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DOI:
10.57938/00e94f03-0297-45e3-a6e6-8d4436ca952f

Published: 01/12/2011

Document Version:
Publisher's PDF, also known as Version of record

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Institute for the Environment and Regional Development

WIRTSCHAFTS UNIVERSITÄT WIEN VIENNA UNIVERSITY OF ECONOMICS AND BUSINESS

EFMD EQUIS ACCREDITED

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SRE-Discussion 2011/05 2011

RUW Regional- und Umweltwirtschaft

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Draft version

Abstract

Many innovation studies have been focusing on a narrow concept of innovation such as the generation of patents or new products. The performance of companies, however, often depends on innovation defined from a broader perspective. This includes process, organisational and market innovations as was pointed out already by Schumpeter. Drawing on the concept of knowledge bases and innovation networks we argue that these different types of innovation require both internal competencies, and technological and market knowledge from various kinds of external sources. These can be located at regional, national and international levels. In the present paper we are going to analyse evidence from eight European countries in this respect. Based on a multivariate model we are able to show that product, process and organisational innovations indeed rely on quite different types and sources of knowledge, and that in addition also the institutional characteristics of regions and countries matter.

[1] Paper prepared for the 6th International Seminar on Regional Innovation Policies at the Lund University, October 13th-14th 2011.

1) **Introduction**

Already Schumpeter (1934), pioneer of innovation research, has identified different forms of innovation, including product, process, market and organizational innovations. Nevertheless, the research focus has been and largely remains on technological product and process innovations. One reason may be the long prevailing linear innovation model where research and development activities constitute the initiation of a process leading finally to the introduction of new products or processes. Although the linear innovation model has largely been replaced by more interactive and reflexive forms (Kline and Rosenberg, 1986), much of the literature still relates to technological product and process innovations. An important reason is that a number of indicators have become customary to measure different stages of a "technology" driven innovation process, including indicators about research and development, patent activities or output indicators such as the introduction of new process and products and the related market share. Also more policy oriented research activities such as those of the OECD and EC have only recently included other forms of innovation such as organizational and marketing innovations in their methodology (3rd edition of the Oslo Manual, OECD, 2005). At this stage, there is a lack of knowledge and experience of how to measure these innovations. We are especially lacking comparative studies of hard (technological product and process) and soft (organizational, strategic, marketing) innovations that would provide a more holistic insight into innovation performance and the relevant factors. This paper addresses this problem by analyzing the following research questions:

- Do different kinds of innovation rely on specific kinds of internal and external knowledge?
- To what extent do innovation- and knowledge sourcing patterns differ between the investigated sectors and regions?

In the next section, we will elaborate on the conceptual and theoretical background underlying this research paper. In section three, we will provide details about the methodology, the selection of sectors and regions as well as the applied methods of analysis. Section four will then describe in detail the innovation activities of the investigated firms as well as descriptive results of the firms' competencies and knowledge sourcing pattern for each sector and region. Section five describes the results of the multivariate models and connects these with the descriptive results. Finally, section six provides the conclusions of these research efforts.

2) **Conceptual and theoretical background**

Innovation is always related to knowledge processes, may it be the creation of new knowledge, the new combination of knowledge and the application of this knowledge in the context of an organization. Therefore, a company's internal knowledge and acquisition of knowledge from external sources are closely interrelated with its actual or possible innovation activities. A company's internal knowledge can be considered as a complex and practically indefinite combination of qualifications, skills and experiences of its staff as well as knowledge stored in processes, the organization, databases, etc. In order to understand and illustrate the linkages between a company's internal knowledge and innovation activities and performance, the knowledge base concept is useful. In this framework different types of knowledge bases have been identified, which were related to particular innovation processes. The three types are analytical, synthetic, and symbolic knowledge base (Laestadius, 1998; Asheim and Coenen, 2007; Cooke et al., 2007; Trippl et al., 2009).

The analytical knowledge base describes sectors and firms that typically apply more formal innovation processes, even using scientific approaches. Accordingly, they require staff with academic or scientific qualifications and hence also hire from universities. Codified knowledge plays an important role in the innovation process both in terms of inputs and outputs (e.g. patents). Firms with an analytical knowledge base tend to be strong in technological product and process innovations. Typically, an analytical knowledge base can be found in high-tech manufacturing sectors such as life sciences or biotech.

The synthetic knowledge base characterizes sectors and firms with capacities in combining knowledge from different sources. Often innovations are stimulated by interactions with clients or suppliers. Tacit knowledge plays a higher role in such innovation processes and is mainly exchanged through direct face-to-face contacts. The innovation output of firms with a synthetic knowledge base tends to be more incremental. Sectors dominated by a synthetic knowledge base are e.g. machinery or automotives.

Finally, the symbolic knowledge base responds to sectors where fashion, culture and related artifacts and "symbols" play an important role. Typical industries would be moving media or music. The capacity to identify social trends and address these trends with "fashionable" products defines a symbolic knowledge base. Firms with a symbolic knowledge base also rely to a large extent on tacit knowledge. Innovations will usually not be based on technological advancements.

The knowledge base concept highlights relationships between tacit and codified internal knowledge & competences of firms, their external knowledge sourcing, and the way how companies innovate. The concept, however, has also certain drawbacks. First of all, sectors and firms often apply combinations of knowledge base types. This significantly complicates the operationalisation of the concept and the assignment of companies to particular types. Furthermore, the knowledge base concept mainly addresses product and process innovations and, therefore, constrains a more holistic perspective of innovation.

In this paper we aim to disentangle the concept and assess internal and external aspects of the firm's knowledge base that are expected to be relevant for innovation, namely i) firms activities and qualifications (internal competences), ii) recruitment of qualified labour, and iii) sourcing of external market- and technological knowledge. In addition we take sector and regional contexts into account.

Regarding firms' activities, there is evidence that standardized compared to tailor-made production has an impact on innovation processes and outcomes. Standardized production usually involves large-scale investments in machinery. The production technology as such is therefore relatively advanced and also partly based on scientific knowledge. This scientific knowledge can, however, be located at key suppliers of production technologies and less in-house of the sector in question. Technological process innovations are relatively common in firms that perform standardized production. On the other hand, one can consider each tailor-made product an innovation in itself. However, firms that focus on tailor-made production will often find themselves in a situation where large investments may not be feasible as the necessary scale to pay them off is not achieved. Furthermore, some companies engage in product and process development or research and development activities, which can be considered as systematic approaches to improving products and processes or creating new ones. These activities are usually related the technological innovations. In contrast, design and marketing activities may particularly contribute to organizational or strategic innovations while playing a smaller role for technological innovations.

Another important aspect in this context is recruitment of firms. Recruitment can be considered as a key mechanism through which firms can internalize external knowledge. Recruitment is usually related to existing competences and qualifications of companies. Firms that place high importance on recruiting from universities will usually also have staff with analytical and to some extent also scientific competencies. This should be particularly relevant for product and process innovations although analytical capacities can also be important for strategic and organizational innovations. Recruitment from the same sectors will provide insights about processes, organizational structures and routines, strategies and even technology in fields closely related to the recruiting firm. Recruitment from other sectors will bring an outside perspective, not blinded through the routines and habits of a specific sector. The experience of recruits from other sectors can therefore be a good source to reflect about the firm's current organization and strategy and to develop new practices.

Besides internal competences and recruiting, innovation also depends on the capacity of firms to acquire knowledge from outside sources. The concept of "absorption capacity" (Cohen and Levinthal, 1990; Zahra and George, 2002) provides a valuable link between external knowledge sourcing and the internal knowledge base. Partly the absorption capacity depends on the knowledge base of firms, more specifically the knowledge of each individual working for the firm, the homogeneity / diversity of in-house knowledge, the communication processes within the firm, and the role of gatekeepers. The ability to absorb new knowledge depends on what has been learned before; therefore, knowledge processes are cumulative. Also, firms interpret signals from the environment about new knowledge in relation to their current knowledge. Thus, the potential value of new knowledge can be better understood in fields of previous experience, further strengthening the cumulative character and path dependency in the learning process.

New knowledge can be acquired through sourcing it from external sources. Much of existing research focuses on the acquisition of technological knowledge from external sources for instance through research and development cooperations, which follows the research tradition focussing on technological product and process innovations. Innovations, however, also rely on other kinds of external knowledge. Frequently, market knowledge is needed particularly for product innovations and strategic innovations. Product innovations are not only based on inventions but also to the successful commercialisation. Strategy defines the framework for the behaviour of a firm on the market and strategic innovations, thus, need to build also on market knowledge. Technological and market knowledge can be acquired from different sources. In this paper, the following types of sources are investigated: clients, suppliers, competitors and knowledge services (being universities, technical colleges, research institutes, technology transfer organisations, etc.). Typically, one would expect that clients are an important source for market information while suppliers tend to be more relevant for sourcing technological knowledge. Knowledge services and competitors can equally provide technological as well as market knowledge, depending on the demand of the firm.

In the context of knowledge sourcing, it is also a question where the knowledge sources are located. In order to understand the spatial patterns of knowledge sourcing, it is useful to reflect about the characteristics of knowledge and their implications on knowledge transfer. Some knowledge exists in codified form in patent descriptions, scientific journals, magazines, books, Internet, etc. This knowledge can in theory be transferred with ease over large distances under the precondition that adequate information and communication technology is available and that the receiver has the required education, experience and skills to understand the codified knowledge.

Other parts of knowledge are not codified and may even be not codifiable. The transfer of such knowledge usually requires interactive learning methods, which are significantly facilitated through geographic proximity and actual face-to-face contact. Nevertheless, also tacit knowledge can be transferred over distance. This usually requires more efforts, technology and experience in collaborating over distance and can be facilitated for instance by establishing temporary project groups, utilising video conferences or organising regular face to face meetings. (Polanyi, 1966; Lundvall, 1992)

Knowledge transfer is facilitated by similar knowledge bases (cognitive proximity) of the involved firms as this supports the understanding of the transferred knowledge. However, the above mainly explains the ease or difficulty of transferring knowledge over distance based on knowledge characteristics. Equally, important is whether firms are willing to exchange knowledge. This depends on relational ties between the firms. Relational ties develop for instance through personal contacts, reliable previous business interactions, organisational integration or institutional factors (Boschma, 2005; Capello and Faggian, 2005). With clients and suppliers, firms regularly maintain relationships on an international scale. These regular input-output relationships are also a basis for the development of relational ties. Furthermore, with clients and suppliers, firms would usually have significant overlaps in their knowledge bases. Both, the relational and cognitive proximity will facilitate knowledge sourcing over larger distances. However, the exchange of more sensitive and confidential information requires stronger social bonds and trust and might therefore occur predominantly in the region.

In relation to knowledge providing organisations, the sector characteristics play an important role. High-technology firms with significant in-house research capacities will have a close cognitive proximity with research institutes and universities. Research institutes and universities utilise and produce to a large extent codified knowledge, which can be absorbed by high-technology companies also over larger geographic distance. However, medium- and low-technology companies tend to have less research capacity and accordingly knowledge transfer with knowledge services should be relatively complicated and rather regionally defined.

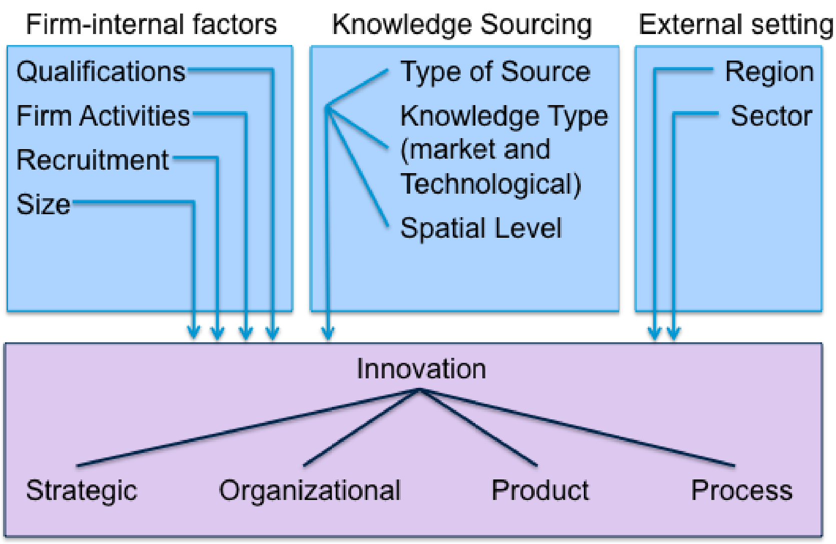
Overall, we consider internal and external knowledge fundamental for firms' innovativeness. We expect that different types of innovations are associated with different configurations of activities, qualifications, recruitment and knowledge sourcing. However, an analysis of firms' innovativeness needs to consider the regional and sector context. A sector comprises firms that produce a specific type of products. These types are usually connected with typical production technologies and processes as well as input and output markets. Hence, the context for innovation processes is also defined by the sector. Accordingly, the expected types of innovation and related knowledge configuration depend on the sector a firm belongs to. For instance, a high-tech sector such as life sciences or biotech will comprise firms that tend to be strong in technological product innovations and accordingly should have a high share of university graduates, apply formal innovation processes, maintain links to universities and generate patents regularly (Owen-Smith and Powell, 2004; Coenen et al., 2004; Cooke, 2006; Gertler and Levitte, 2005; Trippl and Tödtling, 2007). In contrast, in medium and low-tech sector innovation will frequently be triggered by interactions with clients and suppliers and potentially supported by laboratories or technical institutes. Engineers and staff trained on the job will form the knowledge base while academics and scientists will hardly play a role (Tunzelmann and Acha, 2005; Hirsch-Kreinsen et al., 2005; Bender, 2006). Hence, knowledge bases differ both by sector and firm.

In relation to the impact of regional characteristics on innovation performance, the Regional Innovation System approach provides a useful conceptual framework. It integrates the findings of cluster research, the potential positive effects of demand and input conditions, related industries and industry structure with potential effects based on institutional factors and policy interventions. Furthermore, it has been recognised that a RIS is connected to other RIS and the National Innovation System. The characters of the region, the RIS (Cooke et al., 2004; Tödtling and Trippl, 2005) as well as of the country and the NIS (Lundvall, 1992; Edquist, 1997) are argued to have an impact on the innovativeness of firms. Countries and regions well endowed with knowledge generating and transmitting organisations, with high level educational bodies and schools and with abundant finance for innovation and risk capital are more supportive environments for innovative firms than countries and regions lacking such environments. Within Europe we find disparities between the North –South as well as between West and East in this respect (see e.g. the EU Innovation Scoreboards).

Although a differentiation of innovativeness by sector or type of RIS is not focus of this paper, it will be necessary, therefore, to control these effects.

In summary, this paper will analyse the relationships shown in graph 1. The association between firms that have introduced innovations in strategy, organization, products or processes and firm-internal factors, knowledge sourcing and external setting will be analysed. The firm-internal factors include the qualifications of staff, firm activities, recruitment and firm size. Knowledge sourcing will differentiate in links per partner type (clients, suppliers, competitors, knowledge services), knowledge type (technological or market) and spatial type (regional, national, international). For each combination the association with the different innovation types will be estimated. Furthermore, the external setting will be presented by the firms' sector classification and location.

Graph 1: Model of investigated relationships



3) Methodology

This paper presents results of the research project "Constructing Regional Advantage" funded by the European Science Fund. Eight universities from as many countries cooperated in order to analyze the main factors influencing the innovativeness of specific sectors considering their regional context. Similar questionnaires were used in all countries targeted at generating data especially about firm's knowledge networks and knowledge bases.

The data from all eight countries were combined into one file. Although the underlying questionnaires were similar, it was still required to standardize the data in order to make it accessible for statistical analysis. Mainly, this refers to adjustments in the categories of some variables and accordingly a reclassification of the responses. After standardizing the data, a plausibility and conformity check was undertaken by comparing different variables per case and region. Also, to the extent possible, the codification of the data was implemented in a more homogenous manner; e.g. a firm that has implemented product innovations new to the market must also score positively for the variable related to product innovation in general (i.e. the former is more radical than the latter). Overall, we found that fifteen cases from seven countries provided comparable data. A case represents a firm-based survey on one specific sector in one region of the seven countries. In total, these fifteen cases comprise 467 completed questionnaires of firms.

As a first step, the data about innovation indicators, firm-internal factors and knowledge sourcing per case was analyzed using descriptive statistics. The indicators described in table 1 were included in the analysis.

Table 1. Indicators and scale included in the analysis of this paper

Indicator	**Scale**
Which of the following innovative changes has your company implemented in the last three years?	
Introduction of new or significantly improved products	Binominal
Product innovations that are also new for the market	Binominal
Application of new or significantly enhanced processes, components or materials	Binominal
Application of new or significantly enhanced strategies	Binominal
Application of new or significantly enhanced organizational structures	Binominal
Introduction of a significantly advanced marketing concept	Binominal
Registration of patents	Binominal
Activities on which firms' competitive edge depend	
Production of tailor-made, individual products/processes for individual clients	Binominal
Production of standardized goods/processes	Binominal
Product and process development	Binominal
Design	Binominal
Marketing	Binominal
Employment of staff in research and development	Binominal
What kind of education do your employees have; based on the total number of employees?	
Share of employees with a bachelor or university diploma	Metric 0-1
Share of employees with a natural science degree	Metric 0-1
Share of employees with a technical degree	Metric 0-1
Share of employees with a social science or artistic degree	Metric 0-1
Share of knowledge produced in-house (importance of in-house knowledge)	Metric 0-1
From which institutes/organizations/firms do you recruit highly qualified employees and how important are they for your firm?	
Universities	5 point Likert scale
Technical institutes	5 point Likert scale
Companies of the same sector	5 point Likert scale
Companies of other sectors	5 point Likert scale
Please indicate organizations, firms, universities, research institutes, public bodies etc. with which your firm is in contact to exchange information/knowledge about markets that is relevant for innovations. Please indicate[2]:	
Where the organization/firm is located (regional, national, international)	Categorical
How this organization/firm is related to you (supplier, client, competitor,	Categorical

[2] In some countries the survey included more detailed categories. In this case they were consolidated to have comparable categories.

knowledge providing organisations)	
Same as above for "technological knowledge"	
How important are the following information sources for the acquisition of knowledge about the market for your company	
Fairs	5 point Likert scale
Industry magazines	5 point Likert scale
Market studies	5 point Likert scale
Academic publications / journals	5 point Likert scale
How many employees does your firm have? * logarithm of number was used for the regression analysis	Metric
Region and sector was recorded as dummy variable	Categorical

After assessing the descriptive statistics, binomial logistic regression models were calculated, using different innovation indicators as dependent variable. Binomial regression models compare two groups, which are assumed to be distinctively different, i.e. innovative and non-innovative firms. In order to increase the distinctiveness of the firms in the two compared groups, combinations of innovation indicators were used as dependent variables.

As regards technological innovations, we consider that a combination of product or process innovations with patents indicates more complex and technologically advanced innovation activities. Furthermore, it is plausible that companies with neither one nor the other are significantly less innovative. Also, the indicator "applied for patents" is highly correlated with the one "introduce products new for the market" and "introduce new processes". Hence, in order to assess product and process innovations, we created the following variables:

- Product innovations:
    - Firms that have introduced products new for the market AND applied for patents
    - Firms that have NEITHER introduced products new for the market NOR applied for patents
- Process innovations:
    - Firms that have introduced new processes AND applied for patents
    - Firms that have NEITHER introduced new processes NOR applied for patents

In the models presented below, the observations of firms that had either product/process innovations or patents were excluded in order to compare more distinct groups of highly innovative and lowly innovative companies.

The same logic was applied to construct the dependent variables for organizational and strategic innovations. It can be argued that organizational and strategic innovations are more radical and relevant if the company also introduces new market concepts, i.e. if these innovations also have an impact on the behaviour of the company on the market as opposed to changes that are only internal. Furthermore, the indicator "introduce new market concepts" proved to be highly correlated with strategic and organizational innovations. Accordingly the following variables were used:

- Organizational innovations:
  - Firms that have introduced organizational changes AND new market concepts
  - Firms that have NEITHER introduced organizational changes NOR new market concepts
- Strategic innovations:
  - Firms that have introduced strategic changes AND new market concepts
  - Firms that have NEITHER introduced strategic changes NOR new market concepts

In the description of the results, the focus will be on the four-abovementioned models. The same models were calculated for the individual, non-combined indicators, which are included in the annex for comparison and interpretation. By comparing these models, it becomes clear that the above combination of innovation indicators leads to a significant increase in the quality and explanatory power of the models.

The explanatory variables covered firm-internal factors, external knowledge sourcing, as well as the respective cases using dummy variables. It was decided to pursue a step-wise inclusion / exclusion of explanatory variables always using the same set of variables available for inclusion / exclusion. Variables were included that had a p-value of below 0.15 and excluded if they had p-values of above 0.15. A p-value of 0.15 is relatively high, however, almost all of the included variables in the resulting models have a p-value of below 0.1 and are thus highly significant. The details about the explanatory variables and the individual models can be found in the annex.

Below, we will firstly describe the indicators related to innovation outputs, firm internal knowledge as well as knowledge sourcing per case. Then, we will elaborate on the results of the multivariate analysis before drawing conclusions.

4) Innovation, firm-internal competencies and external knowledge sourcing in investigated sectors and regions

As table 2 illustrates, the analysis includes data from Austria, the Czech Republic, Germany, the Netherlands, Norway, Sweden and Turkey, i.e. countries with different levels of economic development and innovation conditions. The number of observations per case ranges from 16 to 58. The overall mean of company employees is 195.67 while the median corresponds to 26.5. The Swedish case “Scania Food” has a particularly skewed size distribution. Hence, it is clear that the observations relate to large, medium and small firms, implying that company size needs to be one of the control variables.

Table 2. Company size

	n	median	mean	standard deviation
Southwest Saxony Automotive	58	95	150	179
Adiyaman Textile	20	70	133	153
Raufoss Mechanical Engineering	22	59	147	184
Scania Moving Media	27	55	144	253
Brno Electronics	29	50	105	172
The Netherlands Aviation	43	48	97	123
The Netherlands Space	21	40	141	330
South Moravia ICT Software	30	29	77	223
Vienna ICT Hardware	30	23	430	1403
Upper Austria ICT Software	38	15	64	148
Prague Biotech	16	11	44	98
North Rhine-Westphalia Biotech	23	10	15	15
Salzburg ICT	42	6	42	106
Scania Life Science	30	6	17	25
Scania Food	37	5	1123	6717
Total	466	27	196	1930

4.1 Innovation activities

Table 3 depicts the percentage of firms that have introduced product innovations, process innovations, and those having applied for patents. Here, we find cases representing sectors dominated by an analytical knowledge base to be leading, such as biotech, life science and ICT. ICT firms frequently introduce new product or process innovations. However, firms in ICT software development usually score lower with respect to the application for patents. This illustrates the minor importance of patents to measure innovativeness in software development.

On the other hand, the sector "space" in the Netherlands and "textile" in Turkey score high in "applying for patents" while being less active in introducing new products or processes. "Space" is a sector with an analytically dominated knowledge base, which implies a relatively high importance of scientific research systematic innovation processes, codified knowledge and consequently patents. However, it seems that these inventions are rather integrated into existing products and process instead of generating new ones. In comparison, the strength of the textile sector in Adiyaman, Turkey in applying for patents is rather surprising, since the textile sector is usually associated with a more synthetic knowledge base and accordingly a lower importance of patents. A possible reason is that production processes in Adiyaman require more complex machinery, tools and IT. Moreover, technological product innovations in the textile sector may relate to new fabrics with improved functionalities. As 55% of the firms have generated process innovations and only 25% product innovation, the first explanation is more plausible. To some extent, however, it cannot be ruled out that findings might be biased also by the implementation the surveys and interviews in the particular countries and regions.

Table 3. Firms that have introduced technological innovations

	Product innovations firm	Product Innovations market	Rank	Process Innovations	Rank	Total Rank	Applied for patents	Rank
Prague Biotech		100,00%	1	100,00%	1	2	56,3%	4
Scania Life Science	6,70%	80,00%	2	80,00%	5	7	90,0%	1
North Rhine-Westphalia Biotech	13,00%	73,90%	5	91,30%	2	7	60,9%	2
South Moravia ICT Software	23,30%	63,30%	7	83,30%	3	10	,0%	15
Vienna ICT Hardware	13,30%	73,30%	6	80,00%	5	11	60,0%	3
Raufoss Mechanical Engineering	18,20%	77,30%	4	72,70%	8	12	18,2%	10
Upper Austria ICT Software	18,40%	78,90%	3	60,50%	11	14	10,5%	14
Brno Electronics	27,60%	58,60%	8	75,90%	7	15	27,6%	8
Southwest Saxony Automotive	20,70%	41,40%	14	82,80%	4	18	24,1%	9
Scania Moving Media	22,20%	55,60%	9	69,20%	10	19	29,6%	7
Scania Food	30,60%	47,20%	13	69,40%	9	22	10,8%	13
The Netherlands Space	19,00%	52,40%	11	57,10%	12	23	38,1%	5
Salzburg ICT	31,00%	54,80%	10	52,40%	14	24	16,7%	11
The Netherlands Aviation	19,00%	47,60%	12	51,20%	15	27	16,7%	11
Adiyaman Textile	10,00%	25,00%	15	55,00%	13	28	30,0%	6
Total	19,70%	59,60%		70,70%			29,7%	

Similarly, table 4 shows the percentage of firms that have introduced the respective strategic or organizational innovations as well as those having applied new market concepts. For comparison, the companies were ranked and the total of the ranks calculated. In relation to these innovation categories, we find the Swedish cases to be relatively innovative comprising life science, food and moving media. Also cases covering ICT (except Salzburg ICT) seem to be relatively strong in these types of innovation.

Table 4. Companies that innovated in strategies, organization and market concepts (in % of responding companies)

	New Strategies	Rank	New Organization	Rank	New Market Concepts	Rank	Total Rank
Scania Life Science	73%	1	53%	4	67%	1	6
Scania Food	65%	3	54%	3	51%	2	8
South Moravia ICT	70%	2	70%	2	47%	5	9
Scania Moving Media	63%	4	78%	1	48%	4	9
Vienna ICT Hardware	53%	7	47%	7	50%	3	17
The Netherlands Aviation	54%	6	51%	5	40%	7	18
Upper Austria ICT Software	58%	5	40%	9	37%	9	23
North Rhine-Westphalia Biotech	52%	8	26%	13	44%	6	27
Southwest Saxony Automotive	36%	11	47%	8	31%	11	30
Adiyaman Textile	45%	9	35%	11	35%	10	30
The Netherlands Space	33%	13	48%	6	24%	12	31
Brno Electronics	35%	12	28%	12	38%	8	32
Raufoss Mechanical Engineering	36%	10	36%	10	23%	13	33
Salzburg ICT	26%	14	19%	14	19%	14	42
Prague Biotech	0%	15	0%	15	17%	15	45
Total	49%		45%		39%		

4.2 Internal competencies and recruitment

Table 5 illustrates the qualifications of firms' employees and the importance of knowledge produced in-house. The cases are sorted by the first column showing the share of employees with a degree higher than or equal to bachelor. The two high-technology sectors Life Science in Scania and Biotech in Prague and North Rhine-Westphalia rank highest. They also score highest in relation the share of employees with a natural science background. Combined with the observation that these sectors also rank best in terms of technological innovations (see above), these would best fall into the category of sectors with an "analytical knowledge base". We find then a number of sectors that are characterised by an over-proportionate share of employees with engineering background. These sectors include ICT (South Moravia, Upper Austria, Salzburg, Vienna), space (the Netherlands), electronics (Brno), aviation (the Netherlands) and automotive (Southwest Saxony). These show a relatively mixed innovation performance both in relation to the technological as well as strategic and organizational innovations. The ICT sectors tend to be relatively high up in the ranks for all types of innovations, only the patent statistics are mixed due to the differing importance of patents depending on the subsectors (for ICT software, patents have a limited importance). Also, the ICT sector in Salzburg sticks out as being relatively little innovative. However, due to the small size of the ICT sector in Salzburg, it consists of many ICT service companies with little product and process development (see table 7). Referring back to the knowledge base concept, one can associate these sectors with a synthetic knowledge base where innovation processes are linked less to scientific progress and more to the development of solutions to specific problems. These problems are often also of technical nature, require, however, mainly the competences and knowledge of engineers.

We, furthermore, find that the sector food in Scania is characterised by a high proportion of employees with a social sciences or artistic background and a relatively high share of employees with a degree equal or higher to bachelor. This sector also scores well in relation to strategic and organizational innovations while the opposite is true for technological innovations. Then, we have some sectors with a low share of employees with university degrees and that have a high proportion of staff with an "other" background, including moving media (Scania), mechanical engineering (Raufoss) and textile (Adiyaman). The innovation performance of these sectors varies a lot and we lack a clear pattern that would allow an association with a certain typical knowledge base.

Table 5. Qualification (in % of employees)

% of total employees/ % share of knowledge produced in-house	Higher than or equal to Bachelor	engineering background	natural science background	social science/ artistic background	other background
Scania Life Science	92,93	16,97	66,23	-	16,80
Prague Biotech	77,00	2,00	84,33	-	13,67
North Rhine-Westphalia Biotech	68,91	20,74	76,00	-	3,26
South Moravia ICT	68,60	75,83	6,23	4,40	13,53
Scania Food	65,68	15,09	10,42	48,54	25,95
The Netherlands Space	54,38	67,85	21,15	0,25	10,75
Upper Austria ICT Software	43,64	69,12	8,42	22,45	-
Salzburg ICT	37,44	66,93	10,57	22,50	-
Vienna ICT Hardware	34,88	76,82	6,02	17,17	-
Brno Electronics	34,03	87,90	3,17	0,24	8,69
Scania Moving Media	24,81	15,69	20,38	5,62	58,31
The Netherlands Aviation	22,79	80,38	8,60	-	11,03
Raufoss Mechanical Engineering	20,73	35,91	1,50	0,23	62,36
Southwest Saxony Automotive	9,74	81,73	5,40	-	12,87
Adiyaman Textile	2,50	0,68	0,32	23,95	75,05
Total	41,24	52,91	18,44	10,21	18,45

The recruitment attitude of firms reflects the above description in relation to the high-tech sectors. The firms in this sector place the highest importance on recruitment from universities, which underlines the relevance of scientific methods and approaches for their innovation processes. The recruitment pattern from universities varies significantly for the other cases. Interestingly, the textile sector in Adiyaman places ranks in the average in relation to this indicator while the percentage of staff with a bachelor degree or higher is lowest. In combination with the company size; the sector ranks second in the medium size of the companies; it can be concluded that companies in this sector usually have a comparatively large number of lower qualified staff while the once important for innovation processes are few but higher qualified. Interestingly, exactly the same pattern applies for the automotive sector in Southwest Saxony. Hence, the proportion of highly qualified staff cannot be seen independent from company size and recruitment, especially in cross-sector analysis. Overall, the same sector is considered most important for the recruitment of highly qualified staff, which applies particularly for textile (Adiyaman) and Food (Scania). Recruitment from technical institutes was considered particularly important for ICT firms in South Morvavia and textile firms in Adiyaman. Recruitment from other sectors was considered less important, the highest scores are recorded from the mechanical engineering firms in Raufoss and textile in Adiyaman. Interestingly, the high-tech sectors, biotech and life science sore among the lowest in this category. This indicates that the required knowledge in these sectors is very specialised and that outsiders seem to be able to add little value.

Table 6. Recruitment of highly qualified labour (average importance of particular sources on 5 point Lickert scale)

Average (5 point likert scale - 5 being high importance)	Recruit from univ.	Recruit from same sector	Recruit from technical inst.	Recruit from other sector
Prague Biotech	4,50	,63	,31	,13
North Rhine-Westphalia Biotech	4,35	2,74	3,43	1,70
Scania Life Science	3,93	3,87	1,90	1,77
The Netherlands Space	3,62	2,52	1,76	2,19
Upper Austria ICT Software	3,55	3,37	3,87	2,11
Vienna ICT Hardware	3,45	3,48	3,72	2,55
Raufoss Mechanical Engineering	3,27	3,32	2,86	3,27
Adiyaman Textile	2,85	4,30	4,10	3,20
Scania Food	2,78	4,24	2,14	2,54
Southwest Saxony Automotive	2,71	2,98	3,97	1,86
Salzburg ICT	2,52	3,31	3,29	2,40
Scania Moving Media	2,11	3,96	1,89	2,93
The Netherlands Aviation	2,07	2,79	2,07	2,21
South Moravia ICT	1,87	3,57	4,13	1,30
Brno Electronics	,83	3,69	3,55	1,48
Total	2,84	3,31	2,99	2,13

In relation to activities that mainly define the competitive edge of the investigated firms, we find that tailor-made products have been mentioned most frequently (73%) followed by product and process development (63%). As expected the high-tech sectors score highly in relation to product and process development. Some of the engineering-based firms have also indicated product and process development as important activity, especially mechanical engineering firms in Raufoss and ICT hardware firms in Vienna. Interestingly, also the moving media sector in Scania scores highly in this respect. In relation to tailor-made versus standardised products, Raufoss mechanical engineering shows a deviation from the pattern with few firms considering tailor-made products to be important in contrast to standardised products. Another relatively apparent deviation is the importance of tailor-made products for ICT firms in Salzburg as compared to standardised products. This deviation is related to the small size of the sector that is characterised by many small companies providing ICT services and support. In relation to marketing, ICT hardware in Vienna, ICT software in South Moravia and textile in Adiyaman score highly. Design is considered to be important for many ICT hardware firms in Vienna, mechanical engineering firms in Raufoss and firms in the food sector in Scania. Overall, we find that the category product and process development and to some extent the relative importance of tailor-made versus standardised products result in patterns, which can be interpreted well.

Table 7. Activities of which firms' competitive edge depends (% of responding companies)

% of firms	Average	Tailor made products	Product / process develop't	Standar-dised products	Marketing	Design
Vienna ICT Hardware	67,3%	76,7%	80,0%	56,7%	60,0%	63,3%
South Moravia ICT Software	66,7%	96,7%	73,3%	70,0%	60,0%	33,3%
Raufoss Mechanical Engineering	60,9%	40,9%	100,0%	72,7%	31,8%	59,1%
Upper Austria ICT Software	55,3%	89,5%	65,8%	65,8%	21,1%	34,2%
The Netherlands Space	50,5%	85,7%	71,4%	28,6%	28,6%	38,1%
North Rhine-Westphalia Biotech	48,7%	87,0%	91,3%	39,1%	26,1%	,0%
Brno Electronics	44,8%	72,4%	58,6%	44,8%	20,7%	27,6%
Southwest Saxony Automotive	43,8%	82,8%	63,8%	41,4%	15,5%	15,5%
Scania Moving Media	43,6%	64,3%	75,0%	35,7%	32,1%	10,7%
Scania Food	42,2%	70,3%	37,8%	13,5%	32,4%	56,8%
The Netherlands Aviation	42,0%	70,7%	58,5%	36,6%	22,0%	22,0%
Prague Biotech	36,3%	62,5%	93,8%	12,5%	12,5%	,0%
Salzburg ICT	36,2%	78,6%	33,3%	28,6%	16,7%	23,8%
Scania Life Science	30,0%	50,0%	70,0%	13,3%	13,3%	3,3%
Adiyaman Textile	27,0%	35,0%	15,0%	35,0%	45,0%	5,0%
Total	46,3%	73,1%	63,4%	40,0%	28,0%	26,9%

4.3 External knowledge sources

The following two tables provide an overview about the pattern of external knowledge sourcing of the investigated firms. A detailed analysis per case is not feasible in the context of this paper and is covered in other publications related to the CRA project. A drawback in comparing the data is that naming the knowledge sources was somewhat cumbersome and thus it depended to some extent from the interviewer how comprehensive and complete this section was filled in. The impact of this is less relevant when comparing the distribution of links.

The pattern shown in table 8 reveals the importance of the respective region (RIS) and the country (NIS) for sourcing technological knowledge from knowledge organisations such as universities, research institutes, technical institutes, and knowledge transfer organizations. In this regard, the case "Scania Life Science" can be considered special where 76,7% of the firms have links with knowledge organizations on the international scale next to 80% on the regional and 70% on the national scale. The high number of international links might partly relate to the socio-economic integration of Scania with Denmark and the role of the Oresund Bridge facilitating international cross-border interactions. Scania Life Science is characteristic for sectors with an analytical knowledge base, which also explains the high frequency of links with knowledge organizations. Biotech firms in North Rhine-Westphalia also belong to the most active in this respect, while fewer biotech firms in Prague have indicated such knowledge sourcing activities.

Table 8. Technological Knowledge: Percentage of firms with respective links

% of firms	Suppliers			Clients			Competitors			Knowledge Organisations			Ave-rage
	Reg.	Nat.	Int.	Reg.	Nat.	Int.	Reg.	Nat.	Int.	Reg.	Nat.	Int.	
North Rhine-Westphalia Biotech	43,48	26,09	30,43	43,48	60,87	47,83	17,39	4,35	13,04	86,96	56,52	34,78	38,77
Southwest Saxony Automotive	56,90	67,24	24,14	44,83	51,72	29,31	10,34	6,90	-	68,97	63,79	25,86	37,50
Scania Life Science	10,00	16,67	6,67	-	10,00	3,33	-	3,33	-	80,00	70,00	76,67	23,06
South Moravia ICT Software	23,33	90,00	20,00	16,67	13,33	3,33	3,33	13,33	-	43,33	30,00	10,00	22,22
Upper Austria ICT Software	7,89	18,42	13,16	50,00	39,47	26,32	13,16	5,26	23,68	26,32	15,79	26,32	22,15
Vienna ICT Hardware	6,67	10,00	6,67	46,67	33,33	33,33	6,67	10,00	20,00	33,33	23,33	26,67	21,39
Scania Moving Media	60,71	28,57	46,43	17,86	3,57	7,14	-	-	-	35,71	35,71	14,29	20,83
Brno Electronics	31,03	41,38	20,69	3,45	24,14	6,90	6,90	10,34	3,45	48,28	20,69	31,03	20,69
The Netherlands Space	9,52	14,29	14,29	19,05	52,38	9,52	9,52	23,81	-	19,05	47,62	9,52	19,05
Scania Food	27,03	21,62	35,14	21,62	10,81	5,41	10,81	2,70	10,81	29,73	16,22	10,81	16,89
The Netherlands Aviation	2,33	4,65	6,98	13,95	18,60	16,28	2,33	2,33	2,33	18,60	48,84	9,30	12,21
Salzburg ICT	7,14	9,52	11,90	2,38	14,29	19,05	4,76	9,52	14,29	19,05	7,14	14,29	11,11
Prague Biotech	6,25	-	6,25	6,25	-	18,75	6,25	6,25	-	43,75	6,25	6,25	8,85
Raufoss Mechanical Engineering	-	4,55	-	31,82	27,27	27,27	-	-	-	-	4,55	9,09	8,71
Adiyaman Textile	5,00	30,00	-	-	20,00	5,00	-	-	-	5,00	20,00	-	7,08
Total	21,84	28,05	17,13	22,91	26,34	17,77	6,42	6,42	6,42	38,54	33,19	21,20	20,52

The pattern of links to source market knowledge differs from the above mainly in the higher importance of clients as knowledge sources. 29,8% of the firms have knowledge linkages with regional clients, 31,9% with national clients and 21,2% with international clients (the respective percentages for technological knowledge are 22,9%, 26,3% and 17,8%). Scania Life Science is also particular in relation to the sector's pattern to source market knowledge. 86,7% of the firms have maintained knowledge links with international knowledge services and – in contrast, very few firms have networks with clients. Interestingly, of the sectors with a low proportion of academics and a high proportion of "other" qualification background, Scania moving media appears to be relatively active in knowledge sourcing in general while Raufoss mechanical engineering and Adiyaman textile score very low in this respect. However, knowledge interactions of the mechanical engineering firms in Raufoss are relatively frequent with clients, which is typical for a sector with a synthetic knowledge base. Overall, competitors have rarely been mentioned to be sources for technological or market knowledge.

Table 9. Market Knowledge: Percentage of firms with respective links

% of firms	Suppliers			Clients			Competitors			Knowledge Organisations			Ave-rage
	Reg.	Nat.	Int.	Reg.	Nat.	Int.	Reg.	Nat.	Int.	Reg.	Nat.	Int.	
Southwest Saxony Automotive	37,93	46,55	12,07	46,55	58,62	31,03	8,62	6,90	-	48,28	62,07	20,69	31,61
Scania Food	35,14	27,03	32,43	48,65	35,14	18,92	16,22	10,81	10,81	48,65	35,14	21,62	28,38
South Moravia ICT Software	26,67	40,00	30,00	**50,00**	60,00	10,00	**3,33**	10,00	-	36,67	16,67	-	23,61
Upper Austria ICT Software	7,89	18,42	13,16	50,00	39,47	26,32	13,16	5,26	23,68	26,32	15,79	26,32	22,15
Vienna ICT Hardware	6,67	10,00	6,67	46,67	33,33	33,33	6,67	10,00	20,00	33,33	23,33	26,67	21,39
Scania Moving Media	28,57	28,57	25,00	42,86	35,71	32,14	3,57	-	-	21,43	21,43	14,29	21,13
North Rhine-Westphalia Biotech	8,70	4,35	4,35	34,78	39,13	30,43	-	-	4,35	60,87	30,43	30,43	20,65
The Netherlands Space	9,52	14,29	14,29	19,05	52,38	9,52	9,52	23,81	-	19,05	47,62	9,52	19,05
Scania Life Science	-	3,33	-	-	3,33	13,33	-	3,33	3,33	53,33	50,00	86,67	18,06
Brno Electronics	10,34	6,90	6,90	20,69	17,24	17,24	10,34	10,34	6,90	20,69	20,69	37,93	15,52
The Netherlands Aviation	2,33	4,65	6,98	16,28	18,60	16,28	2,33	2,33	2,33	20,93	48,84	9,30	12,60
Salzburg ICT	7,14	9,52	11,90	2,38	14,29	19,05	4,76	9,52	14,29	19,05	7,14	14,29	11,11
Prague Biotech	6,25	-	6,25	6,25	-	18,75	6,25	6,25	-	43,75	6,25	6,25	8,85
Raufoss Mechanical Engineering	-	4,55	-	31,82	27,27	27,27	-	-	-	-	4,55	9,09	8,71
Adiyaman Textile	5,00	5,00	**5,00**	-	15,00	-	-	-	-	15,00	25,00	-	5,83
Total	14,78	17,56	12,42	29,76	31,91	21,20	6,21	6,64	6,42	32,12	30,41	21,63	19,25

5) **Results of multivariate analysis**

In a multivariate analysis the relationship between types of innovation internal factors of firms, patterns of knowledge sourcing and the external setting was investigated. As regards firm-internal factors, the firms' activities, qualifications, recruitment and size are considered. Knowledge sourcing covers the acquisition of market and technological knowledge from different types of sources and spatial levels. The external setting refers to the sector and location (region/country) of the respective firm. The methodology was outlined in section 3, here we focus on the key findings.

Overall, the table 10 shows that the models are of high quality considering the values for the Cox and Snell R^2, the Nagelkerke R^2 and the percentage of correctly predicted observations.

As regards firms' activities, as to be expected, product and process development is playing an important role for innovation. In all kinds of innovation except organizational innovations, product and process development is positively associated with innovativeness. None of the other activities was found to be significantly related to product and process innovations. For strategic and organizational innovations, design activities and marketing activities are of particular importance. For these types of innovation, design and marketing seem to play the same role as product and process development for technological product and process innovations. Interestingly, the development of tailor made products correlates negatively with strategic innovations. While most firms indicated that the production of tailor made products and processes is an activity important for their competitiveness, such a focus might also imply that firms rather follow the request of the "next" customer than position themselves strategically.

The indicators relating to the qualification of employees show ambiguous results. As to be expected, product innovations are negatively associated with the share of employees with other backgrounds (i.e. lower qualifications), whereas process innovations are negatively related to the share of employees with a qualification higher than or equal to Bachelor. The latter finding is rather surprising and contradicts the assumption that a better-educated workforce supports innovation in general and also the introduction of new processes.

Strategic and organizational innovations correlate positively with the share of employees with social science or artistic background. Qualifications in the field of social sciences, which include management science and business administration among others, seem to support the development of new or changed strategies and organizations. Staff with an artistic background may offer capacities to connect with the societal trends and express the firms' strategic and organizational positioning in this context. Also, capabilities to think creatively and "out of the box" of normal business routines could explain the positive relationship with such kinds of innovations. For organizational innovations more specifically we find evidence for a positive influence of a well educated workforce (higher than or equal to Bachelor) as well as with the importance of in-house knowledge more broadly.

Recruitment as a key mechanism for internalizing external knowledge resources also proves to be relevant for various kinds of innovations. In line with expectations, product innovations are positively related with recruitment of personnel from universities, while recruitment from technical institutes, somewhat surprisingly, seems to have the opposite association. This supports the conclusion that more sophisticated technological innovations (product innovations new to the market combined with patents) require more formal and scientific research and development processes grounded in an analytical knowledge base.

In contrast, strategic and organizational innovations seem to benefit particularly from recruitment of personnel from other sectors. Interestingly, other sectors were overall considered to be the least important for recruiting highly qualified employees. Hence, while only few firms place importance on it, those that do so tend to be more innovative in terms of strategic and organizational changes. Possibly, the experience gained in other sectors opens a new perspective on the organization and its strategy and thus allows for repositioning and innovating in these fields. New strategies, however, are also positively related with the recruitment of staff from the same sector. Hence, strategic innovations seem to be supported by the mobility of highly qualified people both from the same and other sectors. Recruits from the same sector contribute with insight knowledge and experience from competing firms, which can trigger learning either in terms of imitating or in terms of implementing new strategies that are thought to strengthen the competitive position of the recruiting firm. Recruits from other sectors might bring in new ideas, widen the horizon of the firm and help to find solutions beyond sector mental frameworks.

Also, the knowledge-sourcing pattern has an impact on the types of innovation. While technological product and process innovations show a significant positive relationship with the reading of scientific journals, strategic and organizational innovations are positively associated with market studies. Scientific journals are a source for codified, academic knowledge. Usually, the appropriation of such knowledge also requires staff with an academic background. This is supported by the significant positive relationship of recruitment from universities for product innovation stated above.

Market studies, on the other hand, usually aim at receiving information about the market and the preferences and behaviour of customers and other market players. Not surprisingly, market studies have a higher relevance for strategic and organizational innovations than for technologically oriented product and process innovations. Interestingly, firms placing a high importance on industry magazines (codified knowledge) tend to be less innovative in respect to strategy and organization. In contrast, fairs which are key nodes for the exchange of both tacit and codified knowledge constitute a relevant knowledge source for strategic innovations.

The results provide evidence for a positive role of international clients for all four types of innovations. The positive association relates to the sourcing of technological knowledge and not market knowledge. At first sight, this result may seem surprising as clients represent part of the market and through clients, one would assume, firms can source market knowledge. Indeed, as table 9 shows, firms have used clients as source for market knowledge relatively frequently. Therefore, it might be concluded that firms use clients to gather knowledge about the market, this knowledge sourcing activity, however, does not contribute to distinguish firms in their innovativeness. Links with regional clients to source market knowledge show a negative relationship with product innovations and links with national clients to source technological knowledge are negatively associated with process innovations. These results illustrate that innovative firms have a tendency to operate on an international scale and that they have developed capacities to source (especially technological) knowledge from clients over a larger distance. A too strong focus on the region might cause narrow views and as a consequence "lock in".

Regional knowledge sourcing from suppliers is positively related with strategic and organizational innovations, negatively, however, with product and process innovations. Such a negative relationship is unexpected from the point of view of the literature on industrial districts (e.g. Amin, 2000; Becattini et al., 2009). In contrast, product and process innovations show a positive association with sourcing knowledge from international suppliers, which is consistent with more recent works on innovation networks (Fritsch, 2004; Fritsch and Franke, 2004; Tödtling et al., 2009). One reason for this spatial pattern may be found in the kind of knowledge that is sourced from suppliers. In relation to product and process innovations, the relationship with suppliers is usually underpinned by input-output relationships, i.e. suppliers provide machinery, tools or materials constituting important inputs in the production process. Product and process innovations that are related to new machinery, tools or materials are often based on embodied knowledge. The transfer of embodied knowledge over larger geographic distances is in general less problematic than the transfer of tacit knowledge. In addition, the suppliers have an incentive to invest time and money (e.g. through site visits and trainings) for transferring knowledge to clients as this promotes sales. Furthermore, only few suppliers may be sources for cutting edge production technologies and these few supplies may not be located in the neighbourhood. Such key suppliers have contacts to many firms in the sector and thus are also important sources for market knowledge.

In contrast, organizational and strategic innovations are positively associated with technological knowledge sourcing from regional suppliers. This might result from relations to business consultants and knowledge intensive services from the region supporting such innovations (see e.g. Doloreux et al., 2010).

In general, strategic and organizational innovations tend not to create revenues for suppliers (except if these innovations are linked with changes in the production processes). The ease of face-to-face meetings and contacts combined with a shared institutional environment facilitates the development of social ties and trust. This in turn promotes the sharing of confidential information related to internal and strategic issues of firms. Geographic proximity plays, therefore, an important role for gathering knowledge relevant for strategic and organizational innovations from suppliers and service firms.

The pattern of knowledge sourcing from competitors is not very conclusive. We observe a positive association of strategic innovations with national links for sourcing market knowledge and a negative association of organizational innovations with regional links for sourcing technological knowledge. In contrast, product innovations are negatively related to international links for sourcing technological knowledge and positively to the ones for market knowledge. Considering the few firms that use competitors as knowledge sources for both technological and market knowledge (see table 8 and 9), it seems that competitors are less important as a knowledge source than the other types of sources. However, this does not preclude the role of competitors in general, e.g. observation, reverse engineering, recruitment and peer pressure are considered to be important driving forces for innovation.

The category "knowledge providing organizations" includes links to universities, technical institutes, consultants, technology transfer centres and the like. While the international dimension proved to be significant for knowledge transfers from clients and customers, especially in relation to the sourcing of technological knowledge and the sourcing of knowledge that is linked to input-output relations, the regional and national levels are of greater importance for links with such knowledge providing organisations. National links show positive relationship with strategic innovations (sourcing of market knowledge), organizational innovations (sourcing of technological knowledge) and process innovations (sourcing of technological knowledge). Regional links show positive associations with product innovations (sourcing of technological knowledge) and process innovations (sourcing of technological knowledge). Regional links are negatively related with organizational innovations if used for sourcing market knowledge.

Accordingly, the national level seems to be mainly relevant for strategic and organizational innovations, while the regional level is particularly important for product and process innovations. Links with knowledge providing organisations on the regional level to source technological knowledge was also the category, which was most frequently used by all firms (38,5% of the firms had such links, see table 8). This is in line with other literature. Therefore the role of knowledge providing organizations in regional innovation systems for more technologically oriented product and process innovations is strongly supported by this study. It implies a network pattern where firms reach out globally in their input-output relations and knowledge sourcing from clients and suppliers while they still depend to a large extent on the regional endowment of organizations that actively search, combine, generate and transfer new knowledge. Recruitment from such organizations, spillovers, contract research as well as cooperation on the regional level are mechanisms to source knowledge with knowledge services and create value in innovation processes.

Table 10 also shows the significant control variables and external factors. Company size turned out to be significantly positively related to organizational innovations and product innovation. Furthermore, the individual cases were included as dummy variables. The cases represent a specific sector in a particular region or country. The sectors represent different knowledge bases to some extent, whereas the regions stand for the quality of the respective RIS and NIS. Furthermore, the research teams in each country to some extent showed a certain variation in the implementation of the firm survey. Accordingly, these dummy variables for the cases represent different kinds of influences. Nevertheless, it is worth noticing that – as expected – firms belonging to the

Swedish cases (especially life science) tend to be more innovative. Also, the technological oriented product and process innovations are dominated by biotech, life science, ICT hardware, and electronics (moving media only for product innovations). Biotech and life science are typical high-tech sectors with a dominance of an analytical knowledge base. ICT hardware and electronics as well as space industry and aviation are sectors combining analytical and synthetic knowledge and having strong focus on sophisticated engineering. In mechanical engineering, automotives, textiles and food synthetic knowledge seems to be more relevant in comparison. In moving media symbolic knowledge is important whereas software seems to combine all three types.

Table 10. Results Binomial Models

	Strategy & Market Concepts (low-high)		Organization & Market Concepts (low-high)		Product Innovations & Patents (low-high)		Process Innovations & Patents (low-high)	
Activities	- Tailor made products + Product and process development + Design + Marketing		+ Design + Marketing		+ Product and process development		+ Product and process development	
Qualifications / Importance of in-house knowledge	+ Share with social science & artistic background		+ Higher than or equal to Bachelor + Share with social science & artistic background + Importance of in-house knowledge		- Share with other background		- Higher than or equal to Bachelor	
Recruitment	+ Same sector + Other sectors		+ Technical Institutes + Other sectors		+ Universities - Technical Institutes			
Size			+		+			
Knowledge sourcing	Tech	Market	Tech	Market	Tech	Market	Tech	Market
Other sources	- Magazines + Studies	+ Fairs	- Magazines + Studies	+ Studies	+ Journals		+ Journals	+ Journals
Clients	+ International		+ International		+ International	- Regional	- National + International	
Suppliers	+ Regional		+ Regional		- Regional	+ International	- Regional + International	
Competitors		+ National	- Regional		- International	+ International		
Knowledge services		+National	+ National	- Regional	+ Regional		+ Regional + National	
Sectors	- Vienna ICT Hardware - Salzburg ICT + South Moravia ICT - SW Saxony Automotive - NL Space - Raufoss Mechanical Engineering + Scania Life Science - Adiyaman Textile		- Salzburg ICT + South Moravia ICT + NL Aviation + Scania Food + Scania Moving Media + Scania Life Science		+ Vienna ICT Hardware - Salzburg ICT + Prague Biotech + Brno Electronics - SW Saxony Automotive + Scania Moving Media + Scania Life Science		- Upper Austria ICT Software + Vienna ICT Hardware + Prague Biotech + Brno Electronics + Scania Life Science	
Cox& Snell R^2	0,378		0,429		0,550		0,519	
Nagelkerke R^2	0,508		0,584		0,739		0,693	
Correctly predicted	80,0%		82,2%		89,1%		86,3%	
N	275		253		230		204	

6) **Conclusion**

Overall, we find distinct patterns of innovation, firm-internal capacities and knowledge sourcing depending on the investigated sector and region. The pattern is most clearly defined for high-tech sectors and sectors related to engineering while other sectors show more diffuse results. Also, we find that different types of innovations are associated with different configuration of firm-internal capacities and knowledge sourcing.

In this study biotech and life sciences were investigated as knowledge intensive sectors with a high importance of analytical knowledge. It was shown that these sectors generate technologically advanced product and process innovations and rely on a high share of highly educated staff qualified to apply scientific methods. A natural sciences background is most relevant in these sectors. Also, they tend to acquire knowledge intensively, particularly from knowledge providing organizations such as universities, technical institutes, research institutes, etc. While, in general, knowledge acquisition from such sources is found to be more geographically bound, especially the life science sector in Scania demonstrates that the international level can be very important for high-tech sectors.

Furthermore, a number of sectors with a focus on engineering were included in the analysis. Firms in these sectors tend to have a lower share of staff with a bachelor degree or higher. Most of the workforce has an engineering background. The firms have a lower innovation performance including patenting, especially related to patenting (thus technological innovations). In general, the engineering-related sectors can be associated with a synthetic knowledge base, although there are strong differences in the innovation outputs between the sectors. In this context, the networks with suppliers and clients are important and especially the development of solutions to concrete problems that frequently are of technical nature. The solutions, however, usually do not require a scientific approach.

Some sectors, however, could not be well classified such as textile or moving media. As both sectors strongly depend on social trends, one would expect that characteristics of a symbolic knowledge base should prevail. However, the indicators and results do not provide a very consistent picture of the innovation processes in these sectors. Obviously, the indicators used do not cover very well the innovation process in these kinds of sectors and firms. We, therefore, argue that innovation research needs to devote efforts in understanding innovation in these other sectors.

In relation to the knowledge bases, we found the concept of an analytical and synthetical knowledge base helpful in analysing innovation processes and knowledge sourcing patterns. The findings largely fit the expectations from the literature in this respect (Asheim and Coenen, 2006; Asheim und Gertler, 2005). However, we found the concept to be less useful in relation to strategic and organizational innovations and the sectors less related to high-tech or engineering. In general the concept is also hard to operationalize. Furthermore, it fits better for a classification of sectors than for an analysis on the firm level. As the data of this research was gathered on the firm level, we considered a different perspective on knowledge bases more suitable. The knowledge base of a firm can be considered as total of its staff qualifications, skills and experiences, the knowledge saved in routines, organizations, processes and firm databases as well as the knowledge the firm can access through outside sources. This knowledge base, however, cannot be measured and observed as such. Hence, we consider it more appropriate to measure different aspects of the knowledge base such as the qualification of staff, the firms' activities, recruitment preferences and knowledge sourcing. Once analysed, this set of indicators allow for an understanding of the underlying knowledge base. As mentioned above, the indicators used are more suited to explain technological innovations. Hence, in order to improve the understanding of innovativeness from a broader perspective, additional work is required to identify the main factors and develop adequate indicators related to less technologically oriented innovations (and the sectors to which such innovations apply).

Nevertheless, the multivariate analysis has shown that the associations between technological product and process innovations and strategic and organizational innovations are clearly different. Design and marketing activities are positively associated with strategic and organizational innovations, less however with technological innovations. Product and process development is positively associated with all innovation types except changes in the organization. While the strategic and organizational innovations are positively related with market studies, technological innovations are supported by knowledge drawn from scientific journals. Knowledge providing organizations seem to be more relevant on the regional level for technological innovations while the national level of such sources is more important for strategic and organizational innovations. Technological innovations are positively associated with knowledge sourcing from international suppliers while for the other innovation types the regional suppliers are essential. Sourcing technological knowledge from clients is positively associated with all types of innovation. To a large extent these patterns can be explained by the utilised theories and concepts related to knowledge bases and knowledge sourcing. In general, this cross-sector analysis in different countries has shown that results of the multivariate analysis always need to be compared with descriptive statistics and qualitative information and checked for plausibility. For instance, most firms are active in tailor-made production and consider this activity to be important for their competitiveness. On the other hand, this indicator only appears being negatively associated with strategy and market concepts. Hence, the interpretation of this result will point to the possible problem associated with tailor-made production, i.e. that this might lead firms to pursue individual contracts as they come along without strategic positioning. However, at the same time, the importance of tailor-made production cannot be rejected.

Finally, this cross-sector and cross-regional study clearly shows the diversity and complexity of innovation processes. Innovation was assessed from a broad perspective considering strategic and organizational as well as technological product and process innovations. The different types of innovations are associated with different knowledge configurations in terms of firm-internal knowledge and knowledge sourcing. It follows that also the underlying processes and knowledge bases are different. This demands for a specific reasoning, which, however, needs to be placed within an overall framework providing for the different dimensions of innovation.

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