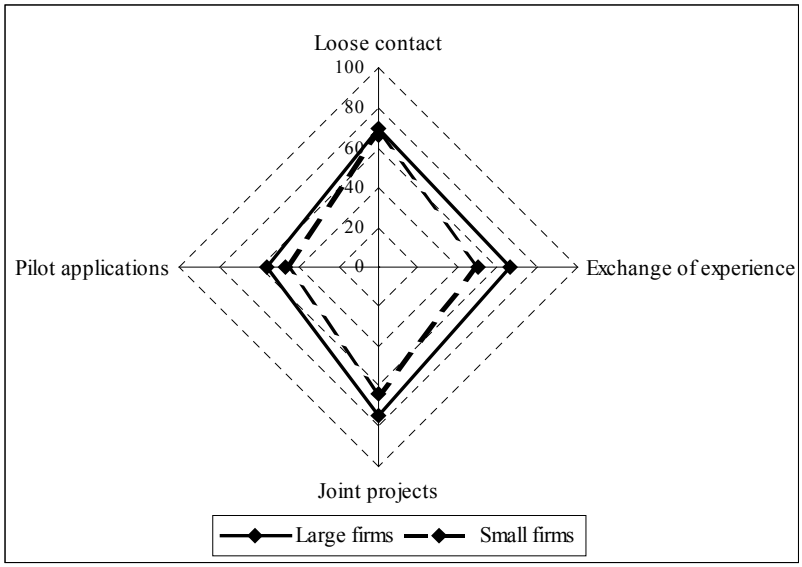
5 Using the same database but including data from Saxony, Fritsch (1999: 12) found out for vertical cooperations "...that not only the propensity to have at least one cooperative relationship but also the number of cooperative relationships increases with size." This is indirectly supported by our results which reveal a slightly higher percentage share for large firms, although the differences are statistically insignificant.

Figure 2: Important or very important forms of vertical co-operation
(share of firms in %)



Concerning *horizontal networking* with other firms and research institutes, a total different pattern can be found. Not only are horizontal co-operations rated to be less important than vertical relationships, especially by small firms of which 59.0 % do not co-operate at all, but also are the differences between small and large firms statistically significant (cf. Table 16). While 64.9 % of the large firms assessed these networks to be important, only 34.1 % of the small gave the same assessment. Since horizontal relations are characterised by a high degree of freedom in partner search, firms can select between different partners, but have to carry out this search on their own and also have to establish trustworthy relationships. This is sometimes a costly and time consuming process which requires competencies in network management and knowledge processing. Usually networking is not a one-way street, but a mutual interaction in which each partner brings in his specific knowledge. This requires a knowledge base interesting to others. All these requirements favour large firms in establishing horizontal innovation networks.

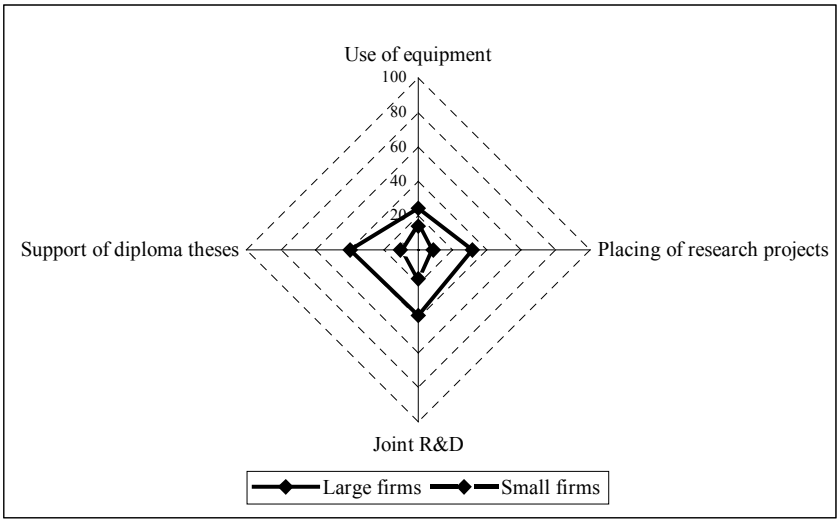
Table 16: Importance and spatial range of horizontal networking by small and large manufacturing firms according to type of region
(share of firms in %)

Importance/ Spatial range	Total		Central		Intermediate		Rural	
	SF (n=173)	LF (n=225)	SF (n=50)	LF (n=65)	SF (n=73)	LF (n=115)	SF (n=50)	LF (n=45)
no co-operation	59.0	32.9	50.0	24.6	63.0	38.3	62.0	31.1
less important	6.9	2.2	12.0	0.0	1.4	3.5	10.0	2.2
very important	34.1	64.9	38.0	75.4	35.6	58.3	28.0	66.7
χ^2	0.000		0.000		0.004		0.001	
regional (1)	12.7	22.7	16.0	24.6	11.0	20.0	12.0	26.7
interregional (1)	11.7	21.3	16.0	26.2	11.0	17.4	6.0	24.4
χ^2 (2)	0.011		0.260		0.104		0.069	
χ^2 (3)	0.006		0.191		0.227		0.011	

(1) Firms which stated to have regional resp. interregional co-operations
(2) for regional networking: within the same federal state
(3) for interregional networking: outside the federal state

With respect to co-operations with research institutes, the general differences between large and small firms in horizontal networking become evident when looking at the different aspects in this form of collaboration (cf. Figure 3). Small firms are much less engaged in relationships with research institutes. Large firms, on the other hand, make strategic use of diploma theses as a kind of knowledge exchange, but generally more important, for personnel acquisition. Other major forms of co-operation are joint R&D projects, in which bilateral learning processes can be realised, and the placing of research projects to institutes. The joint use of equipment does not play a major role for large firms, but seems to be relatively more important for small firms.

Figure 3: Important or very important forms of horizontal co-operation with research institutions (share of firms in %)



Compared to vertical networks where no regional differentiation was found, the importance rating for horizontal networks also discriminates between the types of regions. Especially in central regions large and also small firms seem to establish more horizontal relations than in the two other types of region. This might be partly attributed to the larger supply of possible co-operation partners, because compared to the total sample a slightly higher share of small and large firms maintain regional relationships (16.0 % and 24.6 % resp. 12.7 % and 22.7 % for the total sample). On the other hand, also the shares of interregional networking are higher compared to the average figures. So the higher activity in horizontal networking of small and large firms located in central regions seem to be a characteristic behaviour for this type of region.[6] With respect to the already mentioned spatial range of horizontal co-operations it can be clearly stated that large firms are more actively engaged in both regional and interregional networking. While in central and intermediate regions the differences are not pronounced enough to be statistically significant, they are in rural regions and in the total sample. Especially in the rural areas of the sample only a few of small firms have interregional collaborative relationships, while relatively more large firms are engaged in both regional and interregional interaction compared with the total figures. The figures do not provide an explanation for this collaborative behaviour, but it can at least be concluded that horizontal networking activities differ slightly with respect to the type of the regional environment of the firm.

Besides manufacturing firms or research institutions, business-related service firms play an increasing role in knowledge creation and exchange. This is especially the case for organisational and social innovations, but for technological innovations as well (Muller/Zenker 1998). Service firms support knowledge creation and innovative activity of their industrial and service clients. Because of the intensive linkages between manufacturing and service firms, the supply of innovation supporting services plays a crucial role in the stimulation of regional innovation activity (Bellini 1998; Cappellin/Nijkamp 1990; Coffey/Polèse 1987; Wood 1995). While ubiquitous services (e.g. standardised tax and legal accounting) are dispersed in space, high order services like advertising and marketing or specialised software support are spatially concentrated and only offered at certain locations. For both kinds of services personal contacts and intensive communication are essential, but the latter do not require spatial proximity; interregional or even international co-operations dominate (Schamp 1986; Strambach 1995). In this paper, *manufacturing-service co-operation* is viewed from two perspectives. The first perspective points to the importance of service interaction in the view of manufacturing firms.

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6 In his analysis of 1,000 small and medium-sized manufacturing and service enterprises, Keeble (1997: 290) came to a similar finding of a higher collaborative activity in central regions. In his study over twice as many metropolitan service firms reported collaborative arrangements compared to service firms in peripheral regions.

84.4 % of the large and 59.5 % of the small manufacturing firms co-operated with technical and advisory services for innovation purposes (cf. Table 17). Advisory services comprise accounting and business consultancy, technical services computer-related activities and engineering. This makes clear that large firms make much more use of the complementary knowledge base service firms offer than small firms. With the share of 84.4 %, service firms are even a more important knowledge base for large firms than customers and suppliers (cf. Table 15). Among small firms, a higher share of co-operations with advisory services can be found, so that technical information and knowledge is less acquired by these firms. Great differences between the regions do not exist, but in rural areas the collaborative behaviour of small and large firms is less different (i.e. statistically insignificant) than in the other regions.

Table 17: Networking with service companies by small and large manufacturing firms according to type of region

(share of firms in %)

Collaborative activity	Total		Central		Intermediate		Rural	
	SF (n=173)	LF (n=225)	SF (n=50)	LF (n=65)	SF (n=73)	LF (n=115)	SF (n=50)	LF (n=45)
no co-operation	19.1	7.6	16.0	6.2	23.3	8.7	16.0	6.7
with advisory services only	20.2	7.1	22.0	7.7	19.2	5.2	20.0	11.1
with technical services only	1.2	0.9	4.0	0.0	0.0	0.9	0.0	2.2
by both types	59.5	84.4	58.0	86.2	57.5	85.2	64.0	80.0
χ^2	0.000		0.006		0.000		0.177	

Similar to horizontal networking, small manufacturing firms have a much closer spatial range in their interaction with service companies than large firms. This applies for networking with advisory and technical services, as well as for the three types of region, where only firms in the rural areas make an exception for technical services co-operation (cf. Table 18). In interacting with advisory services, many small firms limit their search radius to their region, so that 68.4 % (in intermediate regions even 75.0 %) co-operate with partners from the same area. Large firms have a wider search radius and are more selective in choosing their partners, because nearly 55 % have complementary linkages with advisory and technical services from within and outside the region. Although the high regional percentage share recorded for small firms in advisory services co-operation would suggest a limited ability for longer distances interaction, this is not the case for technical services. The share of small firms which co-operate only with partners from outside their own region (32.4 %) is higher than for the large firms (23.7 %). Especially for small manufacturing firms the search radius does not only seem to depend on the availability of local services, but as well on personal contacts and trust, which are rated to be more important for legal activities and tax accounting than for standardised software support, for example. Between the regions

there are only slight deviations in the spatial range of co-operations, so that the identified pattern is independent of the type of region. A slight restriction refers to central regions in which large firms have a slightly higher regional co-operation share than on average. This might reflect the better service supply there, but this tendency is far from being statistically significant.

Table 18: Share of regional and interregional networking of small and large manufacturing firms with services according to type of region

(share of firms in %)

Range of co-operation	Co-operation with advisory services							
	Total		Central		Intermediate		Rural	
	SF (n=136)	LF (n=197)	SF (n=39)	LF (n=58)	SF (n=56)	LF (n=98)	SF (n=41)	LF (n=41)
only region	68.4	28.9	69.2	32.8	75.0	27.6	58.5	26.8
only outside region	8.8	16.2	7.7	10.3	3.6	17.3	17.1	22.0
in- and outside region	22.8	54.8	23.1	56.9	21.4	55.1	24.4	51.2
χ^2	0.000		0.002		0.000		0.011	
Co-operation with technical services								
	SF (n=102)	LF (n=190)	SF (n=29)	LF (n=55)	SF (n=42)	LF (n=98)	SF (n=31)	LF (n=37)
only region	35.3	21.6	31.0	23.6	38.1	19.4	35.5	24.3
only outside region	32.4	23.7	34.5	12.7	31.0	28.6	32.3	27.0
in- and outside region	32.4	54.7	34.5	63.6	31.0	52.0	32.3	48.6
χ^2	0.001		0.020		0.030		0.373	

As already pointed out in the section dealing with innovative activity, 72.6 % of the small and 69.6 % of the large service firms supported manufacturing clients in their innovative activity. Unfortunately, for reflecting service-manufacturing interaction in view of the service firms, information are only available for the success factors in co-operation. Among four success factors, spatial proximity ranks fourth for both small and large service firms behind personal contacts, familiarity with the industrial branch and the existence of similar qualifications (cf. Table 19). For 31.6 % of the small and 40.5 % of the large firms spatial proximity is important. Although this slight difference is statistically insignificant, it is interesting to note that for large service firms spatial proximity seems to play a slightly higher relevance in client interaction than for small service firms. Also between the types of region, no statistically significant size effect can be found. But again, 45.0 % of the large firms in central regions rated spatial proximity to be as important (compared to 31.0 % in the intermediate regions), so that this relatively high share can be seen as an indication for favourable business conditions in metropolitan areas.

Table 19: Importance of success factors in the co-operation between small and large service firms and industrial clients

Importance (share of firms in %)	**Spatial Proximity**		**Personal contacts**		**Similar qualifications**		**Familiar with branch**	
	SF (n=95)	LF (n=79)	SF (n=95)	LF (n=79)	SF (n=95)	LF (n=79)	SF (n=95)	LF (n=79)
no co-operation/ unimportant	68.4	59.5	37.9	36.7	57.9	45.6	40.0	38.0
important	31.6	40.5	62.1	63.3	42.1	54.4	60.0	62.0
χ^2	0.221		0.872		0.105		0.785	

As kind of synthesis of the knowledge acquisition and networking pattern of the firms, a homogeneity analysis was carried out again to see whether the results obtained by cross-tabulations and χ^2 testing hold also true for interrelated variables. Limiting the analysis to two dimensions, the discrimination measures per variable for manufacturing and service firms are shown in Table 20.

Table 20: Discrimination measures for manufacturing and service firms

Variables	**Dimensions**	
Manufacturing	**1**	**2**
REGION	0.027	0.201
REG_VERT	0.105	**0.642**
INTREG_VERT	0.145	**0.506**
REG_HOR	**0.323**	0.072
INTREG_HOR	**0.387**	0.035
REG_SERV	0.151	0.002
INTREG_SERV	**0.336**	0.053
COOP_RESEAR	**0.260**	0.055
TURNOV_RANGE	0.133	0.145
COORD_INNO	0.168	0.165
SIZE	**0.351**	0.192

Variables	**Dimensions**	
Services	**1**	**2**
REGION	0.010	0.051
COOP_SERV	**0.540**	0.118
COOP_RESEAR	**0.334**	0.176
CLIENT_RANGE	**0.578**	**0.335**
REG_VERTINFO	**0.297**	**0.501**
REG_HORINFO	0.198	**0.380**
REG_OTHERINFO	0.248	0.226
TURNOV_RANGE	0.099	**0.267**
SIZE	0.023	0.000

It can be seen that for the manufacturing firms size (SIZE) is a discriminating variable in a way that large firms are more strongly engaged in horizontal networking (both regionally and interregionally; REG_HOR, INTREG_HOR), and also in interregional co-operations with service firms (INTREG_SERV) and in co-operations with research institutes (COOP_RESEAR). Small firms, on the other hand, are more regionally oriented, both with respect to co-operation behaviour and markets. The type of region in which the firms are located (REGION) discriminates more on the second dimension which points to the importance of vertical networking. In this respect, firm size plays only a minor role compared to the first dimension. In the plot of the two dimensions decentral innovation co-ordination is much closer linked to large then to small firms.

For the service firms, size (SIZE) as well as the type of region (REGION) are not discriminating. Therefore a clear distinction between small and large service firms and their collaborative behaviour is not possible. Nevertheless, the plots show that service firms which often co-operate with other services co-operate also quite often with research institutes. Those ones which mainly use vertical information sources from within their region also have a high share of industrial clients from the same region. All in all, the homogeneity analysis confirms the results already derived by descriptive statistics that the networking behaviour differs especially between small and large manufacturing firms. The discrimination measures make also clear that for service firms the firm size (as defined in this paper) is a much less discriminating factor in information exchange and innovation co-operation than for manufacturing firms.

4.5 Assessment of the region

Both manufacturing and service firms were asked to assess their regional framework conditions for innovative activity. Four out of five aspects are differently assessed by small and large manufacturing firms (cf. Table 21). In the binary rating spectrum of bad and good, large firms seem to have a more positive attitude towards their region, because the labour market and the research supply received much more positive than negative assessments. For the small firms, this is only the case for the access to suppliers. Compared to large firms, small manufacturing firms seem to have more difficulties with the regional labour market. This corresponds to the ratings in the obstacles to innovation, where more small firms suffered from a lack of personnel than large firms (cf. Table 9). For both small and large firms, the regional access to customers is more worse than good, while the availability of suppliers is seen more positively.

Table 21: Assessment of regional framework conditions for innovative activity by small and large manufacturing firms

Assessment	**Labour market**		**Access to customers**		**Access to suppliers**		**Research supply**		**Innovation climate**	
(share of firms in %)	SF (n=168)	LF (n=221)	SF (n=166)	LF (n=222)	SF (n=165)	LF (n=220)	SF (n=166)	LF (n=219)	SF (n=166)	LF (n=218)
bad	25.0	15.8	28.9	33.8	17.6	23.6	20.5	13.2	34.9	25.2
medium	49.4	42.5	48.2	46.4	44.2	49.5	60.8	54.8	48.2	60.6
good	25.6	41.6	22.9	19.8	38.2	26.8	18.7	32.0	16.9	14.2
χ^2	0.002		0.549		0.049		0.007		0.048	

The "innovation climate" is quasi a summary of the different regional factors affecting the innovative activities of firms. The ratings of large firms are less bad than those of the small firms, but for both firm types negative ratings prevail. A deeper look into the ratings for the different types of region reveals a slightly different picture (cf. Table 22). The central regions are best assessed compared to intermediate and rural areas, especially by large firms which gave more good than bad ratings. But also the small

firms assigned their highest score for a good innovation climate to the central regions. In the comparison between intermediate and rural regions, the innovation conditions seem to be better in the rural areas. Here the bad ratings are lower and large firms gave a more positive assessment than in the intermediate regions. Also for these results it has to be pointed out that they reflect a tendency and are (besides the different shares for the "medium" rating) statistically insignificant. Significant, although only at the 10 % level, are the differences between small and large manufacturing firms in the intermediate regions.

Table 22: Assessment of the regional innovation climate by small and large manufacturing firms according to types of region

(share of firms in %)

Assessment	Total		Central		Intermediate		Rural	
	SF (n=166)	LF (n=218)	SF (n=47)	LF (n=63)	SF (n=72)	LF (n=112)	SF (n=47)	LF (n=43)
bad	34.9	25.2	29.8	17.5	40.3	29.5	31.9	25.6
medium	48.2	60.6	46.8	63.5	44.4	60.7	55.3	55.8
good	16.9	14.2	23.4	19.0	15.3	9.8	12.8	18.6
χ^2	0.048		0.185		0.093		0.669	

Service firms seem to have a worse perception of their regional environment than manufacturing firms. Only for the assessment of the regional client base more positive than negative ratings were given by the large firms. Otherwise the negative assessments prevail (cf. Table 23). While small and large manufacturing firms clearly differed in their assessment of the regional labour market, no distinction is possible between small and large service firms. The same holds true for the client base, which is nearly identical assessed by the two firm groups. It is interesting to note that more large firms had a bad perception of the quality of the regional research supply than small firms. Nevertheless, this does not seem to be a major problem, because only 7.7 % of the large service firms had severe problems in their co-operation with research institutes (cf. Table 10). As for manufacturing firms, the innovation climate is more positively assessed by large service firms. The differences between small and large firms are, however, only significant at the 10 % level.

In the regional breakdown, the central regions have a much better innovation climate than the two other types of region. 36.8 % of the large service firms located in central areas rated the innovation climate positively, compared to 23.7 % which gave a negative assessment. Since this is a similar result as for manufacturing firms, large firms (manufacturing and services) either seem to adapt better to this kind of regional environment or are able to make better use of it. In the two other regions, the percentage shares for a negative assessment are much higher than for a positive rating, and small firms gave more negative votes for the intermediate regions, while large firms did this for the rural areas. All in all, small and large firms differ in their assessment of their

location. Especially large firms can make a better use of their regional environment, even in those regions which are generally rated as having a bad innovation climate, as can be seen from the higher positive shares attributed by large firms.

Table 23: Assessment of regional framework conditions for innovative activity by small and large service firms

Assessment (share of firms in %)	Regional labour market		Suitable client base		Quality of research supply		Readiness for co-operation		Innovation climate	
	SF (n=88)	LF (n=77)	SF (n=92)	LF (n=76)	SF (n=39)	LF (n=46)	SF (n=91)	LF (n=75)	SF (n=89)	LF (n=76)
bad	34.1	28.6	31.5	25.0	12.8	37.0	40.7	24.0	39.3	31.6
medium	48.9	48.1	40.2	44.7	74.4	56.5	49.5	56.0	49.4	44.7
good	17.0	23.4	28.3	30.3	12.8	6.5	9.9	20.0	11.2	23.7
χ^2	0.542		0.645		0.035		0.035		0.099	

5. Summary and Conclusions

The results derived from an analysis of the German regional innovation survey covering manufacturing and service firms can be summarised according to the research questions raised in section 1 as follows:

(1) By which structural characteristics do small and large firms differ?

Small firms, both from manufacturing and services, have a higher regional market share than large firms. The regional market orientation of small service firms is stronger than that of small manufacturing firms. This makes small firms more dependent on regional demand conditions.

The relative degree of human capital intensity, measured by the share of highly qualified personnel in total employment, is significantly higher in small manufacturing firms. When it comes to absolute figures, however, large firms employ many more highly qualified people.

Small service firms are more dependent on private enterprises as clients, while large service firms have a more diversified client base.

(2) Which innovation strategies are applied in each group?

Innovation in small manufacturing firms is more focussed on product innovation than on a combination of product and process innovation (as in large firms).

Small manufacturing and service firms invest a higher share of expenditures and personnel in R&D and innovation, but the absolute input of large firms is greater.

More small manufacturing firms carry out development work on an occasional basis (just when needed), while large firms are permanently engaged in development, reflecting routines in the innovative behaviour.

(3) What external information sources are used by small and large firms and how is the distribution of this information within the firm being organised?

Small manufacturing firms are characterised by a strong central information and innovation co-ordination gatekeeping, with a high dependence of the knowledge-base and absorptive capacity of the gatekeeper. In large firms, information flows are more decentrally co-ordinated which, according to the concept of the absorptive capacity of a firm, supports innovativeness and reduces the risk of not being able to monitor and process relevant information.

Compared to large manufacturing firms, small manufacturing firms acquire less information from competitors, suppliers and research institutes. Small service firms have a fairly similar information spectrum than large service firms with the exception that they significantly use less research-based information.

In the spatial range of vertical and horizontal information networking there is no significant difference between small and large service firms. In horizontal information exchange slightly more regional sources are used by small firms which, especially in central regions, are accessing significantly less international information than large service firms.

(4) Which knowledge sources are used for innovation by the firms and what is the spatial range of innovation networking? Can differences in information and knowledge acquisition and the spatial range of networking be found for small and large firms between different types of regions?

Vertical networking and interactions with service firms are more important knowledge sources for manufacturing firms than horizontal co-operations, irrespective of firm size.

In vertical networks, small and large firms behave similarly, so that size is not a discriminating factor for this kind of knowledge exchange. There are also no regional influences on vertical networking activities, so that a clear dependence on the quality of the regional environment could not be detected. A similar result was found for vertical information networks of small and large service firms.

Horizontal networks are much more used by large firms in acquiring complementary knowledge than by small firms. The latter seem to rely more on production based (vertical) relations, while more large firms make strategic use of additional expertise knowledge. This is especially the case in central regions which positively influence the propensity to co-operate. This holds true for small firms as well. In rural areas, small firms are less integrated in horizontal networks, perhaps because of a limited supply of possible co-operation partners.

Also in co-operations with services, many more large manufacturing firms make use of the innovation supporting function of advisory and technical services than small firms. Small firms show a higher propensity to co-operate with advisory services only. This pattern holds also true for the three types of regions, so that besides some slighter differences between small and large firms in rural areas the co-operation behaviour is not affected by the kind of the regional environment.

In all three kinds of networking activity, small manufacturing firms co-operate significantly more with partners from the same region than large firms which have a higher share of complementary, i.e. regional and interregional network relations. Due to this stronger regional embeddedness, small firms are more dependent on the availability and quality of regional knowledge sources, while large firms try to minimise co-operation risks by selecting partners from several regions. Especially in the co-operation with advisory services, small firms highly depend on the regional supply of such services.

While within the three types of regions the knowledge exchange pattern differs between small and large firms for horizontal and services networking, it is only slightly affected by the regional environment. The type of region in which a firm is located only plays a role for horizontal networking activity in a way that especially in rural areas small manufacturing firms are less engaged in interregional co-operations.

Although in information exchange large service firms had a slightly (but compared to small firms insignificant) higher orientation towards non-regional partners, they found spatial proximity to be more important in interactions with industrial clients than small firms. Since both results are statistically insignificant, they only reflect a tendency but no sound empirical finding.

(5) What are the major obstacles for innovation and how do firms assess the region in which they are located?

Major obstacles for small manufacturing firms compared to large firms are a lack of marketing personnel and the access to external knowledge. Small service firms faced major problems in acquiring financial capital and qualified personnel. In general, there are less differences between manufacturing and service firms, but more between size. The problems of small manufacturing and small service firms are more similar than between the two firm groups within each industry.

Small manufacturing and service firms have a worse perception of their region than large firms. In comparison between the three types of region, the innovation climate is best rated in central regions, both by small and large firms. Large firms, however, can make a better use of their regional environment, because they face less problems compared to small firms even in the regions of the sample which do not seem to provide most favourable innovation conditions.

(6) Are there similarities between small manufacturing and small service firms in their innovation behaviour, or do firms from both sectors differ significantly in innovation, irrespective of size?

There are more similarities between small manufacturing and small service firms than between small and large manufacturing firms. In their information and co-operation activities, small and large service firms behave fairly equal. This seems to be an indication that firm size is a distinctive variable for the differentiation between structural and behavioural characteristics of firms, especially within the manufacturing sector, less among service firms. This can at least be concluded for the firms of our sample.

(7) Which conclusions can be drawn for regional innovation policy with respect to small firms innovation and regional supply supporting factors?

Based on the findings of this empirical analysis, the conclusion seems justified that small firms more strongly depend on regional information and knowledge sources for their innovative activity than larger firms.[7] This paper could not address the differences between small and large firms in their innovative success. Therefore the question arises how the stronger regional embeddedness influences the innovative and economic performance of small firms. If it is influenced positively, there seems no need to support small firms in their innovative activity by region specific innovation policy measures. If they face problems because of their stronger dependence on regional networking, innovation policy support seems justified, especially with respect to the reduction of disadvantages compared to large firms.

For small firms in general the question can be answered with reference to the small firms innovation literature as: "it depends". With respect to a high share of regional networking and the kind of region in which a firm is located, the results of this paper allow a second answer. The generally more favourable assessment for the innovation climate in central regions and the worse perception for the other two regions indicate that firms in intermediate and rural areas seem to face more problems in innovation than those in central regions. Due to the shorter range of networks small firms cannot compensate knowledge deficits in their regional environment in the same way as large firms can. But there is a regional differentiation. Small firms in central regions can not only benefit from the better supply of knowledge sources by regional networking, but are as well more strongly engaged in interregional networking, especially in horizontal knowledge

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7 In this respect, our results seem to follow a general pattern since also Feldman (1994: 370) came to a similar conclusion for firms from the United States. She summarises "... that small firms rely more on external sources of input to the innovation process" and "... that small businesses have a less well developed internal R&D capability than their larger counterparts and thus rely more heavily on external R&D from universities".

exchange. Whether both depend on each other may be an assumption, but cannot be checked with the data. Small firms in intermediate and in rural areas have or use less possibilities to interact with partners from outside the region and are more strongly embedded within their region. This reduces their knowledge input to regionally available sources and to knowledge acquired by autonomous learning (e.g. literature use). In the light of knowledge economics' argumentation that information and knowledge are important prerequisites for innovative activity and regarding the worse perception of the regional environment, it may be assumed that especially small manufacturing and service firms in intermediate and rural areas are discriminated in knowledge access compared to small and large firms in central regions. On the other hand, this should not automatically imply negative impacts on the innovative performance of small firms located outside the metropolitan cores. At least with respect to innovation intensity no major difference compared to firms located in central areas could have been found in this analysis. This supports at least findings of other empirical studies that firms in peripheral areas are not less innovative, but apply different innovation strategies (Keeble 1997: 289). Nevertheless, innovation policy support should be given to these firms.

The analysis could not answer the question which policy measures could reduce this disadvantage. This would demand more detailed studies about the knowledge accessing and processing behaviour of the small firms. On a general level, the results of the empirical study recommend that regional innovation policy support should improve

- the abilities for autonomous learning in small manufacturing and service firms,
- the knowledge accessing and knowledge processing abilities of small manufacturing and service firms

located especially in intermediate and peripheral areas. This would not only improve the firm's own learning abilities, but also qualify more firms in intermediate and peripheral areas to become a network partner – in regional and interregional networking.

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