The Use and Appreciation of Knowledge-Intensive Service Activities in Traditional Industries

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Abstract

This research investigates the role and the importance of knowledge-intensive service activities in the traditional sectors. Knowledge-intensive service activities are defined as innovation-related service activities delivered from inside or outside the innovating company. As such, we investigated the interaction between the innovating company and the various partners supplying knowledge-intensive services to the innovating firm, such as universities, research institutes, private research facilities (R&D labs, e.g.) and consulting companies. We used both firm-level data as well as innovation-level data.

Keywords
knowledge-intensive service activities, traditional sectors, collaboration, community innovation survey, Sfinno

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Contents

Preface

This paper is at the intersection of two projects carried out by VTT Technology Studies. The first project is financed by Tekes and the Ministry of Trade and Industry under the ProACT umbrella. It investigates patterns of innovative activities of Finnish firms. At the heart of the innovative activities is the fact that firms cannot innovate in a vacuum. We observe a trend that innovation is fostered by collaboration among different actors. Hence a description of the patterns of innovative activities requires analysis of the patterns of collaboration. The second project more directly relates to knowledge-intensive service activities in traditional industries. The analysis in this project is genuinely qualitative. The insights in this paper serve as a background to the research carried out there.

The innovator and the researcher share a certain feature: neither one can carry out his or her task without the help, inspiration and collaboration of others. In this regard the author thanks Olavi Lehtoranta for supplying the CIS data and inspiring discussions. Jukka Hyvönen and Torsti Loikkanen initiated this paper as the intense discussions with them revealed the overlap of and the interface between the projects. Jukka Hyvönen and Jani Saarinen introduced me to the structure and the peculiarities of the database of Finnish innovation.

October 5, 2004

1. Introduction

Two observations motivate the analysis in this paper. First, it has been argued that it has become increasingly difficult for firms to innovate alone. A number of relationships within the innovating firm, as well as with partners outside the firm, are essential for successful innovation. Collaboration and research joint ventures are important ingredients for successful innovation, not only in high-tech industries but also for firms in low technology sectors and it has become an integral part of the innovation strategy to involve outside actors in the innovation process (see e.g. Palmberg 2001).

Second, manufacturing and services have become more and more interwoven. This can be attributed to two trends. The first trend is that corporate innovation strategies stress the service content of their new products associated with the de-materialization of the products and the production processes. New business models follow slogans such as "from products to services". The second trend is that services play an increasing role in the generation of new products. According to den Hertog et al. (1997) more than four-fifths of the value added in manufacturing occurs due to service activities. Recently, the importance of interaction with knowledge-intensive services has been emphasized (e.g. Müller and Zenker 2001, Czarnitzki and Spielkamp 2000, Strambach 2001). In this research we focus on the increasing interrelatedness of manufacturing and services manifested by the increasing role knowledge-intensive services play in firms' innovation activities.

When discussing the contribution of knowledge-intensive services to the innovation process, their bridging function (Czarnitzki and Spielkamp 2000) or their participation in knowledge distribution and their role in the moderation of the knowledge flow has to be considered (e.g. Hauknes 1998). He stresses the growing importance of the role of knowledge-intensive services in innovation when he points out that "the generation and diffusion of innovations rely more and more upon new technological knowledge which is generated not only by learning processes implemented by internal research and development laboratories, but also and to a growing extent, by the daily interaction, communication and trading of information of learning firms among themselves and with other scientific institutions. KIBS firms play a major role in this context as qualified interfaces. KIBS firms in fact act more and more as bridges and converters between technological and business expertise and localised knowledge and capabilities, becoming problem-solving actors specialised in the provision of the complementary knowledge inputs allowing the generation of innovations." (Hauknes 1998, p. 5)

Various definitions of knowledge-intensive service activities (KISA)[1] are maintained in the literature. For example: "KIBS can be described as firms performing, mainly for other firms, services encompassing a high intellectual value-added" (Müller, 2001, p. 2), Czarnitzki and Spielkamp (2000) use the industrial classification to distinguish knowledge-intensive services from other services and describe them as a "bridge to innovation". Miles et al. (1995) define knowledge-intensive business services as "services [which] rely heavily upon professional knowledge, and either supply products which are themselves primarily sources of information and knowledge to their users, or use their knowledge to produce services which are intermediate inputs to their clients' own knowledge generating and information processing activities, having other businesses as their main clients."

As no clear-cut and universally accepted definition of knowledge-intensive service activities is available, we use a rather broad definition for this research. We define knowledge-intensive services to be services that are *innovation services provided either internally or externally to a firm or an organization*, where *innovation services* are understood as services targeted towards the development of an organization and its patterns and objectives of innovation. In this definition, public and not-for-profit research institutes are also considered knowledge-intensive services. So are universities. Consulting companies are also consistent with the notion of knowledge-intensive services here. So, our definition here goes beyond the pure corporate and business dimension brought forth by Müller (2001) and Czarnitzki and Spielkamp (2000). Our definition strongly hinges on the interaction between the knowledge-intensive services and the innovating company. Hence it references the observations in Hauknes (1998).

In this paper we analyze the relevance of the interaction between innovating companies and knowledge-intensive services in Finland. In particular, we focus our attention on the traditional manufacturing industries and on companies in the forest cluster. These are firms from NACE classes 20 (Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials), 21 (Manufacture of pulp, paper and paper products) and 361 (Manufacture of furniture). This concentration is in part a reflection of the theoretical discussion within the system of innovation literature[2] that has been extended towards the notion of sectoral systems of innovation (cf. Breschi and Malerba 1997,

[1] Knowledge-intensive business services and knowledge-intensive service activities are used synonymously in some literature.

[2] The boundaries of the system are commonly defined with reference to spatial and political terms: national systems of innovation (Freeman 1987, Lundvall 1992, Nelson 1993) regional/local systems of innovation (Castells and Hall 1993, Saxenian 1996, Cooke et al. 1997).

Malerba 2002). Considering the size of the forest cluster within the Finnish economy and its prominent role in the technological funding schemes, the focus on the forest cluster is also a reflection of the economic reality.[3]

1.1 Research questions

The notion of systems of innovation and, in particular, the refinement of sectoral systems strongly emphasizes the interaction between different actors in shaping the innovation capability of each single actor in the system. Actors do not collaborate because they are equal, they co-operate for innovation because they are heterogeneous. Co-operation is a channel to make available and exchange complementary assets, knowledge and capabilities. Hence the story about co-operation for innovation is a story about sharing. As the evolutionary strand of the literature stresses the heterogeneity of actors, collaboration is about sharing assets, capabilities and knowledge. So, accumulation of learning and knowledge is an integral motive for and part of co-operation (Nelson and Winter 1982, Malerba 1992, Pyka 1999, 2000). The first question in this context is about the **role and the magnitude of interaction** with knowledge-intensive services in traditional industries, and in the forest cluster in particular.

Besides a formal mode of interaction, such as joint R&D ventures and collaborations, or the establishing of technological standards, interaction may also include more informal practices, such as reverse engineering and information exchange networks among engineers and scientists (see e.g. Foray 1995). Reverse engineering can be understood as the involuntary leaking of new technical information, involving only a one-way flow of information (Pyka 1997). Informal communication in networks, however, consists of the mutual and voluntary exchange of information. In formal networks, such as R&D collaboration, contractual agreements are the very basis of the information exchange. Yet contractual agreements are burdened with problems, such as the intrinsic uncertainty of the innovation processes and moral hazards for the participating actors. In terms of transaction costs, informal relationships seem to have the advantage of being simple and uncomplicated, and therefore less expensive with regard to co-ordination efforts. This brief discussion suggests that we should **distinguish between formal and informal** interaction in the analysis.

[3] Pentikäinen (2000), Salo et al. (2004) and www.woodwisdom.fi demonstrate the pervasiveness of the Finnish Forest Cluster program. Salo et al. (2004) discuss an ex-ante evaluation, whereas Pentikäinen (2000) discusses an ex-post or interim evaluation of the program.

Regardless of whether companies interact with the knowledge-intensive services formally or informally, the notion of collective innovation suggests that different types of partners are required for successful innovation (Allen 1983). However, the sheer number of different partners is not the whole story. Laursen and Salter (2004) discuss search strategies for innovation. They characterize the number of different types of knowledge sources as *breadth*. We argue that this notion is not only applicable to sources of knowledge for innovation, it also applies to interaction. They also stress the *depth* of search matters, where their notion of depth relates to the intensity or the assessed value of the knowledge source. This notion, we would argue, also applies to interaction, where the depth denotes the intensity of interaction within the chosen portfolio of the interaction partners. Both the **breadth and the depth of the interaction** are analyzed below. The notion of depth leads us to the analysis of the **evaluation of the impact** of the interaction captured by the perceived value the interacting firm assigns to the interaction.

The discussion of the systems of innovation also stresses that it is not only private actors shaping the system but also state involvement also plays a crucial role. The involvement of the state is analyzed from two different features. First, we distinguish the knowledge-intensive services based on their being offered by **public or private organizations**. Second, we analyze the **influence of public R&D funding** on both the breadth and the depth in the use of knowledge-intensive service activities. The latter analysis is inspired by the fact that the Finnish collaboration culture has, to a large extent, been established by linking R&D subsidies with the requirement to collaborate.

1.2 Structure of the analysis

By and large, the analysis is empirical and explorative. It draws on two distinctively different data sets. The first data set used for this study is the Community Innovations Survey (CIS), to be described in more detail in the discussion below. The distinctive feature of the innovation survey is that it focuses on the innovating firm; it follows the subject approach. The second data source utilized in this exercise is the database of Finnish innovations (Sfinno), which focuses on the innovation itself; it follows the object approach. A combination of both data sets allows us to shed some light on the relevance of knowledge-intensive services for innovation in traditional industries.

The analysis unfolds as follows. Section 2 presents the analysis of the firm-level data. The analysis of the innovation-level data is discussed in Section 3. Section 4 concludes.

2. Firm-level analysis

The analysis in the following section investigates the role and importance of knowledge-intensive services within the firms' innovation activities. We particularly focus on certain actors, which can be subsumed under our rather broad definition of knowledge-intensive services. These actors include universities, private and public research institutes and consulting companies. The importance of the actors is measured by the fraction of companies involving the respective partner in collaborative innovation activities. In addition, we analyze the subjective importance of the role those partners play for firms.

The analysis distinguishes between service companies and manufacturing companies. Within the manufacturing companies we differentiate between the traditional sectors, combining the low-technology manufacturing sectors with low to medium-technology manufacturing (Hatzichronoglou 1997). The traditional sectors are split into companies belonging to the forest cluster, defined by the NACE industrial classes 20, 21 and 361.

2.1 Data

The data set used in this exercise is taken from the third wave of the Community Innovation Survey. This survey was implemented in 2001 and is based on the core Eurostat Community Innovation Survey (CIS) questionnaire. The method and types of questions used in this innovation survey are described in the OECD's Olso Manual (OECD 1997). CIS data are increasingly being used as a key data source in the study of innovation at the firm level in Europe. CIS surveys are usually conducted every five years. They are often denoted as following the 'subject-oriented' line because they ask individual firms directly about innovative activities and innovation results, such as product innovations or process innovations. Furthermore, the CIS surveys various characteristics of the firm relating to the innovation processes. The questionnaire also asks the individual firms to assess the value of certain influences on their innovation process, such as the value of certain collaboration partners or knowledge sources. Ever since the CIS was first launched in the early 1990s it has been widely piloted and tested before implementation.

The CIS questionnaire itself is based on previous generations of innovation research, including the Yale survey and the SPRU innovation database (Klevorick et al., 1995; Pavitt, Robson and Townsend, 1987). It provides an opportunity to investigate patterns of innovation across a large number of industrial firms. It also enables researchers to explore the relationship between indicators of performance and different strategies for innovating (see e.g. Dachs, Ebersberger

and Pyka 2004, Cassiman and Veugelers 2002). Although imperfect, the CIS data does provide a useful complement to the traditional measurements of innovation, such as patent statistics. Compared with R&D and patent data, innovation output indicators in the CIS have the advantage of measuring innovation directly (Kleinknecht et al. 2002).

The Finnish innovation survey, which is the database for the analysis in this section, was conducted by Statistics Finland. The questionnaire was sent to 3,462 companies, 50% of which replied (Statistics Finland 2002). The inclusion of sampling weights allows for extrapolating the analysis to the whole economy.

2.2 Results

This section gives a brief overview over the results of the analysis. First, we investigate the innovation activities and the collaboration pattern across the sectoral breakdown sketched above. The analysis in the following sections draws on the five following items surveyed by the CIS.[4]

1. Companies are asked to state whether they had co-operation arrangements for R&D.[5] If so, they are to indicate the co-operation partners. Amongst others, companies are asked to differentiate between (i) universities, (ii) commercial laboratories / R&D enterprises, (iii) government or non-profit research institutes and (iv) consultants.

2. Companies are also asked to assess the importance of the co-operation partner on a 0 to 3 Likert scale.

3. The sources of information for innovation are inquired about. Amongst others, companies can indicate the importance of (i) universities or (ii) governmental or private non-profit research institutes on a 0 to 3 Likert scale: 0 means that the source is not used.

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[4] The questions in the CIS 3 refer to the three-year period 1998 to 2000.

[5] Innovation co-operation is defined in the EUROSTAT questionnaire as: "Innovation co-operation means active participation in joint R&D and other innovation projects with other organizations (either other enterprises or non-commercial institutions). It does not necessarily imply that both partners derive immediate commercial benefit from the venture. Pure contracting out of work, where there is not active collaboration, is not regarded as co-operation."

4. Companies are asked whether or not they received governmental funding for their innovation activities.

5. Companies are asked to indicate whether or not they

a. introduced new or significantly new products to the market.
b. introduced new or significantly new production processes.
c. had ongoing or abandoned R&D projects.

We talk about a company showing innovative activities or being an innovator if it reported a product innovation, a process innovation, or an ongoing or an abandoned innovation project. Collaborative companies are companies that have indicated collaboration, regardless of the type of partner.

2.2.1 Innovation activities and collaboration in general

Table 1 depicts the propensity to conduct innovative activities in the first column, the frequency to collaborate among all firms in the second column and the frequency to collaborate only among innovators in the third column. As expected, the likelihood of innovation activities is higher in the manufacturing sectors than in the service sectors. Within the manufacturing sector, the frequency of innovation activities increases with the knowledge intensity of the sectors. The sub-sample of companies from the traditional sectors subsuming the low-technology manufacturing and the medium to low-technology manufacturing (see Hatzichronoglou (1997) for a definition) contains 45.1% of companies with innovation activities. The other manufacturing sectors, consisting of the high-technology manufacturing sector as well as the medium to high-technology manufacturing sectors, show a significantly higher share of companies with innovation activities. Companies from the forest cluster do not, however, differ from companies in the other traditional sectors.

If we examine the sheer proportion of companies with innovation collaboration, we can draw the same picture as in the case of innovation activities. This result, however, may be distorted by the fact that only innovators collaborate for innovation. Having accounted for this fact in the third column of Table 1 we observe that the difference in collaboration behavior between the service sectors and the manufacturing sectors vanishes. The difference within the manufacturing sectors still remains. The propensity to collaborate for innovation increases with the technology intensity

Companies receiving public funding for R&D exhibit a higher propensity to collaborate than companies that do not receive public funding. We tend to argue that the causation runs from public funding to collaboration rather than the other way round. Public funding succeeds in promoting and fostering collaboration. The findings here are in accordance with the findings in Dachs et al. (2004) and the prevailing funding schemes in Finland. Public funding is intended to foster collaboration for innovation. Hence the funding schemes succeed in influencing firms' collaborative behavior.

Table 1. Innovation activity and collaboration.

	Innovation activities	**Collaboration**	**Collaboration (innovators only)**
All companies			
Services	0.383	0.187	0.488
Manufacturing	0.493 ***	0.255 ***	0.517
Manufacturing			
Other Manufacturing	0.608	0.373	0.614
Traditional Sectors	0.451 ***	0.212 ***	0.470 ***
Traditional sectors			
Other Traditional Sectors	0.448	0.217	0.485
Forest Cluster	0.462	0.190	0.410
Traditional sectors			
No public funding	-	0.120	0.364
Public funding	-	0.627 ***	0.627 ***
Forest cluster			
No public funding	-	0.107	0.320
Public funding	-	0.537 ***	0.537 *

Note: Traditional sectors consist of the low technology manufacturing and the low medium technology manufacturing. The forest cluster is represented by firms from the NACE classes 20, 21 and 361. The numbers in the first three columns give the fraction of companies with the respective characteristic extrapolated to all innovative Finnish companies. The last column gives the average number of the collaboration partners (maximum number: 4). *** (**, *) indicates a significance level of 1% (5%, 10%).

2.2.2 Formal interaction

As discussed above, the interaction between the knowledge-intensive services and the innovating company can either be formal or informal. The CIS data sets cover the formal interactions as they ask the innovating firms about their collaborative relationships concerning R&D. Table 2 and Table 3 display the analysis of the formal interaction between innovating companies and the knowledge-intensive service providers. We analyze the public sector first before we turn to the discussion of the private sector.

Public sector knowledge-intensive services

The public sector providers of knowledge-intensive services covered in the Community Innovation Survey are universities and government research institutes. Table 2 shows the importance of collaboration with universities for innovation. Disregarding the firms' status of innovation activities, manufacturing firms have more frequent collaboration with universities than service firms. Within the manufacturing sectors, companies from the traditional sectors, as defined above, prove to co-operate with universities less frequently. Yet there is no significant difference in collaboration between firms from the forest cluster and firms from other traditional sectors. When restricting the sample to innovating companies, the difference between firms in the service sectors and firms in the manufacturing sectors vanishes. Innovating service firms and innovating manufacturing firms exhibit an equal propensity for collaboration with universities. The difference between the traditional sectors and high and medium-high technology sectors persists, even if we only look at innovating companies.

Regardless of whether they collaborated with universities or not, companies from the traditional sectors regard the collaboration with universities as less important[6] than companies from the high and medium-high technology sectors. Interestingly, this differential valuation disappears if we assess the valuation of the companies that collaborated with universities, although there may be a selection bias in that companies that *a priori* assess the collaboration with universities as more important have a higher propensity for collaboration. However, we tend to interpret the result as showing that the true value of the collaboration reveals itself through co-operation.

[6] The importance of the collaboration is indicated by the fraction of companies in the group reporting that collaboration with the partner in question was of significant “merkittävä” or high “suuri” importance (categories 3 and 2 on the 0 to 3 Likert scale).

Firms from the forest cluster that pursued co-operative R&D with universities tend to value this partner higher than other companies in the traditional sectors. Note that although being higher than in the other firms of the traditional sectors, the appreciation of the university collaboration in the forest cluster is approximately as high as in manufacturing. Still, it is lower than in the high and medium to high-technology manufacturing.

The pattern of collaboration with government research institutes resembles the collaboration with universities, although the absolute level of collaboration is considerably lower. Take for example the collaboration of innovating manufacturing companies: 39.8% of all innovative manufacturing companies collaborate for innovation with universities; only 24.9% collaborate with government research institutes. Astonishingly, the assessment of the importance of government research institutes among companies involved in co-operative R&D with research institutes is significantly lower among firms from the forest cluster than in companies from other traditional sectors. Close inspection of the sectoral decomposition reveals that the high average valuation in the other traditional sectors is based on the firms from the NACE 15 (food products, beverages and tobacco), NACE 28 (fabricated metal products) and NACE 35 (transport equipment).

Up to this point the discussion suggests that the knowledge-intensive services provided by the public sector are of considerable importance for innovating companies from the forest cluster. About 37.7% of the companies that have been involved in collaborative research with government research institutes report that the collaboration was of high or significant importance. For universities, the assessment is even more favorable: 53.4% of the firms having collaborative experience with universities assess the collaboration being of high or significant importance.

Private sector knowledge-intensive services

The knowledge-intensive business services from the private sector covered in the CIS survey are private sector research institutes and consulting companies. Table 3 reports the results of the analysis of the knowledge-intensive services from the private sector. We find comparable collaboration patterns for both partners. Collaboration is more frequent in the manufacturing sectors. Within the manufacturing sectors the collaboration frequency in the traditional sectors is about half the frequency in the high and medium to high-technology sectors.

Once we account for the differences in the propensity to innovate across sectors, we find no difference in the frequency to collaborate with commercial research facilities or consulting companies between the average innovating company and the average manufacturing company. Still, companies from the traditional sectors formally interact less frequently with private-sector KISA providers than the high and medium to high-technology companies do. The common assessment of the importance of private knowledge-intensive services does not differ across the analyzed sectors. However, the assessment of the importance judged by the companies that do have collaborative experience with partners reveals a remarkable difference: the sectors do not differ in their assessment of the importance of formal interaction with private research organizations for their innovative activities. Yet, in the Forest Cluster we observe a strong statement in favor of the importance of the collaboration with consulting companies for the innovation activities; more than 72% of the companies with collaborative experience state that the collaboration is of significant or high importance for their innovation activities.

Generally, the knowledge-intensive service providers from the private sector receive quite a high valuation of their services for the innovative activities; about 60% of the collaborating companies report high or significant importance of collaboration with private research organizations for their innovative activities.

Table 2. Knowledge-intensive services from the public sector.

	Collaboration	Collaboration (innovators only)	Assessment of the collaboration (innovators only)	Assessment of the collaboration (collaborators only)
Universities				
All companies				
Services	0.099	0.259	0.175	0.675
Manufacturing	0.153***	0.311	0.168	0.541
Manufacturing				
Other Manufacturing	0.242	0.398	0.255	0.640
Traditional Sectors	0.121***	0.268***	0.125***	0.468
Traditional sectors				
Other Traditional Sectors	0.128	0.285	0.130	0.456
Forest Cluster	0.093	0.201	0.107	0.534*
Government res. institutes				
All companies				
Services	0.080	0.210	0.097	0.462
Manufacturing	0.091	0.185	0.110	0.593
Manufacturing				
Other Manufacturing	0.151	0.249	0.123	0.493
Traditional Sectors	0.069***	0.154**	0.104	0.673*
Traditional sectors				
Other Traditional Sectors	0.071	0.157	0.117	0.742
Forest Cluster	0.065	0.141	0.053*	0.377**

Note: The traditional sectors consist of the low-technology manufacturing and the low to medium-technology manufacturing. The forest cluster is represented by firms from the NACE classes 20, 21 and 361. The numbers give the fraction of companies with the respective characteristic extrapolated to the level of the Finnish economy. *** (**, *) indicates a significance level of 1% (5%, 10%).

Table 3. Knowledge-intensive services from the private sector.

	Collaboration	Collaboration (innovators only)	Assessment of the collaboration (innovators only)	Assessment of the collaboration (collaborators only)
Private research facilities				
All companies				
Services	0.066	0.171	0.116	0.675
Manufacturing	0.097*	0.196	0.123	0.624
Manufacturing				
Other Manufacturing	0.158	0.260	0.156	0.600
Traditional Sectors	0.074***	0.165**	0.106	0.642
Traditional sectors				
Other Traditional Sectors	0.078	0.174	0.116	0.666
Forest Cluster	0.061	0.131	0.068	0.523
Consulting companies				
All companies				
Services	0.070	0.183	0.102	0.557
Manufacturing	0.117***	0.236	0.118	0.501
Manufacturing				
Other Manufacturing	0.180	0.296	0.132	0.446
Traditional Sectors	0.093***	0.207**	0.112	0.539
Traditional sectors				
Other Traditional Sectors	0.093	0.207	0.102	0.492
Forest Cluster	0.096	0.207	0.150	0.724*

Note: The traditional sectors consist of the low-technology manufacturing and the low to medium-technology manufacturing. The forest cluster is represented by firms from the NACE classes 20, 21 and 361. The numbers give the fraction of companies with the respective characteristic extrapolated to the level of the Finnish economy. *** (**, *) indicates a significance level of 1% (5%, 10%).

Table 4. Depth and breadth of the search strategy.

	Breadth of collaboration (collaborators only)	Depth of collaboration (collaborators only)
All companies		
Services	0.823	1.003
Manufacturing	0.929	1.003
Manufacturing		
Other Manufacturing	1.204	1.084
Traditional Sectors	0.794 ***	0.951
Traditional sectors		
Other Traditional Sectors	0.824	0.957
Forest Cluster	0.679	0.923
Manufacturing		
No public funding	0.495	0.524
Public funding	1.438 ***	1.330 ***
Traditional sectors		
No public funding	0.484	0.528
Public funding	1.257 ***	1.318 ***
Forest Cluster		
No public funding	0.322	0.506
Public funding	1.185 ***	1.274 **

Note: Traditional sectors consist of the low technology manufacturing and the low medium technology manufacturing. The forest cluster is represented by firms from the NACE classes 20, 21 and 361. Breadth and depth is evaluated only for companies that collaborated with at least one of the partners given in the survey. *** (**, *) indicates a significance level of 1% (5%, 10%).

Breadth and depth of collaborative behavior

The breadth of the formal interaction between innovating companies and the knowledge-intensive services is approximated in this analysis by the number of different types of partners the collaborating company co-operated with.

Table 4 displays the average breadth of the formal interaction. By and large, there are no differences in the breadth of the interaction between services and manufacturing. Within manufacturing, however, we find high-technology manufacturing and high to medium-technology manufacturing firms maintaining broader interaction than companies from the traditional sectors. Distinguishing the traditional sectors in firms from the forest cluster and other firms does not lead to significant differences.

The depth of the interaction is approximated here by the number of collaboration partner types that are considered important. We find that, on average, there is no difference within the sectors.

However, statistically significant differences do show up if we distinguish the sectors further into companies that received public funding for R&D and companies that did not. Publicly funded companies turn out to maintain significantly broader and deeper interactions than companies that do not receive public funding. Implying a causal link that goes from public subsidies to the pattern of collaboration, we can interpret this finding as supporting the effectiveness of the public subsidy schemes in inducing collaboration. It seems that not only is the size of the network influenced by public funding but also the quality of collaboration is affected positively. This finding is in accordance with earlier findings, such as Dachs et al. (2004).

2.2.3 Informal interaction

The informal interaction between innovators and knowledge-intensive services can only be approximated by the question in the innovations survey inquiring about the importance of

certain knowledge sources for the innovation activity.[7] Contrary to the collaboration question, the question about the information sources does not explicitly refer to formal relationships or arrangements. This particular difference in the formulation of the question is utilized here to approximate informal interaction. Companies that reported using universities or government research institutes as a source of knowledge, and which, at the same time, did not report formal collaboration, are classified as interacting informally.

Table 5 shows the results of the analysis of the informal interaction. Across the different sub-samples, we do not observe a significantly different propensity to engage in informal interaction with universities and government research institutes. However, we do observe a strong difference in the valuation of universities as knowledge sources for informally interacting companies from the forest cluster. Only about 5% of the companies state that universities are a large or significant knowledge source, whereas about 25% of the companies from other traditional sectors attribute large or significant importance to the universities as a knowledge source for innovation. Concerning the government research institutes, we find a slightly positive difference in the valuation between manufacturing firms and service firms, where the latter exhibit a less favorable assessment than the former.

From the observations here we cannot deduce a minor role of informal interaction as compared with formal interaction. For both universities and government research institutes we find the propensity for formal interaction as being of the same magnitude as the propensity for informal interaction: 20% to 30%. The assessment of the informal interaction shows remarkably lower values than that of the formal collaboration. The rather low valuation of the informal interaction compared with the formal interaction suggests that most use can be derived from formal interaction. Knowledge and information exchange with universities and government research institutes is most efficiently conducted through formal channels. Our classification of informal interaction systematically underestimates the frequency of informal interaction as companies formally interacting with a partner can, at the same time, also interact informally. This cannot be covered with the available data.

[7] The innovation survey differentiates between 9 sources of knowledge: (i) sources from within the enterprise (ii) sources from within the enterprise group (iii) supplier, subcontractor (iv) clients and customers (v) competitors and companies in the same sector (vi) universities and institutions of higher education (vii) government and non-profit research institutes (viii) conferences, meetings, literature (ix) exhibitions and fairs.

Table 5. Informal interaction with knowledge-intensive services.

	Informal interaction with universities	Assessment of informal interaction with universities	Informal interaction with governm. research institutes	Assessment of informal interaction with gov. res. inst.
All companies				
Services	0.270	0.169	0.237	0.109
Manufacturing	0.312	0.203	0.306	0.208*
Manufacturing				
Other Manufacturing	0.345	0.198	0.295	0.276
Traditional Sectors	0.295	0.206	0.311	0.176
Traditional sectors				
Other Traditional Sectors	0.285	0.252	0.307	0.189
Forest Cluster	0.334	0.052***	0.328	0.129

Note: The traditional sectors consist of the low-technology manufacturing and the low to medium-technology manufacturing. The forest cluster is represented by firms from the NACE classes 20, 21 and 361. The numbers give the fraction of companies with the respective characteristic extrapolated to all innovative Finnish companies. *** (**, *) indicates a significance level of 1% (5%, 10%).

3. Innovation-level analysis

In this section we shift the level of analysis from the firm to individual innovation projects. We here leave the subject approach and focus on the object approach.

3.1 Data

The data source used for this analysis is the database of Finnish innovations (Sfinno) established and maintained by the Technical Research Center of Finland (VTT). In contrast to the CIS data used above, the Sfinno database contains information on innovations marketed in Finland from 1985 to 1997. We used data on about 802 innovations for which detailed survey data about the nature of the innovation and the process of its generation is available. The concept of the object approach implies that only successful innovations are recorded. This results in a data source where information on unsuccessful innovation projects is excluded by definition.

The detailed information about the innovation and its coming about is gathered by surveying the innovating firm. As in the CIS, companies and, especially, project managers of the innovation projects are asked about the collaboration and their assessment of its relevance in the development of the particular innovation. A detailed description of the information contained in the Sfinno database and its generation can be found in Palmberg et al (1999) and Palmberg et al (2000).

3.2 Results

Within this section we are interested in analyzing the importance of knowledge-intensive services for the development of innovation. We have utilized the innovating companies' project or innovation-based assessment of the relevance of collaboration with universities, research institutes and consulting companies, where we only focus on the companies' high esteem of the collaboration. Table 6 gives the fraction of innovation projects in which collaboration with the given type of partners was regarded as highly important.

Table 6. Relevance of collaboration partners for innovation.

	Universities	Research inst.	Consulting comp.
All companies			
Other Manfacturing	0.627	0.550	0.544
Traditional Sector	0.606	0.652***	0.391**
Traditional Sectors			
Other Traditional Sectors	0.690	0.702	0.467
Forest Cluster	0.565	0.624	0.351

Note: The cells contain the fraction of innovations generated in co-operative projects where the partner was assessed as highly important. Sector classification is according to the sector of the innovating company. The traditional sectors consist of the low-technology manufacturing and the low to medium-technology manufacturing. The forest cluster indicates innovations originating from or being diffused to firms from the NACE classes 20, 21 and 361. The numbers give the fraction of innovation with the respective characteristic. *** (**, *) indicates a significance level of 1% (5%, 10%).

We observe that the valuation of universities does not differ significantly between the whole sample of innovations and innovations introduced by companies from the traditional sectors. Also the assessment of the importance of collaboration with universities does not differ between the sample of innovations from other traditional sectors and the sub-sample of innovations related to the forest cluster.

We find a significantly higher valuation of research institute collaboration for innovations in traditional sectors than for innovations in the high and medium-high-technology manufacturing sectors. At the same time, we do not observe a difference in the valuation between innovation projects in the forest cluster and innovation projects in other traditional sectors. This pattern resembles the pattern of valuation of private research labs in the firm-level analysis. We see no different valuation in the forest cluster than in the average traditional sectors

These observations are largely in line with the findings for universities and research institutes at the firm level, yet the results for the consulting companies require some further consideration. The firm-level data suggests collaboration with consulting services for the innovation activities is highly important. The project-level data suggests a comparatively lower level of importance in the traditional sectors. It also suggests a strong difference in the valuation between the high-technology sectors and the traditional sectors. We find no difference in the valuation within the traditional sectors. The question in the project-related Sfinno survey relates to the development of the innovation. Hence it clearly focuses on the technological development phase of the innovation. The question in the firm-level database relates to the innovation activities in general,

which includes more than just the technological development phase covered by the project-level data; it also includes commercialization, marketing and management in general. The slightly different focus and the differences in the results lead us to deduce a low relevance of consulting services in the technological development of an innovation in the forest cluster. We also suggest the importance of consulting services in commercialization and marketing of innovations, and, most probably, in management.

4. Conclusion

This research investigated the role and the importance of knowledge intensive service activities in the traditional sectors. Knowledge intensive service activities are defined as innovation related service activities delivered from inside or from outside the innovating company. As such, we investigated the interaction between the innovating company and various partners supplying knowledge-intensive services to the innovating firm, such as universities, research institutes, private research facilities (R&D labs, e.g.) and consulting companies. We used both firm-level data and innovation-level data.

Summarizing the findings, we can first state that there are some differences in the pattern of formal collaboration between services and manufacturing firms, as well as between high-technology manufacturing firms and the traditional sectors. Concentrating on innovating companies eliminates some of the differences.

Second, although there are differences in the pattern of formal collaboration, it seems there are virtually no significant differences in the assessment of the importance of the collaboration partners. Some results stand out though. Companies in the forest cluster maintain a valuation of the partners that differs from the assessment of the average company in the traditional sectors.

Third, the analysis of the patterns and valuation of informal collaboration does not reveal any striking differences across the sectors and across types of partners.

Fourth, public funding induces companies to collaborate with a larger spread of types of collaboration partners delivering knowledge-intensive services. It also succeeds in inducing companies to collaborate more intensely.

Fifth, the project-level or innovation-level data by and large confirms the observations from the firm-level data. However, it also suggests that consulting companies are more likely to be involved in the non-technical developmental phases of the innovation process.

Finally, based on the analysis, we can suggest a ranking of the average importance of the formal interaction with the four partners for the traditional manufacturing sectors:

First	Government research institutes
Second	Private research facilities
Third	Consulting companies

Fourth Universities.

A caveat has to be issued here. As the whole analysis is based on observation of the average, and it is based on survey data, we may have averaged away certain aspects that could be relevant for understanding the role of knowledge-intensive service activities in the innovation activities of traditional manufacturing sectors. In this regard, case studies may shed more detailed light on the particular role knowledge-intensive services play in the traditional industries.

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