Fraunhofer Institute Systems and Innovation Research

TIPIK

Technology and Infrastructures Policy in the Knowledge-based Economy

The Impact of the Tendency towards Codification of Knowledge

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Foreword

The present report attempts to synthesise the contribution of the ISI team - in terms of empirical investigations and analyses - to the TIPIK network. In this respect it summarises the efforts devoted to the relationships between generation and use of knowledge, codification, innovation capacities, proximity and socio-territorial contexts. This piece of work is expected to support the formulation of policy implications, which will be the object of the final part of the research project.

The following questions have been addressed by the ISI team and have led the empirical investigations:

- What are the consequences of a growing codification of knowledge on the evolution capacities of European firms and regions?
- In how far are innovation capacities of firms depending on their knowledge base?
- To what extent does proximity influence knowledge exchanges and innovation-related interactions?
- Is knowledge generation and diffusion at regional level depending from specific groups of actors?
- Is it possible to identify and characterise regional specific patterns in terms of knowledge exchanges and innovation capacities?

In order to find answers to these questions, three aspects have been stressed in the ISI work: Particular attention has been paid to two actors, namely knowledge-intensive business services (KIBS) and institutions of the technological infrastructure (ITI). Both kinds of actors provide specific knowledge and therefore innovation support to manufacturing firms. In addition to the focus on these two types of actors and their specific contributions to innovation, the analyses adopt a regional approach. This is based on the assumption that besides national arrangements, innovation patterns are influenced by regional characteristics such as infrastructure, institutions, cultures, network and communications structures and the like. Thus, the empirical parts are based on an innovation survey performed by the Universities of Hanover, Cologne and Freiberg and the Fraunhofer-Institute for Systems and Innovation Research Karlsruhe on behalf of the German Research Association in the period 1995-1997 in different regions. The whole survey covers ten European regions: Alsace, Baden, Barcelona, Gironde, Lower Saxony, Saxony, Stockholm, South Holland, South Wales and Vienna.

The papers presented hereafter, elaborated between 1997 and 2000, constitute an attempt to highlight the questions raised, each of them corresponding to a certain perspective or focusing on a particular aspect and thus trying to give answers to the different dimensions evoqued in the research questions:

(1) "There is no territorial fatality! (or how innovation interactions between KIBS and SMEs may modify the development patterns of peripheral regions)" suggests that the activity of knowledge-intensive business services (KIBS) may particularly benefit regions with no or only little traditional innovation infrastructure.

(2) The paper entitled "The Regional Embeddedness of Small Manufacturing and Service Firms: Regional Networking as Knowledge Source for Innovation?" deals mainly, at the level of the region, with innovation behaviours of firms, knowledge exchanges and the influence of size.

(3) "Knowledge, Innovation Processes and Regions" aims at exploring the complex relations between knowledge exchanges and the introduction of innovation in considering the influence of the regional environment.

(4) The paper entitled "Knowledge-intensive Business Services (KIBS) and Regional Innovation Capacities" examines the links between the activities of knowledge-intensive business services (KIBS), the impact on innovation capacities of small and medium-sized manufacturing firms and the consequences in terms of unequal regional evolution patterns.

(5) The final paper "The Impact of Knowledge Codification on the Evolution Capacities of European Firms and Regions" assumes a close relationship between the way firms deal with knowledge and their evolution capacities. The distinction is made between internal and external knowledge factors and the influence of structural characteristics is investigated.

As a result of exchanges and discussions within the TIPIK team, the four first papers have been presented at conferences such as the 39th European Regional Science Association Congress in Dublin (1999), the conference "Innovation Networks – Concepts and Challenges in the European Perspective" in Karlsruhe (1999), the conference "*L'économie du savoir: enjeux économiques et enjeux de gestion*" in Montreal (2000) and the Six Countries Programme Conference "Services in Innovation" in Utrecht (2000).

Title

There is no territorial fatality! (or how innovation interactions between KIBS and SMEs may modify the development patterns of peripheral regions)

Author(s)

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References

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Introduction

Observing regions, for instance in Europe, one may easily notice inequalities in the resources they devote to innovation activities and in the results they reach in terms of economic success. In this respect, it may be assumed at first glance that a hierarchy of regional environment could be established. Nevertheless, it is advocated in the paper that this does not obligatorily imply a "territorial fatality".

More precisely, the analysis constitutes an attempt to highlight the role of actors who have been insufficiently taken into account by comparison to the ones traditionally examined: large companies, universities and other higher education institutions, technology transfer organisations, regional administrations and other public bodies. The actors on which the paper focuses are: (i) small and medium-sized manufacturing firms (SMEs); and (ii) knowledge-intensive business services (KIBS). In particular the case of SMEs is of interest since SMEs represent the largest proportion of manufacturing firms located in peripheral regions (and in certain peripheral regions, the whole population of manufacturing firms). For similar reasons, it seems relevant to examine also KIBS. The expansion of KIBS reflects the growing importance of their economic activity. Moreover, they are locally available even in regions with no or only little traditional innovation infrastructure. Additionally, the hypothesis is made that potentially the virtuous circle linking the innovation activities of SMEs and KIBS may compensate the impact of less favourable regional environments.

The paper contains two main sections. The first section establishes the theoretical framework of the analysis. At first, the nature of the innovation phenomenon is examined, stressing its interactive character. Then, since some regional environments seem to be more favourable to innovation than others, the question of territorial fatality is addressed. In this respect, the concept of a regional hierarchy featuring the inequality between environments in terms of innovation support is introduced. Finally, two models sketching interactions implying KIBS are discussed: the first arguing that the development of KIBS reinforces the domination of core regions, the second showing a possibility for peripheral regions to escape from territorial fatality thanks to the virtuous circle of innovation linking potentially KIBS and SMEs. The second section examines empirical results. With the help of three distinct statistical treatments, the regional innovation hierarchy is contested. In fact, the empirical evidence establishes that the influence of the type of regional environment is negligible compared to other determinants. Considering that SMEs and KIBS mutually benefit from the virtuous circle associating them, the consequences regarding regional evolution patterns are discussed in the concluding section.

The present paper has been written with support from the German Research Association (Deutsche Forschungsgemeinschaft, Programme "Technological Change and Regional Development in Europe") and from the EU programme TSER (TIPIK project: Technology and Infrastructures Policy in the knowledge-based economy - the Impact of the Tendency towards Codification of Knowledge).

1 Innovation interactions between KIBS and SMEs and the evolution capacity of peripheral regions

This section provides a theoretical framework for the discussion of the potential impact of the growing importance of innovation-related interactions involving KIBS on regional evolution patterns. Firstly, the main features of the innovation phenomenon are shown adopting the views of evolutionary economics. In a second step, the influence of spatial factors on innovation is questioned, which leads to the introduction of the concept of a regional hierarchy, which seems to imply a territorial fatality. Finally, two diverging visions of interactions involving KIBS are considered: the first arguing that a reinforcement of the dominant position of core regions seems inevitable, the second allowing to potentially refute the territorial fatality.

1.1 Innovation interactions as an expression of firms' evolutionary capacities

The *neo-schumpeterian* or evolutionary approach of economics has profoundly modified the understanding of innovation phenomenon. As a synthesis, it can be assumed, that, from an evolutionary perspective, innovation is interpreted as **a non maximising, interactive, cumulative, specific and institutionalised process** (*cf.* AMENDOLA and GAFFARD,1988; and LARUE DE TOURNEMINE, 1991).

Firstly, evolutionary economics attribute a cumulative and interactive character to innovation processes. The importance of accumulation and interaction appears especially when analysing learning effects, for instance of "learning by doing" (ARROW, 1962), or "learning by using" (ROSENBERG, 1976) and of "learning by interacting" (LUNDVALL, 1988). Secondly, in the evolutionary approach, innovation reveals a specific character. The specifics of innovation abide by the principle of historical trajectories and paradigms (DOSI, 1982) and integrate the conception of the tacit nature of acquired knowledge. This leads to the idea of a programmed character of innovation in the behaviour of the firm (CLARK, 1986). Finally, innovation has an institutionalised character. The institutionalisation features mainly the role played by the selection environment of innovation (NELSON and WINTER 1974, 1975, 1977) and the importance of R&D departments (FREEMAN, 1982). As a consequence, **"innovation is a process"**, innovation-related knowledge is not *a priori* available, thus innovation constitutes a process, an action which is performed and diffused simultaneously **which is**: (i) **"non maximising":** due to the bounded rationality hypothesis, routines and heuristic behaviours are substituted to optimisation procedures; (ii) **"interactive"**: the notion of interaction allows the suppression of the apparent contradiction and for the link between the "demand pull" and "science push" approaches to be made; (iii) **"cumulative":** innovation appears as a dynamic phenomenon which results partly from cumulative processes like learn effects; (iv) **"specific"**: innovation-related knowledge and technology are not "manna from heaven" and innovation is perceived as a problem-solving activity; **and** (v) **"institutionalised":** the institutional dimension of innovation covers the role played by R&D (*i.e.* the institutionalisation of problem-solving activities) and the influence of innovation selection environments.

With regards to the focus of the paper on the relations between SMEs and KIBS and on their meaning for regional innovation potential, two additional remarks should be considered about the nature of innovation. Firstly, it is particularly important to underline that innovations take place in manufacturing firms as well as in service firms. This remark is necessary since innovation in services is often neglected by analysis which prefer to concentrate on manufacturing firms and manufactured artefacts (on this point, *cf.* GADREY *et al.*, 1993). The second remark deals with the meaning of the innovation phenomenon. One may easily observe the huge diversity of innovation in manufacturing and services in terms of forms, genesis and consequences. For an overview of this diversity, one may for instance consider the typologies of innovating firms provided respectively by PAVITT (1984) for the manufacturing sector and by HIPP (1999) for the service sector. Nevertheless, beyond this apparent diversity, a conceptual unity of innovation can be established from the evolutionary perspective. In fact, innovation is a phenomenon by which firms try to evolve in order to survive and expand, which means in economic terms to reach a reinforced competitiveness. This specific feature of the innovation phenomenon is of particular significance, notably for analysing changes affecting regions.

1.2 Firms innovation and regional hierarchy

As has been shown, the innovation phenomenon may be interpreted as a process based on knowledge development and exchanges. Knowledge flows are immaterial: one may refer for instance to KRUGMAN (1991, pp. 53-54) asserting that : "*Knowledge flows* (...) *are invisible; they leave no paper trail by which they may be measured and tracked, and there is nothing to prevent the theorist from assuming anything about them that he likes*"[1]. However, this does not necessarily imply that space is neutral in terms of innovation. On the contrary, arguments may be developed along three main dimensions showing that "space matters for innovation": proximity, systems and environment.

A first dimension introducing the influence of space on innovations relies on the **question of proximity, accessibility of information and learning**. This questioning deals primarily with knowledge spillovers. In this respect, ANSELIN, VARGA and ACS (1997), by establishing an empirical demonstration based on geographic spillovers taking the form of concentric rings, claim they have proved that "(...) *the positive and significant relationship between university research and innovative activity, both directly, as well as indirectly through its impact on private sector R&D.* (...) *the spillovers of university research on innovation extended over a range of 75 miles from the innovating MSA*[2]*, and over a range of 50 miles with respect to*

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1 This assertion is neverthelss discussed by authors focusing on knowledge codified in the form of patents pretend, who consider in opposition to KRUGMAN (1991) that knowledge flows do sometimes leave a "paper trail" (*cf.* JAFFE, TRAJTENBERG and HENDERSON, 1993).

2 MSA: Metropolitan Statistical Area.

private R&D" (ANSELIN, VARGA and ACS, 1997, p. 11). This can be interpreted for the present purpose as a first indication of a regional inequality in terms of innovation capacities.

The second dimension stressing divergences between territorial units consist of the systemic approach of innovation phenomena. In fact, this approach considers the **role and impact of innovation systems**, distinguishing mainly two levels: the national and the regional one. Systems may be defined in this respect as "*complexes of elements or components, which mutually condition and constrain one another, so that the whole complex works together, with some reasonably clearly defined overall function*" (EDQUIST, 1997, p. 13). In the continuation of FREEMAN (1987) and LUNDVALL (1988 & 1992) abundant literature can be found related to national innovation systems (NIS). The regional innovation system (RIS) approach (*cf.* COOKE *et al.* 1996; COOKE 1998) encompasses the concepts of "industrial district", "innovative milieu" and "regional learning" to the greatest extent. It allows a summary of the arguments in favour of an influence of the regional environment on firms' innovation capacities[3]. RIS can be perceived as a transposition of NIS at the regional level. From both regional and national perspectives, the system of innovation is constituted by elements and relationships interacting in the production, diffusion and use of new knowledge. Thus, it provides a set of arguments highlighting why and how certain regions (and *a fortiori* some countries) are more innovative than others.

The third dimension, which is interrelated with the two first dimensions discussed (i.e. proximity in knowledge interactions and differences between systems), consists of the **regional environment** surrounding a firm and potentially influencing its innovation capacities. The innovation environment encompasses and goes beyond the sole selection environment sketched in evolutionary economics [4]. In fact, referring to the view provided by CAMAGNI (1991), three "spaces" in which firms evolve may be identified[5]: (i) the "synergy space" or milieu (*i.e.* the environment of the firm); (ii) the "competition space" (*i.e.* the market); and (iii) the "co-operation space" (*i.e.* the networks in which the firm is involved). In a similar way, JULIEN (1996) stresses the importance of small firms' integration capacity within their environment. This integration favours shared learning effects, which in turn accelerate the development of an entrepreneurial spirit in facilitating risky decision-making for instance: "(...) *the stronger a small firm links with a dynamic environment, the more innovative it will be, and the greater its stimulating effect on the environment, through a double loop effect*" (JULIEN, 1996, p. 13). In this respect, an important aspect related to the influence of the regional environment relies on the "endowment" in terms of **Institutions of Technological Infrastructure (ITI)**. Apart from their legal identity such institutions can be defined, according to KOSCHATZKY and HÉRAUD (1996), as entities: (i) located in a specified territory; (ii) having

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3 An alternative perception, which can be found in the literature but not retained here, should be briefly evoked. In fact, it is possible to define a region from an economic perspective, for instance with the help of the approach in terms of clusters (in the sense of industrial clusters given by PORTER, 1990). From this point of view, the industrial cluster may be seen as the sum of all the economic actors contributing directly to the dominant production process of the considered region.

4 As shown for instance by NELSON and WINTER (1974, pp. 891-894).

5 Apart from what CAMAGNI (1991) designates as the "organisation space" (*i.e.* the firm itself).

a potential technological impact within this territory; and (iii) whose activities provide the input for research and innovation of firms[6]. Since ITI can be considered as constituting elements of the regional environment, uneven quantitative and qualitative endowments in terms of ITI imply inequities in the way innovating firms benefit from their regional environment.

Assuming that the impact of the innovation environment of a firm overlaps: (i) the effects of proximity with other actors involved in the innovation process; and (ii) the influences of the innovation system(s) from which the firm depends, one may try to synthesise the three dimensions. In fact, this leads to the consideration of **a hierarchy of firms' regional location in terms of innovation capacities**. To a certain extent, such a hierarchy seems coherent with the views expressed by the new growth theory (*cf.* in this respect ROMER, 1990; and BARRO and SALA-I-MARTIN, 1995) since it corresponds to a vision in which endogenous knowledge development leading to innovation) is more accurate in core regions than in peripheral ones. Schematically, it can be asserted in this approach that a regional hierarchy in terms of innovation environment implies that firms located in core regions mainly outperform the ones located in intermediate regions, which broadly benefit from better opportunities than the ones belonging to the "periphery"[7]. Consequently, the terms of "territorial fatality" can be evoked to outline a situation in which peripheral regions seem to be forced to lag behind in terms of knowledge exchanges and development. Nevertheless, the goal of the paper is to refute this fatality in arguing that the "regional hierarchy" may be compensated for, at least potentially, by the virtuous innovation circle linking SMEs and KIBS shown in the next section.

1.3 Two visions of the way KIBS may affect regional evolution capacities

This section examines two visions of interactions involving KIBS and their possible consequences in terms of regional evolution capacities. The objective here is not to set these two visions against each other but to understand how the expansion of business consultancy could exert a crucial influence on the development of the innovation capacities of firms located in different regional environments.

According to the first vision, proposed in WOOD (1998), the expansion of KIBS leads to a reinforcement of the domination of the core. The model developed (*cf.* figure 1) features interactions involving KIBS and their clients on different spatial levels. This approach pays particular attention to large enterprises both in consultancy and manufacturing sectors as well

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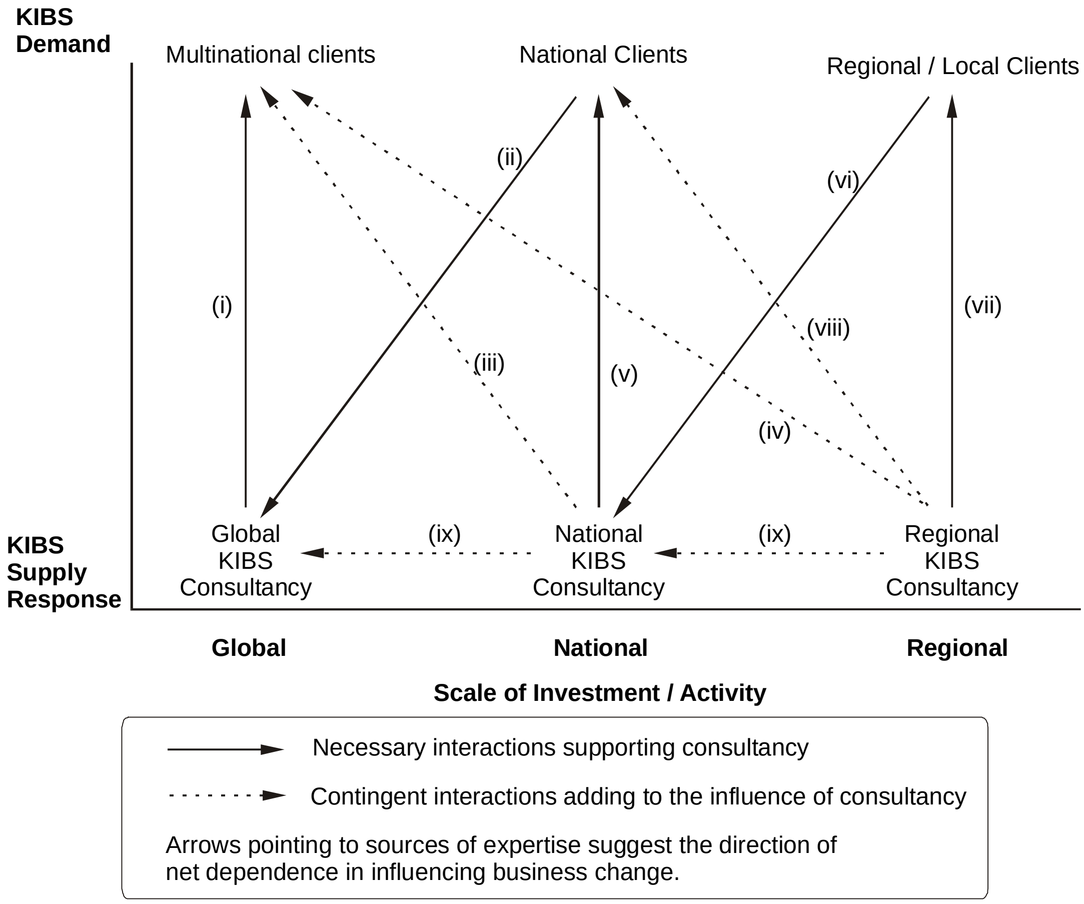
6 The original development of the concept of ITI, as well as reflections on the possible measurement of their activities on a territorial level, have been performed in the frame of the Upper Rhine Valley (*i.e. Alsace* and *Baden*) which constitutes the area of empirical investigation of the present analysis (*cf.* KOSCHATZKY and HÉRAUD, 1996). Additionally, HÉRAUD and MULLER (1998) provide, for the same geographical area, a complementary analysis focusing on certain categories of French and German ITI.

7 This basic categorisation presents the advantage of being easily compatible with most national classification of regions for instance on NUTS III level.

as to the role of international and national-scaled interactions. In this perspective, the growing role of KIBS appears to be an opportunity for core regions (in particular big metropolis) and a threat for peripheral regions. Basically, KIBS bring knowledge and practice to bear on client activities which their own staff do not possess or would otherwise not be able to implement. In this respect, the model sketches a circulation of knowledge flows but since access to the different stages is not equal everywhere, the knowledge flows generate a reinforcement of regional inequalities. This could be compared to a kind of bottom-up effect "sucking up" the knowledge developed along the multiple clients-KIBS relations at the different levels of interaction. To summarise, it can be concluded that WOOD's model: (i) stresses the growing importance of consulting on innovation; (ii) highlights that the impact of KIBS on the different spatial levels is highly dependent on specific relationships with their clients; and (iii) implies as a consequence an increased regional inequality in both access and expansion of innovation-related knowledge.

Figure 1: KIBS demand and supply response from a spatial perspective



(i) Global consultancies respond primarily to the requirements of multinational clients and agencies.
(ii) Global consultancies increasingly act as conduits of innovative ideas and methodologies between the global and national scales.
(iii) Successful medium-small nationally-based consultancies may develop internationalisation strategies by serving multinational clients seeking specialist expertise or familiarity with home country conditions.
(iv) Successful regionally-based consultancies may also work for multinational clients operating in their regions on a similar basis to (iii), although their growth more often depends on serving national clients (viii).
(v) Nationally-based consultancies, serving private and government clients within that market, provide the predominant volume of consultancy exchanges across a wide variety of expertise.
(vi) Within national systems of consultancy-client interaction, regionally-based clients seeking consultancy support often depend on nationally-based consultancies.
(vii) Regionally-based consultancies originate largely to serve regional clients, and adapt to these needs on the basis of local exchange and innovativeness.
(viii) Successful regionally-based consultancies most often grow by serving national or even international (iv) clients on the basis of specialist skills or knowledge of local conditions.
(ix) Contingent links may exist between international, national and regionally-based consultancies, either directly through subcontracting or networking relationships, or indirectly as a result of client tendering policy.

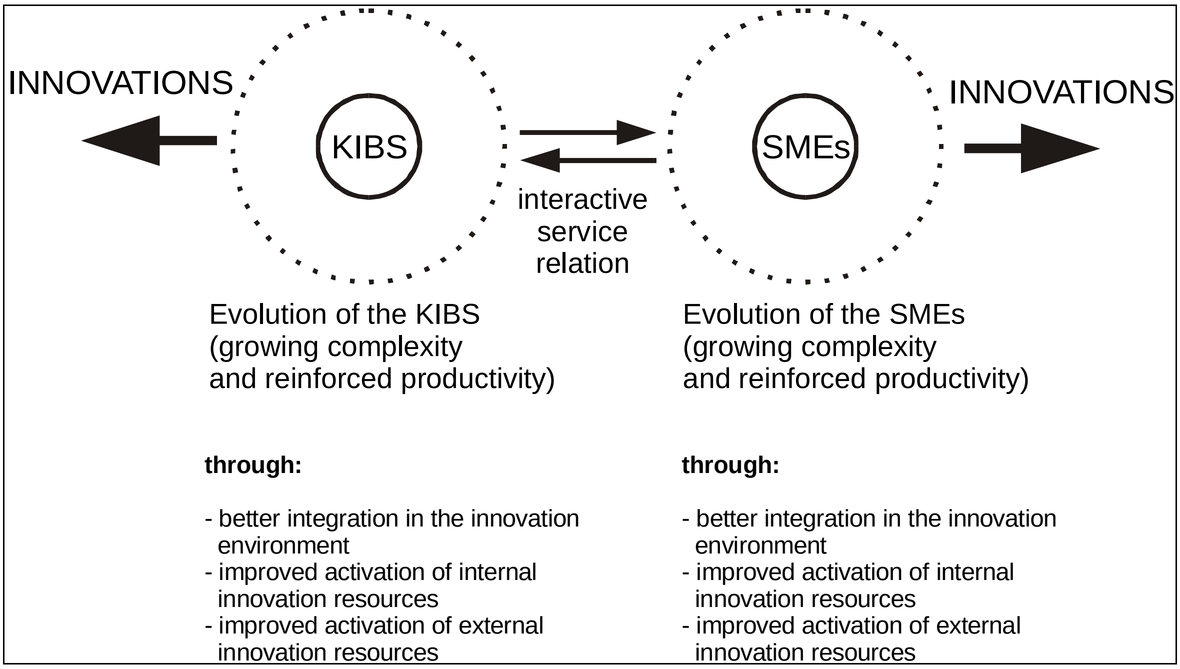
Adapted from W*OOD* *(1998, pp. 13-14, 21)*

The second vision of interactions involving KIBS consists of the virtuous circle linking the innovation capacities of KIBS and SMEs as shown in MULLER (1999). In this approach the interactive service relation linking KIBS to their manufacturing clients plays a central role. As has been shown notably by GALLOUJ (1994) business consultancy firms may assume a role of co-innovator for their clients. In turn, SMEs support the development of the knowledge base of KIBS. As CALLON, LARÉDO and RABEHARISOA (1997, p. 34) assert: "*the service* [relation] *creates a complex system of relationships between supply and demand: the conception of the service and its realisation cannot be divided and mobilises at the same time the producer and the consumer who co-operate closely*"[8]. Considered as a whole this mutual contribution constitutes a virtuous circle in which KIBS and SMEs may respectively benefit from their interactions through: (i) a better integration in their respective innovation environments; (ii) an improved activation of their internal innovation resources; and (iii) an improved activation of their external innovation resources (*cf.* figure 2). To summarise, "*it can be argued that **interacting KIBS and SMEs mutually contribute to their respective innovation capacities, in a similar but not identical way**. This mutual contribution is based on a "core sequence" which can be approximated with three "sub-sequences": (i) the interaction itself; (ii) the resulting knowledge base expansion; and (iii) the ensuing evolution of the firm. These three constituents of the whole phenomenon should not be seen in a linear perspective but as potentially inter-linked in a "knowledge-based loop" thanks to feed-back effects*." (MULLER 1999, p. 144).

The question to be answered is to what extent could the virtuous circle play a particular role for the development of peripheral regions? In fact, it appears that peripheral regions present a singularity: in relative terms, the proportion of SMEs in manufacturing and the share of small (not-national or international-oriented) business services is usually higher than in core and intermediate regions. This may be seen as a weakness (in addition to other factors hindering peripheral regions). Nevertheless, without contesting the validity of WOOD's model as a whole, this singularity may also constitute an opportunity for peripheral regions if one considers the mutual benefits SMEs and KIBS can gain from the virtuous circle shown as an alternative to WOOD's model.

8 "*Le service (...) crée un système complexe de relations entre offre et demande: la conception de la prestation et sa réalisation ne peuvent être séparées et mobilisent à la fois le producteur et le consommateur qui coopèrent étroitement*" (CALLON, LARÉDO and RABEHARISOA, 1997, p. 34).

Figure 2: The mutual contribution of KIBS and SMEs to their innovation capacity



Adapted from MULLER (1999, pp. 48 and 55)

The objective of this paper is not to contrast the two models of interaction with KIBS: they may co-exist in the sense that they describe phenomena occurring parallel or simultaneously at different levels. It is important to underline that **KIBS represent more for SMEs than just a simple information source**. As underlined by STRAMBACH (1998, p. 4): "*The purchase of knowledge-intensive services is not the same as the purchase of a standardised product or service. The exchange of knowledge products is associated with uncertainties and information asymmetries stemming from the special features of knowledge* (...)". The analysis discussed hereafter explores how peripheral region may increase their evolution capacities and in this respect, the empirical investigation provides some evidence of the mutual benefit of interaction for SMEs and KIBS, particularly in the context of a peripheral region. It is assumed that thanks to the virtuous circle, the regional environment hierarchy does not necessarily constitute a fatality.

2 Some empirical evidence

The empirical evidence contesting the fatality of the regional innovation hierarchy will be established with the help of three distinct steps, corresponding to three different statistical methods. In the first step, comparative charts will reveal that in the case regions the hierarchy cannot be established for SMEs and KIBS with regards to basic indicators of firms evolution capacities. The next step, consisting of multiple correspondence analysis, aims at detailing for SMEs and KIBS the variables affecting their behaviour in terms of evolution and at characterising it in terms of regional location. The final step, called "path modelling", is based on the successive combination of PROBIT analysis. With the help of this "path modelling" it can be established that, on the one hand, SMEs and KIBS mutually benefit from the virtuous circle associating them and that, on the other hand, the influence of the type of regional environment is negligible in comparison with other determinants.

The data used for the analysis were collected using a postal inquiry (in the respective national languages) in Alsace and Baden[9] which led to the constitution of two distinct samples: one encompassing SMEs (n=726), the other consisting of KIBS (n=486)[10]. Considering the location of research, communication and transportation infrastructures, three types of innovation-related regional environment can be delimited corresponding to administrative units: (i) core: Bas-Rhin and Mittlerer Oberrhein; (ii) intermediate: Haut-Rhin and Südlicher Oberrhein; and (iii) peripheral: Schwarzwald-Baar-Heuberg (*cf.* figure 3).

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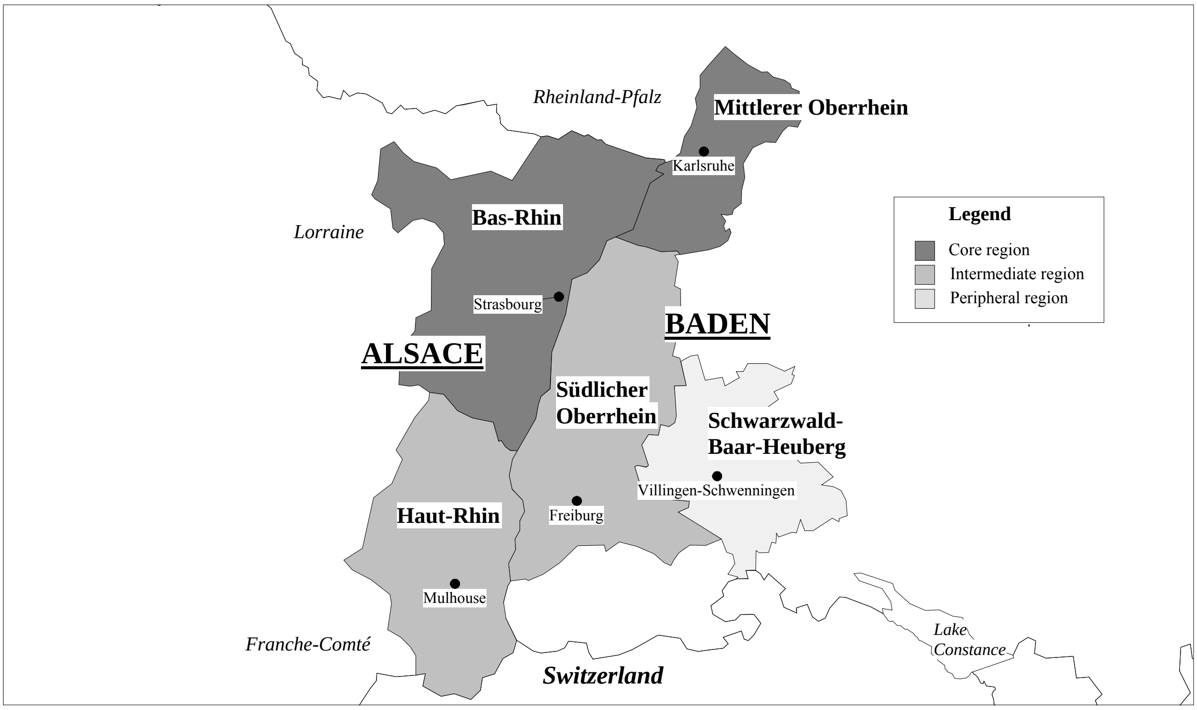
9 The data collection took the form of a postal survey, performed in 1995-1996 asking firm representatives to consider activities related to innovation, interaction and general business for the time period 1992-1995. This operation took place in the frame of a broader project entitled "Technological Change and Regional Development in Europe", granted by the *Deutsche Forschungsgemeinschaft* (DFG, the German Research Association). This joint research project conjointly involved three research teams: the Department of Economic Geography at the University of Hannover, the Faculty of Economics and Business Administration of the Technical University Bergakademie Freiberg and the Fraunhofer Institute for Systems and Innovation Research (FhG ISI) in Karlsruhe. A recent special issue of the review Raumordnung und Raumforschung (RuR 4, 1998) presents different aspects of the methodology and of the results of the overall project.

10 The constitution of the samples are detailed in appendix 1 and 2.

Figure 3: The surveyed regions



2.1 Comparative charts

The following charts show the frequencies of basic characteristics featuring innovation behaviour of firms in distinguishing the type of regional environment in which the firms are located. Three basic variables are retained: (i) the introduction of innovations by the firm during the considered 3-years period; (ii) the research and development (R&D) intensity (*i.e.* the level of expenses in proportion of the annual sales, which can be interpreted as an indicator of the activation of internal innovation resources); and (iii) the existence of interactions between SMEs and KIBS (which can be interpreted as an indicator of the activation of external innovation resources). The charts are drawn respectively for SMEs (*cf.* figure 4) and for KIBS (*cf.* figure 5).

Considering the propensity of SMEs and KIBS to introduce innovation, no significant bias in favour of core regions can be observed. On the contrary, in the case of SMEs, the proportion of innovating firms is higher in the "periphery" than in the "core" (69,4% *vs.* 63,3%). In the same way, no significant differences can be observed between "peripheral'" and "core" KIBS (73,5% *vs.* 74,8% of innovating firms).

The examination of the level of R&D according to firms' location reveals that firms located in the "periphery" clearly overstep their counterparts in the "core". This difference in the propensity to realise a high level of R&D investment can be established for SMEs (11,9% in the "core" *vs.* 14,9% in the "periphery") and for KIBS (26,1 % *vs.* 32,4%).

The third set of charts, depicting innovation-related interactions (respectively with KIBS in the case of SMEs and with SMEs in the case of KIBS), displays similar results. In fact, the proportion of interacting firms is lower in the "core" (SMEs: 63,1% ; KIBS 58,3%) than in the "periphery" (SMEs: 76,9% ; KIBS 66,2%).

To summarise, the comparative charts provide no evidence of a regional hierarchy of environments related to innovation. On the contrary, at least for the examined samples and case regions, SMEs and KIBS seem to adapt themselves successfully to environments supposed to be less favourable for innovation activities. Additionally, the similarity between SMEs and KIBS in terms of results support the hypothesis of a link between the two types of firms

Figure 4: The SME sample

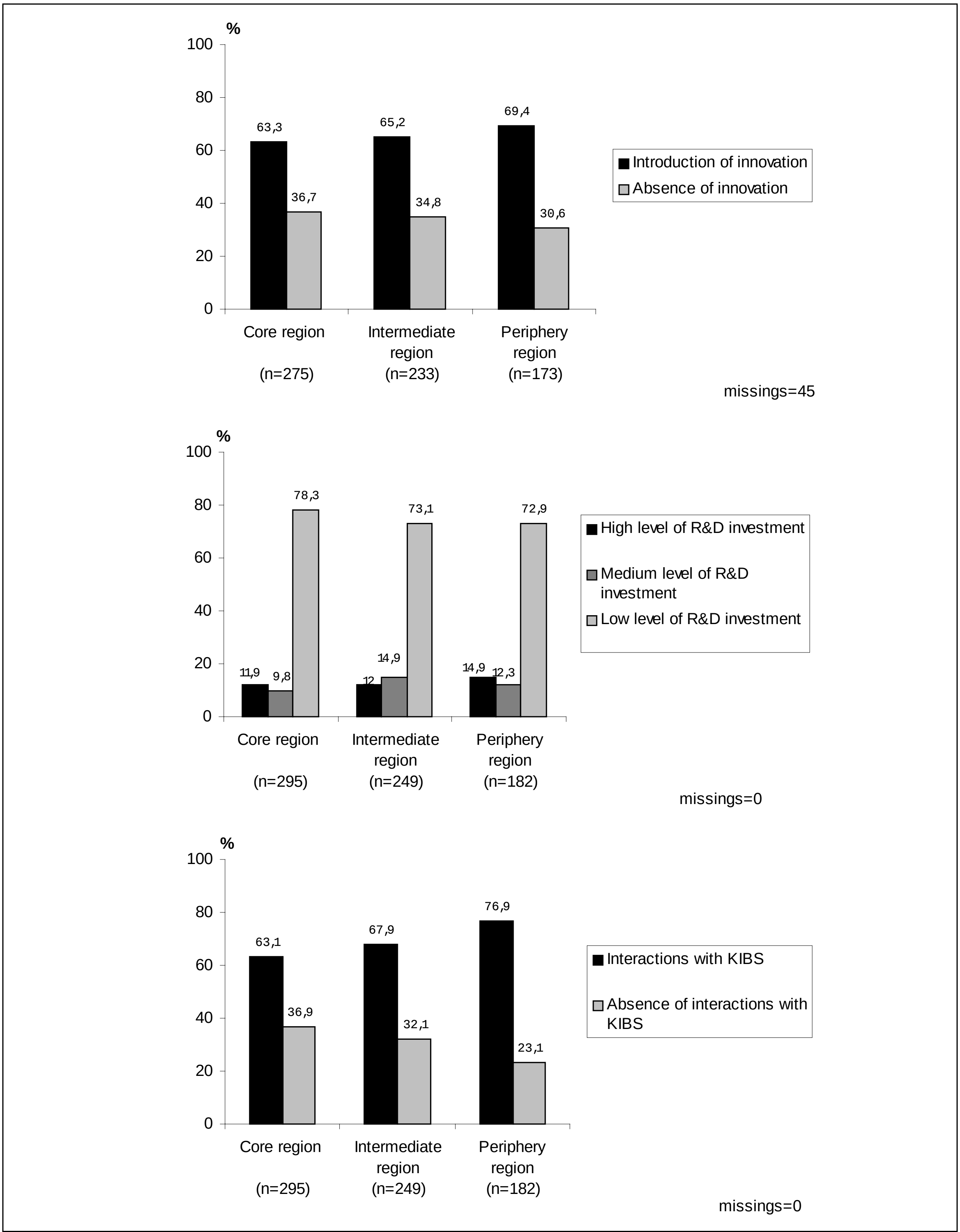
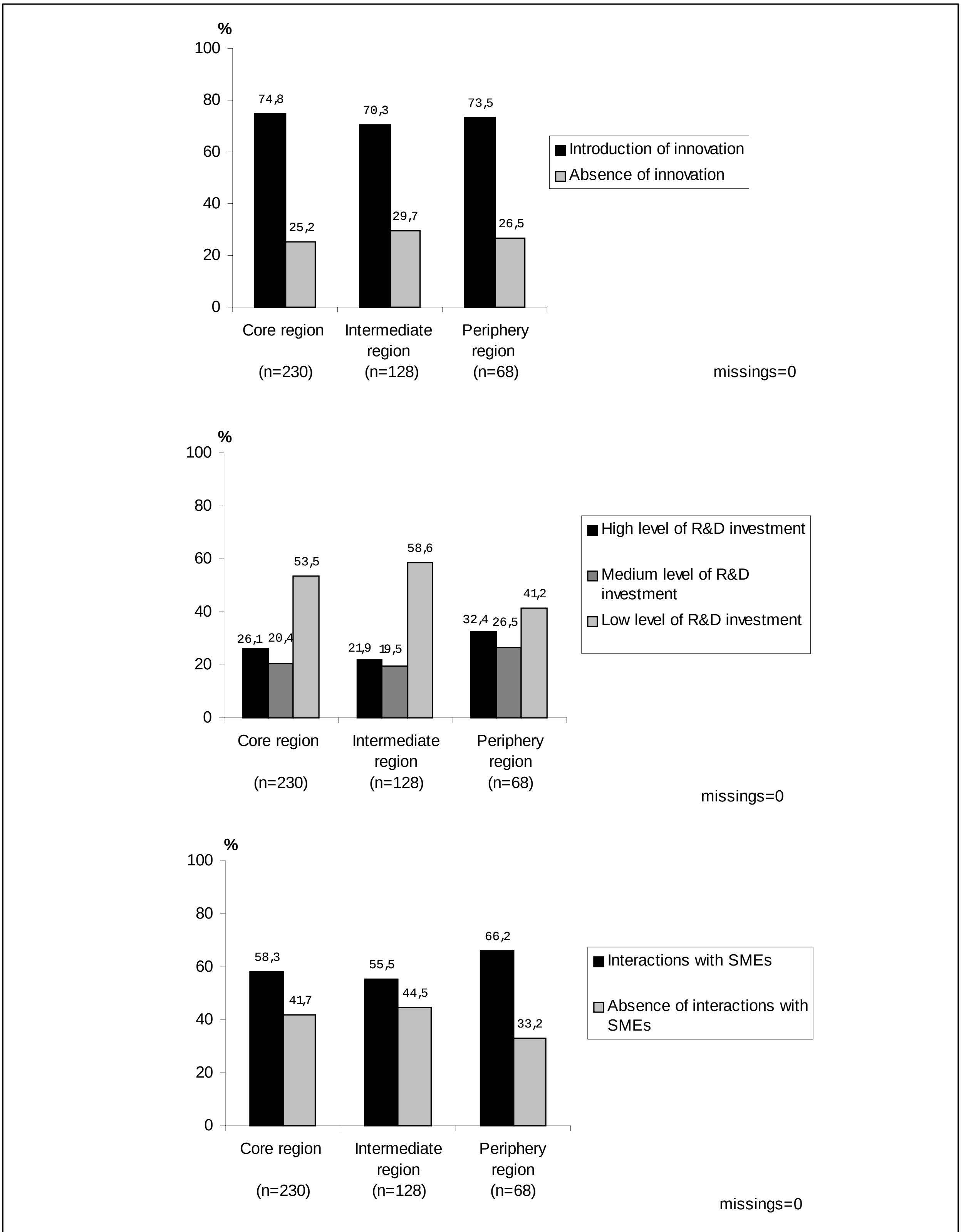


Figure 5: The KIBS sample



2.2 Multiple correspondence analysis

The analysis of the multiple correspondences within a set of variables constitutes an interesting tool allowing relations which could otherwise not be detected to be highlighted. The development of correspondence analysis derives mainly from the pioneer work performed in the 60's by J. P. BENZÉCRI[11]. Originally, such procedures were limited to the analysis of contingency tables (crosstabs of two nominal characters). Meantime, correspondence analysis has been extended (at least theoretically) to an unlimited number of characters. Thanks to their mathematical properties and due to their richness in terms of interpretation potentialities, correspondence analysis constitute a powerful tool for exploiting qualitative data. All variables in a multiple correspondence analysis (also called homogeneity analysis) are inspected for their categorial information only. That is, the only consideration is the fact that some objects are in the same category while others are not. One important advantage (due to the presence of qualitative or categorised variables only) is the possibility of considering non-linear relations between variables.

[11] See for instance BENZÉCRI (1992) for a detailed presentation and overview of the possibilities in this field.

Figure 6: Multiple correspondence analysis of the SME sample

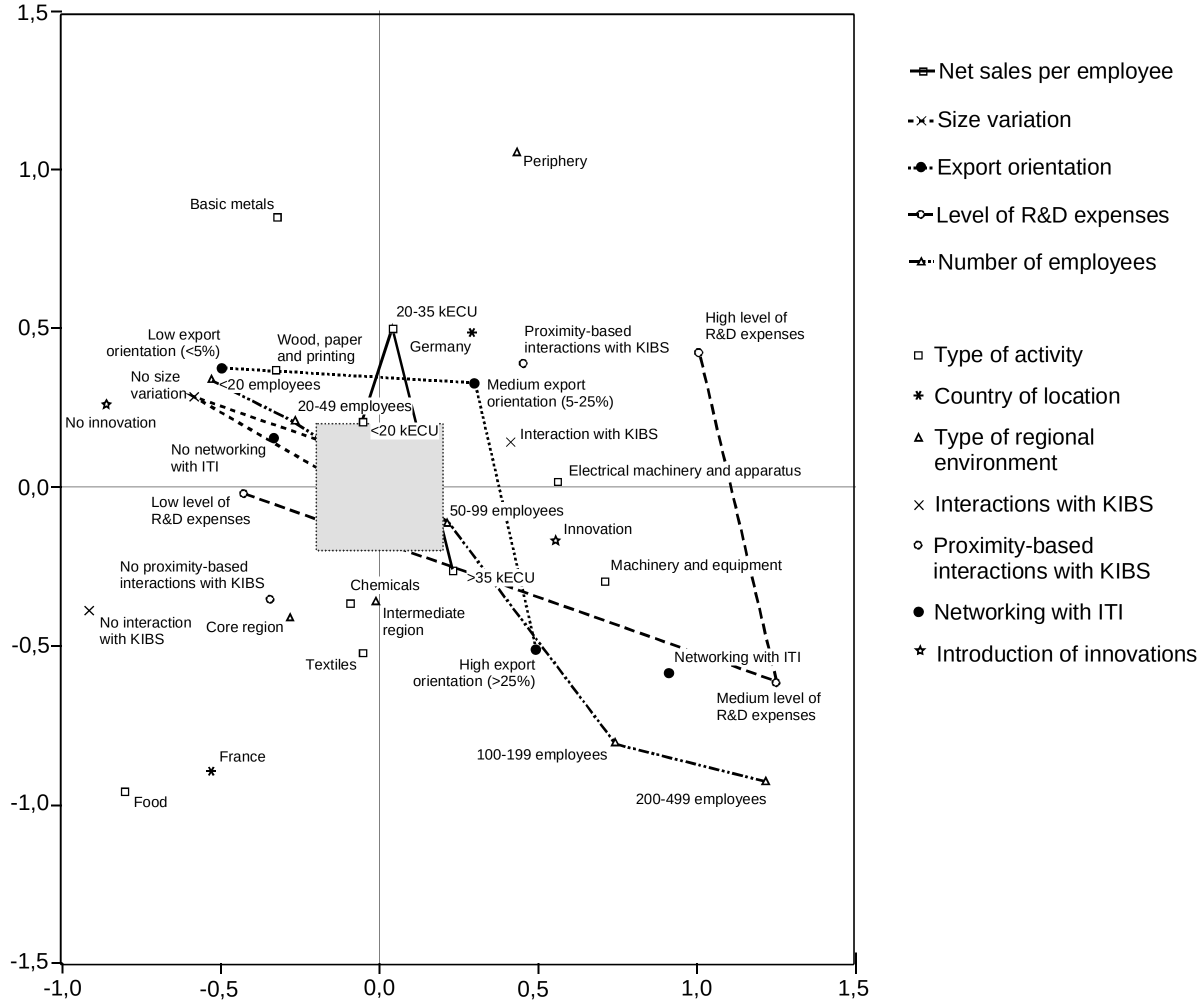
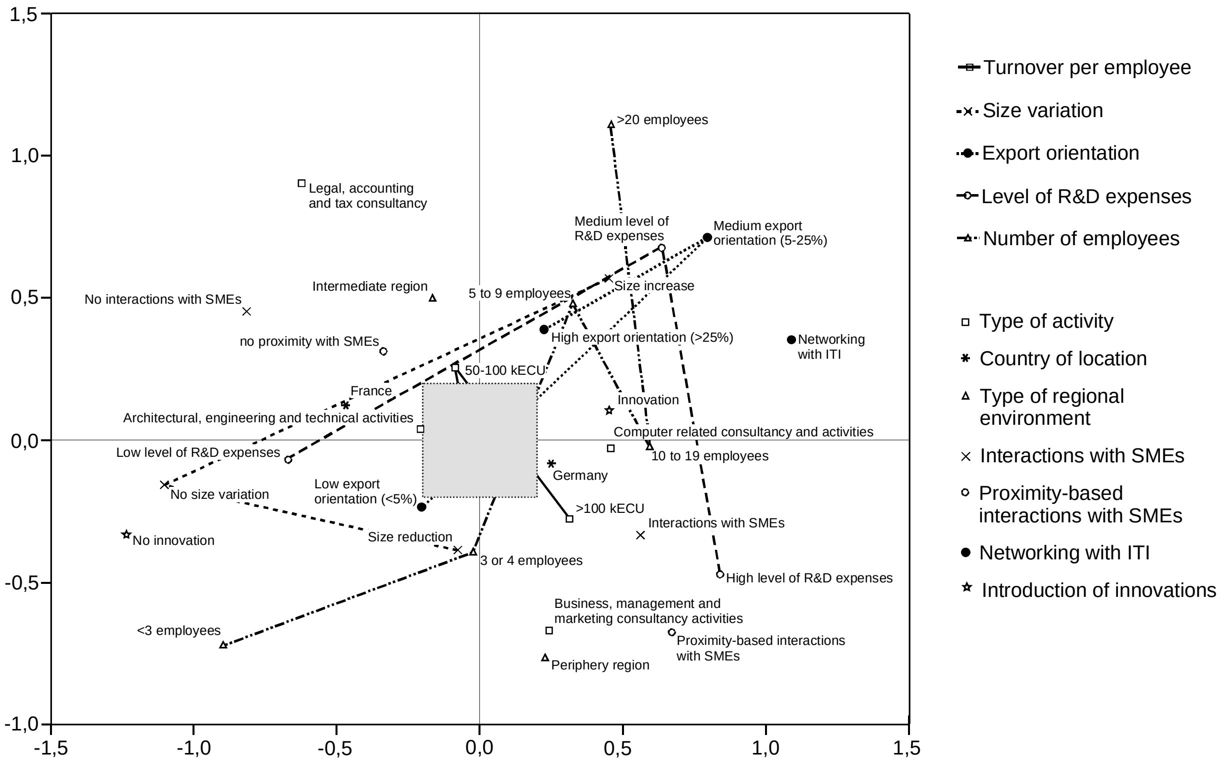


Figure 6 draws the multiple correspondence analysis performed on the SME sample with the help of 12 variables[12]. Basically, the first dimension may be seen as opposing the firms which are R&D-intensive, innovative, interacting with KIBS, relatively bigger and networking with ITI (eastern part of the graph) to their less R&D-intensive, non innovative, non interactive, relatively smaller and non networking counterparts (western part of the graph). In the same way, the country of location, the type of regional environment and the sector of activity constitute the variables which contribute the most to the constitution of the second dimension of the graph. This dimension distinguishes firms located in the "periphery" (northern part of the graph) to firms situated in core and intermediate regions (southern part of the graph). In fact, the analysis quite strongly contrasts two types of behaviour: innovating and interacting *vs.* non-innovating and non-interacting firms (and thus reveals the role potentially played by interactions with KIBS). However, if a clear opposition can be observed related to the country of location which reflects divergent behaviours, notably concerning interactions with KIBS

12 The variables are exposed in appendix 3, the discrimination measures of the multiple correspondence analysis performed on the SME sample are detailed in appendix 4.

(German SMEs are more innovative and interact more with KIBS than their French counterparts) no clear divergence can be observed related to the type of regional environment. In other words, it is not possible, considering the multiple correspondence analysis of the SME sample, to establish any evidence of a regional hierarchy of innovation environments.

Figure 7: Multiple correspondence analysis of the KIBS sample



Examining the multiple correspondence analysis performed on the KIBS sample (*cf.* figure 7) and referring to the most important contributors[13], it can be assumed that the first axis contrasts basically innovating, more R&D intensive and interacting KIBS (eastern part of the graph) with service firms which mostly did not introduce innovations or did not perform R&D and which were not or were less in contact with SMEs (western part of the graph). The constitution of the second dimension is based primarily on the size and sector of the considered firms as well as on the existence of proximity-based interactions with SMEs. As a consequence, the graph may be seen as opposing its northern part (characterised by bigger firms, no or only limited interactions with SMEs on a proximity base and typically being active as legal, accounting or tax consultants) to its southern part (constituted by smaller KIBS, typically doing business, management or marketing consultancy and characterised by a higher propensity to interact with SMEs on a proximity base). As was the case for the SME sample, no indication of an influence of the type of regional environment can be detected on the basis of the results of the multiple correspondence analysis of the KIBS sample.

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13 The discrimination measures of the multiple correspondence analysis performed on the KIBS sample are detailed in appendix 5.

2.3 Path modelling

The methodology of path modelling has been developed specifically for the detection and investigation of influences between variables sets (*cf.* MULLER, 1999, pp. 98-101). The path-modelling procedure is based on the successive performance of PROBIT algorithms. PROBIT algorithms estimate maximum-likelihood model in order to detect dependencies associating a dependent variable to explanatory (or independent) variables. The general form of the model to be estimated is:

$$\mathbf{Pr\ [E = 1] = \Phi[\beta_0 + \beta_1 A + \beta_2 B + ... + \beta_n X]}$$

with Φ being the cumulative normal distribution, E (dichotomic variable) the dependent variable, A, B and X being the explanatory variables. β_0 is the constant, β_1, β_2 and β_n are the coefficients of the independent variables in the equation. The path-model is obtained by placing selected variables (according to the conceptual model developed) alternatively in the role: (i) of dependent variable in respect to some variables; or (ii) of independent variable in comparison to others. Since the application of PROBIT requires *dichotomic dependent variables* it is necessary to binarise the variables of the analysis. This can be done in a relevant way on the basis of the previous analytical steps, especially in exploiting the results of the multiple correspondence analysis. The set of "paths" resulting from the procedure can be interpreted as a "picture" of the interrelations between the variables. Variables can at the same time be explanatory (or independent) and dependent, depending on their relative position. As a consequence the identification of significant dependencies allows the interpretation of the revealed "paths" in terms of causality effects, and to distinguish between direct and indirect dependencies. In the present case, path modelling is used to test interrelations between the variables allocated to three sets enabling the depiction of the characteristics of the examined firms;: (i) the determinants set encompassing the structural and environmental determinants potentially affecting innovation-related behaviours of the firm; (ii) the knowledge set featuring how innovation resources are exploited; and (iii) the evolution set pointing out the effects of the two previous sets on a firm's activities and results (*cf.* MULLER, 1999, pp. 78-79).

The first path diagram allows a synthetic view of the elements significantly determining the evolution mechanisms of the SMEs examined (*cf.* figure 8 and appendix 6). In fact, it appears that the performance of innovation is directly and strongly influenced by most of the variables of the "knowledge set": (i) by the level of R&D expenses; (ii) by the existence of interactions with KIBS; and (iii) by networking with ITI. Additionally, the influence exerted by the variables belonging to the "determinants set" on knowledge and evolution variables give some indication concerning their "relative weights": the size and the sector of a firm appear to have the most influence. The size factor in particular plays a role in influencing the variables in the "knowledge set". Finally, considering territorial determinants, the variable "country of location" discloses no significant influence related to the evolution capacities of the considered SMEs, but indicates strongly that national systems matter in terms of their propensity to interact with KIBS (either on a proximity basis or not) as well as in terms of R&D intensity. Nevertheless, and this constitutes a decisive element regarding the issue considered, the variable "type of regional environment" does not point to any significant influence on other variables.

In this respect, the type of regional environment surrounding a SME seems neither to induce particular behaviours nor to generate specific consequences in terms of firm evolution. This suggests that, at least for the samples and territorial units considered, the idea of a regional hierarchy of innovation environments has no relevance.

Considering the results of the PROBIT analyses dealing with the KIBS sample and the ensuing path modelling (*cf.* figure 9 and appendix 7), the following key findings can be advanced. Firstly, the variables constituting the "evolution set" of the model are influenced by knowledge-base related variables as well as by variables corresponding to structural determinants (*i.e.* the size of the firm and its sector of activity). Secondly, the variable "introduction of innovations" shows an even more complex structure in terms of influences. In fact, it is affected by: (i) internal resources (the level of R&D expenditures); (ii) by external factors (networking with ITI and proximity-based interactions with SMEs); and (iii) by the size of the firm (the propensity to innovate increases with the size). Finally, considering structural and locational variables, it appears that the size of the firm and the sector of activity rather have an impact on variables from the "evolution set" than on the ones related to the knowledge base aspects. On the contrary, the country of location only influences the last category of variables (*i.e.* the R&D intensity and the contacts with KIBS) whereas the type of regional environment does not significantly affect any other variable. At least for the considered KIBS sample and in parallel to what has been assumed for the SME sample, this pleads against the idea of a regional hierarchy in terms of innovation environment.

Figure 8: Path modelling: the SME sample

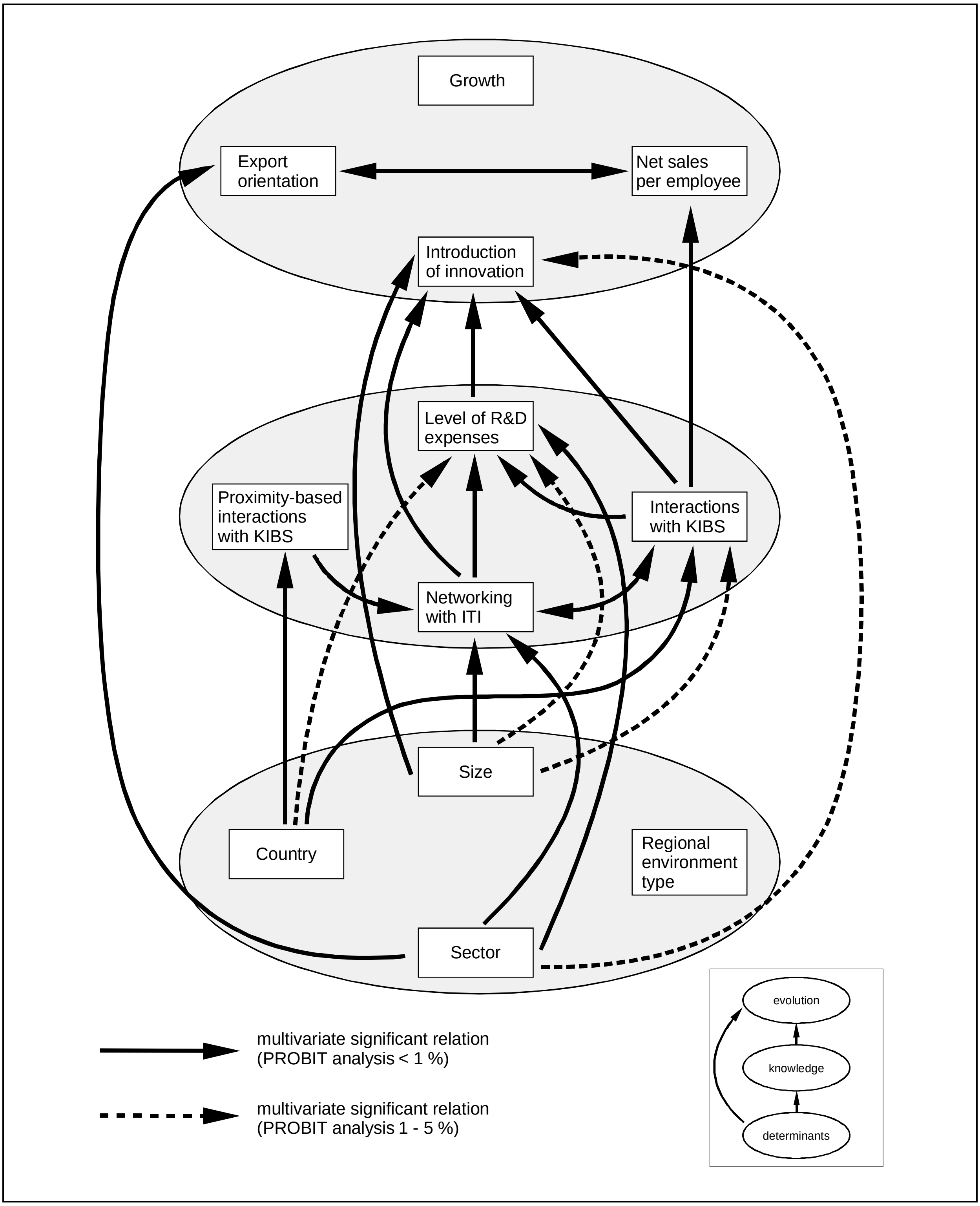
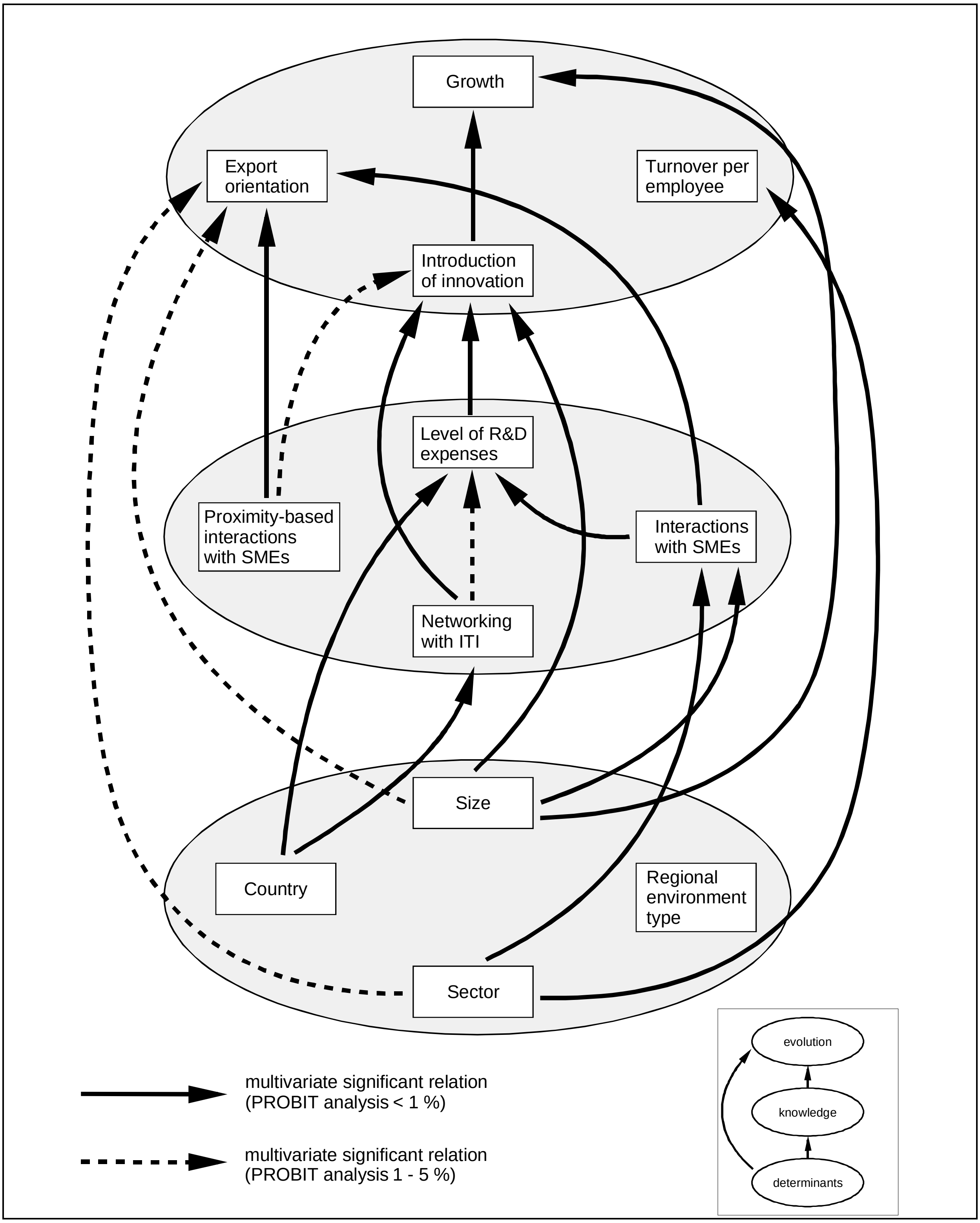


Figure 9: Path modelling: the KIBS sample



Conclusion: Which consequences regarding regional evolution patterns?

Referring to the empirical evidence outlined above for the considered SMEs and KIBS, no significant influence of the observed types of regional environment could be detected: (i) on the activation of their internal resources; (ii) on the activation of their external resources, and (iii) on their evolution capacities. As a consequence, no regional hierarchy can be established in the case of the examined area. The question can be asked to which extent this area is representative of the diversity of regional environments, for instance in Europe, and if these results can be generalised. However, these findings have an exemplary character, arguing against the idea of a territorial fatality.

In fact, these results demonstrate that regional inequalities (in terms of innovation environment) may be successfully compensated by firms located on a specific territory. It appears clearly that innovation is at first a matter of knowledge development and exchanges and as a consequence that the impact of the regional environment should not be overestimated. In this respect, the positive influence of the virtuous circle linking SMEs and KIBS may be seen as contributing actively to the reduction of regional inequalities. One may assume that in regions where firms adopt adequate behaviour such as setting up "knowledge systems" associating KIBS and SMEs" no territorial fatality paralysing innovation capacities should be expected.

Considering the implications for policies, and trying to go beyond the "basics" (development of educational resources, development of physical and knowledge-related infrastructures, improvement of the quality of life, etc.), three categories of recommendations may be of interest for everyone in charge of regional development and innovation support. Firstly, the improvement of innovation-related interactions between KIBS and SMEs may be considered as a way to boost the innovation capacities within a region. Such an improvement is "cheap and flexible", compared for instance to the building-up of an (administrative) technology transfer infrastructure. Secondly, and more generally, it may be relevant for ensuring regional development to focus more on services and less on manufacturing. Since numerous services are linked (both as suppliers and as users) to the manufacturing sector, a crow-bar effect in terms of investment can be expected. Finally, a possibility not to be neglected is to support actors mobilising resources outside the region. This constitutes basically a way to compensate innovation resources leaking at regional level (such as technical knowledge, specialised services, highly skilled manpower). Numerous regional initiatives aiming at supporting innovation capacities pay a particular attention to proximity-based interactions, i.e. to relations associating actors within the region, even if it is not necessarily meaningful. In this respect, it appears crucial to consider regions as open systems to escape the territorial fatality.

References

AMENDOLA, M./GAFFARD, J. L. (1988): La dynamique économique de l'innovation. Economica, Paris.

ANSELIN, L./VARGA, A/ACS, Z. J. (1997): Entrepreneurship, Geographic Spillovers and University Research: a Spatial Econometric Approach. Paper presented at the International Conference on Innovation and Performance of SMEs. 17th March 1997, Cambridge.

ARROW, K. (1962): The Economic Implication of Learning by Doing. In: Review of Economic Studies. Vol. 29, n. 80. pp. 155-173.

BARRO, R. J./SALA-I-MARTIN, X. (1995): Economic Growth. McGraw-Hill, New York.

BENZÉCRI, J.-P. (1992): Correspondence Analysis Handbook. Marcel Dekker, New York.

CALLON, M./LARÉDO, P./RABEHARISOA, V. (1997): Que signifie "innover" dans les services - une triple rupture avec le modèle de l'innovation industrielle. In: La Recherche. 295. pp. 34-36.

CAMAGNI, R. (1991): Local "Milieu", Uncertainty and Innovation Networks: Towards a New Dynamic Theory of Economic Space. In: CAMAGNI, R. (Ed.) (1991): Innovation Networks: Spatial perspectives. Belhaven Press, London, New York. pp. 121-144.

CLARK, N. (1986): Introduction: Economic Analysis and Technological Change: a Review of Some Recent Developments. In: MACLEOD, R. (Ed.) (1986): Technology and the Human Prospect. Pinter Publishers, London. pp. 1-27.

COOKE, P. (1998): Origins of the concept. In: BRACZYK, H. J.; COOKE, P.; HEIDENREICH (1998) (Eds.): Regional Innovation Systems - The Role of Governance in a Globalized World. UCL Press, London. pp. 2-25.

COOKE, P./BOEKHOLT, P./SCHALL, N./SCHIENSTOCK, G. (1996): Regional Innovation Systems: Concepts, Analysis and Typology. Paper presented during the EU-RESTPOR Conference "Global Comparison of Regional RTD and Innovation Strategies for Development and Cohesion". Brussels, 19-21 September.

DOSI, G. (1982): Technological Paradigms and Technological Trajectories: A Suggested Interpretation of the Determinants and Directions of Technical Change. In: Research Policy. 11/3. pp. 147-162.

EDQUIST, C. (Ed.)(1997): Systems of Innovation. Technologies, Institutions and Organizations. Pinter Publishers, London.

FREEMAN, C. (1982): The Economics of Industrial Innovation. Pinter Publishers, London.

FREEMAN, C. (1987): Technology Policy and Economic Performance: Lessons from Japan. Pinter Publishers, London.

GADREY, J./GALLOUJ, F./LHUILLERY, S./WEINSTEIN, O. (1993): La R-D et l'innovation dans les services. Research report for the french "Ministère de l'Enseignement Supérieur et de la Recherche".

GALLOUJ, F. (1994): Economie de l'innovation dans les services. Editions L'Harmattan, Paris.

HÉRAUD, J.-A./MULLER, E (1998): The Impact of Universities and Research Institutions Labs on the Creation and Diffusion of Innovation-Relevant Knowledge: the Case of the Upper-Rhine Valley. Paper presented at the 38th Congress of the European Regional Science Association, August 28-31 1998, Vienna.

HIPP, C. (1999): Innovationsprozesse im Dienstleistungssektor – Eine theoretisch und empirisch basierte Innovationstypologie. Ph.D. dissertation, Institut für Volkswirtschaftslehre und Recht der Universität Stuttgart.

JAFFE, A./TRAJTENBERG, M./HENDERSON, R. (1993): Geographic Localization of Knowledge Spillovers as Evidenced by Patent Citations. In: Quarterly Journal of Economics. August. pp. 577-598.

JULIEN, P.-A. (1996): Information control: a key factor in small business development. Paper presented at the 41st ICSB world conference, June 17-19, Stockholm.

KOSCHATZKY, K./HÉRAUD, J.-A. (1996): Institutions of Technological Infrastructure. Final report to Eurostat on the project "Feasibility study on the statistical measurement of the Institutions of Technological Infrastructure". FhG-ISI, Karlsruhe and BETA (Université Louis Pasteur), Strasbourg.

KRUGMAN, P. (1991): Geography and Trade. The MIT Press, Cambridge.

LARUE DE TOURNEMINE, R. (1991): Stratégies technologiques et processus d'innovation. Les Editions d'Organisation, Paris.

LUNDVALL, B. A. (1988): Innovation as an Interactive Process: From User-Producer Interaction to the National System of Innovation. DOSI, G./FREEMAN, C./NELSON, R./SILVERBERG, G./SOETE, L. (Eds.) (1988): Technical Change and Economic Theory. Pinter Publishers, London. pp. 349-369.

LUNDVALL, B. A. (1992) (Ed.): National System of Innovation. Towards a Theory of Innovation and Interactive Learning. Pinter Publishers, London.

MULLER, E. (1999): Innovation Interactions Between Knowledge-Intensive Business Services and Small and Medium-sized Enterprises – Analysis in Terms of Evolution, Knowledge and Territories. Ph.D. dissertation, Faculté des Sciences Économiques et de Gestion, Université Louis Pasteur, Strasbourg.

NELSON, R./WINTER, S. (1974): Neoclassical vs. Evolutionary Theories of Economic Growth. Critique and Prospectus. In: Economic Journal. December, pp. 886-905.

NELSON, R./WINTER, S. (1975): Growth Theory from an Evolutionary Perspective: The Differential Productivity Puzzle. In: The American Economic Review. 65/2. pp. 338-344.

NELSON, R./WINTER, S. (1977): In Search of a Useful Theory of Innovation. In: Research Policy. 6. pp. 36-76.

PAVITT, K. (1984): Sectoral Patterns of Technical Change: Towards a Taxonomy and a Theory. In: Research Policy. 13. pp. 343-373.

PORTER, M. (1990): The Competitive Advantage of Nations. Macmillan, London.

ROMER, P. M. (1990): Endogenous Technological Change. In: Journal of Political Economy. 98. pp. 71-102.

ROSENBERG, N. (1976): Perspective on Technology. Harvard University Press.

STRAMBACH, S. (1998): Knowledge-Intensive Business Services (KIBS) as an Element of Learning Regions - the Case of Baden-Württemberg. Paper presented at the ERSA Conference, August 28-31 1998, Vienna.

WOOD, P. (1998): The Rise of Consultancy and the Prospect for Regions. Paper presented at the 38th Congress of the European Regional Science Association, August 28-31 1998, Vienna.

Appendix 1: The sector distribution of the SME sample (N_{Alsace} = 267; N_{Baden} = 459)

Sector (in %)	Alsatian population[a)]	Alsatian sample	Badian population [b)]	Badian sample
Manufacture of food products	21,7	22,4	6,9	3,7
Manufacture of textiles	7,3	6,8	5,9	6,1
Manufacture of wood, paper	17,3	14,4	18,2	16,9
Manufacture of chemicals	14,3	13,3	17,9	12,3
Manufacture of basic metals	16,2	19,4	16,0	22,4
Manufacture of machinery and equipment	13,7	9,9	18,6	19,1
Manufacture of electrical machinery and apparatus	9,4	13,7	16,5	19,5
Total	100	100	100	100

a) Distribution based on the data provided by INSEE (French statistical office).

b) Distribution based on the data provided by the IHK (German Chamber of Commerce) of Karlsruhe and Freiburg, detailed data was not available for the sub-region Schwarzwald-Baar-Heuberg.

Appendix 2: The sector distribution of the KIBS sample (N_{Alsace} = 149; N_{Baden} = 277)

Sector (in %)	Alsatian population[a)]	Alsatian sample	Badian population [b)]	Badian sample
Computer related consultancy and activities	15,0	16,3	26,7	27,2
Legal, accounting and tax consultancy	34,8	16,3	8,1	16,1
Business, management and marketing consultancy activities	21,5	25,1	31,2	24,7
Architectural, engineering and technical activities	28,6	42,1	33,9	31,9
Total	100	100	100	100

a) Distribution based on the data provided by INSEE (French statistical office).

b) Distribution based on the data provided by the IHK (German Chamber of Commerce) of Karlsruhe and Freiburg, detailed data was not available for the sub-region Schwarzwald-Baar-Heuberg.

Appendix 3: Variables of the analysis

Variables related to firms evolution capacity	SME sample	KIBS sample
• *Growth of the number of employees*	GROWTH	GROWTH
• *Net sales/employee or turnover/employee*	NETSALES	TURNOVER
• *Export orientation*	LEVEXP	LEVEXP
• *Introduction of innovation*	INNOV	INNOV
Variables related to firms knowledge processing potential		
• *Interaction with KIBS/SMEs*	IKIBS	ISMES
• *Proximity-based interaction with KIBS/SMEs*	PKIBS	PSMES
• *Networking with ITI*	NITI	NITI
• *R&D intensity*	LEVRD	LEVRD
Variables related to firms structure and environment characterisation		
• *Sector of activity*	SECTOR	SECTOR
• *Size*	SIZE	SIZE
• *Location referring to the national system*	COUNT	COUNT
• *Location referring to the type of regional environment*	REGTYP	REGTYP

Appendix 4: Discrimination measures of the correspondence analysis (SMEs)

Variables	Discrimination measures* on dimension 1	Discrimination measures* on dimension 2
COUNT	0,156	0,441
LEVRD	0,470	0,075
SECTOR	0,238	0,285
SIZE	0,308	0,200
REGTYP	0,075	0,393
INNOV	0,423	0,040
IKIBS	0,387	0,061
NITI	0,297	0,108
LEVEXP	0,176	0,130
PKIBS	0,164	0,131
NETSALES	0,012	0,077
GROWTH	0,054	0,020

(*) Discrimination measures indicate the variables' contribution to the constitution of the axes.

Appendix 5: Discrimination measures of the correspondence analysis (KIBS)

Variables	Discrimination measures* on dimension 1	Discrimination measures* on dimension 2
SIZE	0,304	0,378
LEVRD	0,501	0,155
ISMES	0,459	0,150
INNOV	0,558	0,037
PSMES	0,208	0,215
SECTOR	0,141	0,246
GROWTH	0,219	0,157
LEVEXP	0,130	0,127
REGTYP	0,017	0,167
NITI	0,130	0,018
COUNT	0,113	0,008
TURNOVER	0,029	0,043

(*) Discrimination measures indicate the variables' contribution to the constitution of the axes.

Appendix 6: PROBIT analysis (SME sample)

probit growth levexp netsales innov levrd ikibs pkibs niti size count regtyp sector

Iteration 0: Log Likelihood =-497.63196
Iteration 1: Log Likelihood =-489.90571
Iteration 2: Log Likelihood =-489.90295

Probit Estimates — Number of obs = 726; chi2(11) = 15.46; Prob > chi2 = 0.1625; Pseudo R2 = 0.0155

Log Likelihood = -489.90295

growth	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
levexp	-.0264581	.1239865	-0.213	0.831	-.2694672	.216551
netsales	-.0278085	.1237584	-0.225	0.822	-.2703706	.2147536
innov	.187143	.1166413	1.604	0.109	-.0414698	.4157558
levrd	.1439793	.1276901	1.128	0.260	-.1062887	.3942473
ikibs	-.0197486	.139119	-0.142	0.887	-.2924169	.2529197
pkibs	.0928085	.1212172	0.766	0.444	-.144773	.3303899
niti	-.1367577	.1214217	-1.126	0.260	-.3747398	.1012245
size	-.2095225	.1298739	-1.613	0.107	-.4640706	.0450256
count	.2336407	.1136555	2.056	0.040	.01088	.4564015
regtyp	-.1864015	.1212427	-1.537	0.124	-.4240327	.0512298
sector	-.0971811	.1104876	-0.880	0.379	-.3137328	.1193705
_cons	-.1665875	.1345765	-1.238	0.216	-.4303526	.0971777

probit levexp growth netsales innov levrd ikibs pkibs niti size count regtyp sector

Iteration 0: Log Likelihood = -361.6224
Iteration 1: Log Likelihood =-329.15619
Iteration 2: Log Likelihood =-328.88532
Iteration 3: Log Likelihood =-328.88522

Probit Estimates — Number of obs = 726; chi2(11) = 65.47; Prob > chi2 = 0.0000; Pseudo R2 = 0.0905

Log Likelihood = -328.88522

levexp	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
growth	-.0235864	.1134153	-0.208	0.835	-.2458763	.1987034
netsales	.4521262	.1354239	3.339	0.001	.1867003	.7175521
innov	.0734648	.1415536	0.519	0.604	-.203975	.3509047
levrd	.1206269	.1457066	0.828	0.408	-.1649528	.4062067
ikibs	.2596041	.1623882	1.599	0.110	-.058671	.5778792
pkibs	-.2512962	.1379451	-1.822	0.068	-.5216637	.0190712
niti	-.1301741	.141585	-0.919	0.358	-.4076756	.1473274
size	.2292541	.1450866	1.580	0.114	-.0551104	.5136185
count	.2525239	.1351763	1.868	0.062	-.0124168	.5174647
regtyp	-.0205957	.1445533	-0.142	0.887	-.303915	.2627236
sector	.7035514	.1217544	5.778	0.000	.4649172	.9421855
_cons	-1.46276	.1762393	-8.300	0.000	-1.808183	-1.117338

probit netsales levexp growth innov levrd ikibs pkibs niti size count regtyp sector

Iteration 0: Log Likelihood =-348.69595
Iteration 1: Log Likelihood =-332.92009
Iteration 2: Log Likelihood =-332.81581
Iteration 3: Log Likelihood =-332.81579

Probit Estimates — Number of obs = 726; chi2(11) = 31.76; Prob > chi2 = 0.0008; Pseudo R2 = 0.0455

Log Likelihood = -332.81579

netsales	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
levexp	.4561824	.1351723	3.375	0.001	.1912495	.7211152
growth	-.0241915	.1125004	-0.215	0.830	-.2446882	.1963051
innov	.1802831	.136172	1.324	0.186	-.0866091	.4471754
levrd	-.1625968	.1463575	-1.111	0.267	-.4494522	.1242586
ikibs	.514356	.1627816	3.160	0.002	.1953099	.8334021
pkibs	-.1658073	.1340069	-1.237	0.216	-.428456	.0968414
niti	.1276284	.1377912	0.926	0.354	-.1424374	.3976942
size	-.2486895	.15403	-1.615	0.106	-.5505827	.0532038
count	-.053723	.1324467	-0.406	0.685	-.3133138	.2058677
regtyp	.119716	.1421595	0.842	0.400	-.1589114	.3983435
sector	-.1444223	.1314677	-1.099	0.272	-.4020943	.1132498
_cons	-1.364866	.1738245	-7.852	0.000	-1.705556	-1.024176

probit innov levrd ikibs pkibs niti size count regtyp sector

Note: levrd~=0 predicts success perfectly
levrd dropped and 197 obs not used

Iteration 0: Log Likelihood =-365.76602
Iteration 1: Log Likelihood =-326.61253
Iteration 2: Log Likelihood = -326.1773
Iteration 3: Log Likelihood =-326.17704

Probit Estimates — Number of obs = 529; chi2(7) = 79.18; Prob > chi2 = 0.0000; Pseudo R2 = 0.1082

Log Likelihood = -326.17704

innov	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
ikibs	.4994687	.1612672	3.097	0.002	.1833907	.8155466
pkibs	.0932864	.1532947	0.609	0.543	-.2071657	.3937386
niti	.6324277	.158229	3.997	0.000	.3223045	.9425509
size	.6622936	.1742468	3.801	0.000	.3207762	1.003811
count	.1072515	.1340611	0.800	0.424	-.1555035	.3700064
regtyp	-.0117776	.1550419	-0.076	0.939	-.3156541	.2920989
sector	.2810334	.136951	2.052	0.040	.0126144	.5494524
_cons	-.734153	.1559307	-4.708	0.000	-1.039772	-.4285345

probit levrd ikibs pkibs niti size count regtyp sector

```
Iteration 0:  Log Likelihood = -424.4173
Iteration 1:  Log Likelihood = -348.2112
Iteration 2:  Log Likelihood = -345.6933
Iteration 3:  Log Likelihood =-345.67479
Iteration 4:  Log Likelihood =-345.67479

Probit Estimates                                      Number of obs =    726
                                                      chi2(7)       = 157.49
                                                      Prob > chi2   = 0.0000
Log Likelihood = -345.67479                           Pseudo R2     = 0.1855

------------------------------------------------------------------------------
   levrd |      Coef.   Std. Err.       z     P>|z|       [95% Conf. Interval]
---------+--------------------------------------------------------------------
   ikibs |   .7375006   .1642424      4.490   0.000       .4155913     1.05941
   pkibs |   .0232757   .1300986      0.179   0.858      -.2317129    .2782643
    niti |    .413342   .1282257      3.224   0.001       .1620243    .6646597
    size |   .3324186   .1383681      2.402   0.016        .061222    .6036151
   count |   -.288782   .1343281     -2.150   0.032      -.5520602   -.0255038
  regtyp |  -.1483937   .1327111     -1.118   0.263      -.4085027    .1117152
  sector |   .8107999   .1136462      7.134   0.000       .5880574    1.033542
   _cons |  -1.477929   .1649427     -8.960   0.000       -1.80121   -1.154647
------------------------------------------------------------------------------
```

probit ikibs niti size count regtyp sector

```
Iteration 0:  Log Likelihood =-454.10673
Iteration 1:  Log Likelihood =-412.13479
Iteration 2:  Log Likelihood =-411.55381
Iteration 3:  Log Likelihood =-411.55309

Probit Estimates                                      Number of obs =    726
                                                      chi2(5)       =  85.11
                                                      Prob > chi2   = 0.0000
Log Likelihood = -411.55309                           Pseudo R2     = 0.0937

------------------------------------------------------------------------------
   ikibs |      Coef.   Std. Err.       z     P>|z|       [95% Conf. Interval]
---------+--------------------------------------------------------------------
    niti |   .6707749   .1335722      5.022   0.000       .4089781    .9325717
    size |   .3125476   .1438969      2.172   0.030       .0305148    .5945804
   count |  -.6971617   .1173189     -5.942   0.000      -.9271025   -.4672209
  regtyp |   .0077425   .1345739      0.058   0.954      -.2560174    .2715024
  sector |  -.1338844   .1116785     -1.199   0.231      -.3527702    .0850014
   _cons |   .5853824   .1139643      5.137   0.000       .3620164    .8087483
------------------------------------------------------------------------------
```

probit pkibs niti size count regtyp sector

```
Iteration 0:  Log Likelihood =-497.12234
Iteration 1:  Log Likelihood =-488.99401
Iteration 2:  Log Likelihood =-488.99191
Iteration 3:  Log Likelihood =-488.99191

Probit Estimates                                      Number of obs =    726
                                                      chi2(5)       =  16.26
                                                      Prob > chi2   = 0.0061
Log Likelihood = -488.99191                           Pseudo R2     = 0.0164

------------------------------------------------------------------------------
   pkibs |      Coef.   Std. Err.       z     P>|z|       [95% Conf. Interval]
---------+--------------------------------------------------------------------
    niti |   .0621194   .1153937      0.538   0.590      -.1640481     .288287
    size |  -.1016474   .1264205     -0.804   0.421       -.349427    .1461323
   count |  -.3800612    .110407     -3.442   0.001      -.5964548   -.1636675
  regtyp |   -.015481   .1196438     -0.129   0.897      -.2499785    .2190165
  sector |  -.0035422   .1030774     -0.034   0.973      -.2055701    .1984858
   _cons |  -.0095921   .1038094     -0.092   0.926      -.2130548    .1938707
------------------------------------------------------------------------------
```

probit niti ikibs pkibs count size sector regtyp

```
Iteration 0:  Log Likelihood =-414.18731
Iteration 1:  Log Likelihood =-352.44452
Iteration 2:  Log Likelihood =-351.74283
Iteration 3:  Log Likelihood = -351.7419

Probit Estimates                                      Number of obs =    726
                                                      chi2(6)       = 124.89
                                                      Prob > chi2   = 0.0000
Log Likelihood =  -351.7419                           Pseudo R2     = 0.1508

------------------------------------------------------------------------------
    niti |      Coef.   Std. Err.       z     P>|z|       [95% Conf. Interval]
---------+--------------------------------------------------------------------
   ikibs |    .868817   .1517942      5.724   0.000        .571306    1.166328
   pkibs |  -.3592631   .1274199     -2.820   0.005      -.6090015   -.1095247
   count |   .1816331   .1288793      1.409   0.159      -.0709656    .4342318
    size |   .9459261   .1256349      7.529   0.000       .6996861    1.192166
  sector |   .3435802   .1146756      2.996   0.003       .1188203    .5683402
  regtyp |  -.0555008   .1382873     -0.401   0.688      -.3265389    .2155374
   _cons |  -1.503876   .1621525     -9.274   0.000      -1.821689   -1.186063
------------------------------------------------------------------------------
```

Appendix 7: PROBIT analysis (KIBS sample)

probit growth levexp turnover innov levrd ismes psmes niti size count regtyp sector

```
Iteration 0:  Log Likelihood =-276.96985
Iteration 1:  Log Likelihood =-235.97357
Iteration 2:  Log Likelihood =-235.05285
Iteration 3:  Log Likelihood =-235.04971
Iteration 4:  Log Likelihood =-235.04971

Probit Estimates                                  Number of obs =    426
                                                  chi2(11)      =  83.84
                                                  Prob > chi2   = 0.0000
Log Likelihood = -235.04971                       Pseudo R2     = 0.1514

------------------------------------------------------------------------------
  growth |      Coef.   Std. Err.       z     P>|z|       [95% Conf. Interval]
---------+--------------------------------------------------------------------
  levexp |   .2586918   .1634324      1.583   0.113      -.0616298    .5790134
turnover |   .2935072   .1563021      1.878   0.060      -.0128393    .5998537
   innov |   .5730635   .2051875      2.793   0.005       .1709033    .9752237
   levrd |  -.0407501    .163849     -0.249   0.804      -.3618882    .2803881
   ismes |  -.1726563   .1867892     -0.924   0.355      -.5387564    .1934438
   psmes |   .2589506   .1824663      1.419   0.156      -.0986768     .616578
    niti |   .0759467   .2198264      0.345   0.730      -.3549052    .5067985
    size |   .9147817   .1472782      6.211   0.000       .6261218    1.203442
   count |   .2614375   .1553814      1.683   0.092      -.0431045    .5659796
  regtyp |   .2225584   .2054467      1.083   0.279      -.1801098    .6252266
  sector |  -.0933378   .1409467     -0.662   0.508      -.3695883    .1829127
   _cons |  -1.688821   .2547009     -6.631   0.000      -2.188026   -1.189617
------------------------------------------------------------------------------
```

probit levexp growth turnover innov levrd ismes psmes niti size count regtyp sector

```
Iteration 0:  Log Likelihood =-235.63238
Iteration 1:  Log Likelihood =-200.83601
Iteration 2:  Log Likelihood = -200.2099
Iteration 3:  Log Likelihood =-200.20842
Iteration 4:  Log Likelihood =-200.20842

Probit Estimates                                  Number of obs =    426
                                                  chi2(11)      =  70.85
                                                  Prob > chi2   = 0.0000
Log Likelihood = -200.20842                       Pseudo R2     = 0.1503

------------------------------------------------------------------------------
  levexp |      Coef.   Std. Err.       z     P>|z|       [95% Conf. Interval]
---------+--------------------------------------------------------------------
  growth |   .2537634   .1576095      1.610   0.107      -.0551456    .5626723
turnover |   .2841767   .1630888      1.742   0.081      -.0354715    .6038248
   innov |   .0027216   .2273639      0.012   0.990      -.4429035    .4483466
   levrd |   .3752691   .1818668      2.063   0.039       .0188168    .7317214
   ismes |   .7830308   .1822757      4.296   0.000        .425777    1.140285
   psmes |  -.7088483   .1817114     -3.901   0.000      -1.064996   -.3527006
    niti |   .2211765   .2301666      0.961   0.337      -.2299418    .6722947
    size |   .3934704   .1634981      2.407   0.016       .0730201    .7139207
   count |  -.0389084   .1672547     -0.233   0.816      -.3667215    .2889048
  regtyp |   .3562133   .2201699      1.618   0.106      -.0753118    .7877384
  sector |  -.2999891   .1498363     -2.002   0.045      -.5936628   -.0063154
   _cons |  -1.749811   .2703447     -6.473   0.000      -2.279677   -1.219946
------------------------------------------------------------------------------
```

probit turnover levexp growth innov levrd ismes psmes niti size count regtyp sector

```
Iteration 0:  Log Likelihood = -239.0039
Iteration 1:  Log Likelihood =-226.98888
Iteration 2:  Log Likelihood =-226.93761
Iteration 3:  Log Likelihood =-226.93761

Probit Estimates                                  Number of obs =    426
                                                  chi2(11)      =  24.13
                                                  Prob > chi2   = 0.0122
Log Likelihood = -226.93761                       Pseudo R2     = 0.0505

------------------------------------------------------------------------------
turnover |      Coef.   Std. Err.       z     P>|z|       [95% Conf. Interval]
---------+--------------------------------------------------------------------
  levexp |   .2966816   .1657048      1.790   0.073      -.0280939    .6214571
  growth |   .2641894   .1537591      1.718   0.086       -.037173    .5655518
   innov |   .1927117   .2052283      0.939   0.348      -.2095284    .5949518
   levrd |  -.1020388   .1718836     -0.594   0.553      -.4389245    .2348469
   ismes |   .2285387   .1813061      1.261   0.207      -.1268147    .5838921
   psmes |  -.2574605   .1813019     -1.420   0.156      -.6128057    .0978847
    niti |  -.1236488   .2328159     -0.531   0.595      -.5799596     .332662
    size |  -.2073791   .1564588     -1.325   0.185      -.5140326    .0992745
   count |  -.2287497   .1580951     -1.447   0.148      -.5386105     .081111
  regtyp |   .1059018   .1975012      0.536   0.592      -.2811934     .492997
  sector |   .3970765   .1406232      2.824   0.005       .1214601     .672693
   _cons |  -1.107467    .231383     -4.786   0.000      -1.560969   -.6539642
------------------------------------------------------------------------------
```

probit innov levrd ismes psmes niti size count regtyp sector

```
Note: levrd~=0 predicts success perfectly
      levrd dropped and 200 obs not used

Note: niti~=0 predicts success perfectly
      niti dropped and 12 obs not used

Iteration 0:  Log Likelihood =-147.87523
Iteration 1:  Log Likelihood =-125.56874
Iteration 2:  Log Likelihood =-125.34637
Iteration 3:  Log Likelihood =-125.34629

Probit Estimates                                  Number of obs =    214
                                                  chi2(6)       =  45.06
                                                  Prob > chi2   = 0.0000
Log Likelihood = -125.34629                       Pseudo R2     = 0.1524

------------------------------------------------------------------------------
   innov |      Coef.   Std. Err.       z     P>|z|       [95% Conf. Interval]
---------+--------------------------------------------------------------------
   ismes |  -.1866416   .2605415     -0.716   0.474      -.6972935    .3240104
   psmes |   .7530764    .294149      2.560   0.010       .1765549    1.329598
    size |   1.056903   .1889024      5.595   0.000       .6866613    1.427145
   count |   .3188353   .1990749      1.602   0.109      -.0713444    .7090149
  regtyp |   .0988443    .291205      0.339   0.734       -.471907    .6695957
  sector |   .1643506   .1908191      0.861   0.389      -.2096481    .5383492
   _cons |  -.9573663   .2804404     -3.414   0.001      -1.507019   -.4077133
------------------------------------------------------------------------------
```

probit levrd ismes psmes niti size count regtyp sector

```
Iteration 0:  Log Likelihood =-294.48678
Iteration 1:  Log Likelihood =-261.42798
Iteration 2:  Log Likelihood =-261.18637
Iteration 3:  Log Likelihood =-261.18633

Probit Estimates                                        Number of obs =    426
                                                        chi2(7)       =  66.60
                                                        Prob > chi2   = 0.0000
Log Likelihood = -261.18633                             Pseudo R2     = 0.1131

------------------------------------------------------------------------------
   levrd |      Coef.   Std. Err.       z     P>|z|       [95% Conf. Interval]
---------+--------------------------------------------------------------------
   ismes |   .7451784   .1644704      4.531   0.000       .4228224    1.067534
   psmes |   -.155014   .1661879     -0.933   0.351      -.4807362    .1707083
    niti |   .4527946   .2222982      2.037   0.042       .0170982     .888491
    size |   .2084052    .131434      1.586   0.113      -.0492007    .4660112
   count |  -.3904393   .1457869     -2.678   0.007      -.6761764   -.1047022
  regtyp |  -.1790364   .1852699     -0.966   0.334      -.5421588     .184086
  sector |   .2171681   .1306147      1.663   0.096       -.038832    .4731682
   _cons |  -.4480533   .1947872     -2.300   0.021      -.8298292   -.0662774
------------------------------------------------------------------------------
```

probit ismes niti size count regtyp sector

```
Iteration 0:  Log Likelihood =-288.82075
Iteration 1:  Log Likelihood =-268.12995
Iteration 2:  Log Likelihood =-268.01939
Iteration 3:  Log Likelihood =-268.01937

Probit Estimates                                        Number of obs =    426
                                                        chi2(5)       =  41.60
                                                        Prob > chi2   = 0.0000
Log Likelihood = -268.01937                             Pseudo R2     = 0.0720

------------------------------------------------------------------------------
   ismes |      Coef.   Std. Err.       z     P>|z|       [95% Conf. Interval]
---------+--------------------------------------------------------------------
    niti |    .429492   .2338868      1.836   0.066      -.0289178    .8879018
    size |   .3746418    .127878      2.930   0.003       .1240055    .6252781
   count |  -.1803166   .1420441     -1.269   0.204      -.4587178    .0980847
  regtyp |  -.1532309   .1865271     -0.821   0.411      -.5188174    .2123555
  sector |    .577855    .127207      4.543   0.000       .3285339    .8271762
   _cons |  -.0829924   .1837685     -0.452   0.652      -.4431722    .2771873
------------------------------------------------------------------------------
```

probit psmes niti size count regtyp sector

```
Iteration 0:  Log Likelihood =-266.80463
Iteration 1:  Log Likelihood =-262.23199
Iteration 2:  Log Likelihood =-262.23008

Probit Estimates                                        Number of obs =    426
                                                        chi2(5)       =   9.15
                                                        Prob > chi2   = 0.1033
Log Likelihood = -262.23008                             Pseudo R2     = 0.0171

------------------------------------------------------------------------------
   psmes |      Coef.   Std. Err.       z     P>|z|       [95% Conf. Interval]
---------+--------------------------------------------------------------------
    niti |   .1738437   .2132073      0.815   0.415      -.2440349    .5917222
    size |  -.0484944   .1295515     -0.374   0.708      -.3024106    .2054218
   count |   -.014127   .1460805     -0.097   0.923      -.3004396    .2721856
  regtyp |  -.2230986   .1801641     -1.238   0.216      -.5762138    .1300167
  sector |   .3137847   .1280011      2.451   0.014       .0629072    .5646622
   _cons |  -.4293507   .1825892     -2.351   0.019      -.7872189   -.0714825
------------------------------------------------------------------------------
```

probit niti ismes psmes count size sector regtyp

```
Iteration 0:  Log Likelihood = -137.1623
Iteration 1:  Log Likelihood =-126.36177
Iteration 2:  Log Likelihood =-125.79383
Iteration 3:  Log Likelihood = -125.7866
Iteration 4:  Log Likelihood = -125.7866

Probit Estimates                                        Number of obs =    426
                                                        chi2(6)       =  22.75
                                                        Prob > chi2   = 0.0009
Log Likelihood =  -125.7866                             Pseudo R2     = 0.0829

------------------------------------------------------------------------------
    niti |      Coef.   Std. Err.       z     P>|z|       [95% Conf. Interval]
---------+--------------------------------------------------------------------
   ismes |   .3682405   .2294234      1.605   0.108      -.0814211    .8179022
   psmes |  -.0267771   .2112848     -0.127   0.899      -.4408878    .3873335
   count |  -.7876322   .2447246     -3.218   0.001      -1.267284   -.3079808
    size |   .2785939   .1847363      1.508   0.132      -.0834826    .6406704
  sector |  -.0306546   .1806659     -0.170   0.865      -.3847532    .3234441
  regtyp |   .1202182   .2312529      0.520   0.603      -.3330291    .5734655
   _cons |  -1.586852   .2762283     -5.745   0.000       -2.12825   -1.045455
------------------------------------------------------------------------------
```

Title

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

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References

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Abstract

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

1. Introduction

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

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

2. Small and Large Firms in the Innovation Process

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

An important aspect of studies analysing innovation processes in firms (e.g. Nelson/Winter 1982) deals with the relationship between firm size and innovative activity. One common result of these studies carried out during the 1970s and 1980s was that innovation intensity increases with size up to a turning point and then decreases again with increasing firm size, shaping an inverted "U". Although variations in the results of these studies concerning the trend and turning point of the inverted U-curve can be observed depending on the data used for the analysis, the innovation indicators and the firm units, the general pattern was believed to be stable (see Frisch 1993 for a summary of different input- and output-oriented studies).

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

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

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

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

Recent research work in the fields of knowledge and network economics goes beyond the more general concept of the absorptive capacity of an organisation and stresses the importance of systematic learning and the need for interacting in the innovation process (Coombs/Hull 1998; Cowan/Foray 1997; Cimoli/Dosi 1996; Nonaka/Takeuchi 1995; Spender 1996). It is argued there that knowledge can only be acquired by systematic learning and forgetting. Learning within a firm can take place at different levels (Reid/Garnsey 1998) of which the learning processes induced by interactions (networks) between users and producers, competitors, other firms and research institutes are one of the most powerful driving forces for innovative activity (Lundvall 1988). To a certain extent, networking can compensate for lacking internal knowledge and resources, but without the ability to manage network relations and to integrate the transferred knowledge into the firm's production and managerial activity, firms would not be able to benefit from learning effects (Koschatzky 1999). Networking, learning and knowledge accumulation are therefore a cumulative process by which firms might run into path dependence. Those firms which do not interact with others are in the long run not able to utilise and accumulate external knowledge and lose their ability to handle external knowledge and information exchange. Firms which are integrated in a set of network relations continuously improve their learning capabilities and their knowledge base and also their ability to utilise new knowledge (Capello 1999).

Depending on the kind of the exchanged knowledge, spatial and cultural proximity is a more or less important prerequisite for the exchange process. It is argued that codified knowledge can be transferred over long distances at low costs so that spatial proximity between transmitter and receiver is not necessary, while tacit knowledge exchange requires interpersonal contacts, verbal and non-verbal communication and is therefore sensible to an increasing spatial and cultural distance between the interaction partners (Arnold/Thuriaux 1997; Foray/Lundvall 1996; see also Saviotti 1998). It is not only distance as such that influences knowledge exchange, but also the sum of distances to the different partners a firm is interacting with. Firms which can minimise these distances should have an advantage over those firms which can either not realise the transfer of (tacit) knowledge due to distance problems or at higher costs only. A minimising strategy is to locate at those locations where a large selection of possible knowledge sources could be expected. This is especially the case in agglomerations which can be characterised by the availability of localised knowledge and generic assets (Storper 1995; Storper 1997). On the other hand, agglomerations might not necessarily imply a mutually beneficial innovative environment for all industries, because cumulative causation processes based on the pre-existing economic structure of that region pre-determine the location of modern economic activities (Coe/Townsend 1998: 389). Because of the functional relationship between the different types of regions, also non-core regions are able to generate own growth conditions and to provide a favourable innovation climate (Scott 1995; Storper 1997: 77). Nevertheless, there is empirical evidence that firms adapt to their regional environment by applying different innovation strategies. For example, in regions where the supply of skilled labour is limited, labour is substituted by capital (Meyer-Krahmer 1985).[14] It can therefore be concluded that the regional environment in which a firm is embedded has at least some impact on its access to information and knowledge and on its ability for collective learning (Keeble/Wilkinson 1999; Lawson/Lorenz 1999), especially when the firm is small and unable to manage complex networking relations (Klein Woolthuis et al. 1998) and the spatial range of networks is mainly confined to the region itself.

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

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

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

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

- There is ample evidence that small firms are not per se more innovative than larger firms, although small firms that perform R&D tend to be more innovative than large firms and also generate a higher number of innovations per unit of R&D input.
- The amount of firms that do not innovate or that were not engaged in R&D is relatively high among small firms and declines with size. As a matter of fact, large firms are more innovative with respect to the share of firms with R&D.
- An optimal firm size for innovation does not exist.

- Innovation varies between firms, between sectors and between markets.
- Innovation activity depends on the risk aversion of firms, their absorptive capacity, knowledge base, their competencies in organising innovation processes, their learning abilities and information channels and their access to and handling ability of external knowledge.
- Small and large firms play different roles in the innovation process.
- Small firms are the engine of new technological developments, but are often unable to finish innovations because of limited resources.
- R&D activity in large firms is more directed towards incremental innovation and process developments, since the budget for process R&D rises somewhat stronger with size than the one for product R&D.

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

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

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

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

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

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

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

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

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

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

3. Data and Methodology

The data used for this analysis originate from a regional innovation survey, carried out among mainly small and medium-sized manufacturing and business-related service firms in several German and European regions during 1995 and 1998.[15] For this paper, data from Baden, i.e. the western part of Baden-Württemberg, and from south-east Lower Saxony, comprising the cities of Hannover, Braunschweig and Göttingen, are used (for details see Backhaus and Seidel, 1997; Koschatzky and Traxel, 1997; Koschatzky, 1997). The regions under review cover a representative breakdown of German regions, ranging from the automobile regions in eastern Lower Saxony, the service oriented Expo 2000 urban region of Hannover and the technology region Baden. The industrial branch spectrum of the survey ranges from NACE codes 15 to 36. In services, computer and related activities (NACE 72), architectural and engineering activities/technical consultancy and technical testing and analysis (NACE 74.2 and 74.3), legal activities, accounting, tax consultancy (NACE 74.11 and 74.12), and market research, business and management consultancy, and advertising (NACE 74.13, 74.14, 74.4) were included. Within the regions a differentiation was made between three types of functional regions, i.e. central, urban regions (e.g. Hannover, Karlsruhe), intermediate regions (e.g. Freiburg, Göttingen), and rural regions (e.g. the Black Forest region Schwarzwald-Baar-Heuberg), in accordance with the official German planning region classification of 1991.

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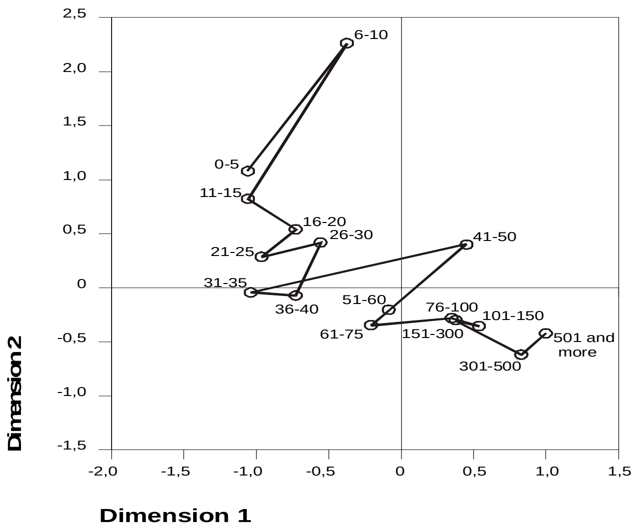
[15] These data originate from the European Regional Innovation Survey (ERIS), jointly carried out by the Fraunhofer Institute for Systems and Innovation Research Karlsruhe, the Department of Economic Geography at Hannover University, the Chair for Economic Policy at the Technical University Bergakademie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

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

In order to divide the sample in size classes according to firms' structural characteristics, their co-operation behaviour and their expected future development[16], a homogeneity analysis has been performed. With the aid of plot outputs, this type of analysis aims at presenting relationships between categorical variables in few dimensions which thus allows to describe structures or patterns in variable relationships that are difficult to detect otherwise.[17] In order to do so, homogeneity analysis is based on optimal scaling and assigns scores to categories which account for as much association between the variables as possible. Consequently, the output indicates similar variable categories and may serve as a basis for characterising and classifying the sample (cf. Figure 1).

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



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

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

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

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

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

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

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

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

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

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

4. Empirical Analysis

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

- structural firm characteristics
- innovative activity

- information exchange
- knowledge exchange by networking
- assessment of the region.

4.1 Structural characteristics

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

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

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

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

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

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

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

Unfortunately, the same question was not asked in the service questionnaire. Therefore the client structure of small and large service firms should serve as a structural characteristic. Table 5 reveals that both in the total sample (significant at the 1 % level) as well as for firms located in central regions (5 % level) small and large service firms distinguish by their client structure. 12.7 % of large firms, but only 2.1 % of small firms realise at least 50 % of their turnover from contracts with clients from the public sector. On the other hand, no large firm of the sample was dependent on private households, compared to 5.3 % of the small firms (in central regions even 8.5 %) which achieved a private households turnover share of more than 50 %. As a matter of fact, small service firms had the majority of clients among private enterprises, while large business-related service firms were also regarded as relevant contractors by the public sector. Small service firms are therefore more dependent on private enterprises as clients, while large service firms have a more diversified client base. Although statistically insignificant for the other two types of region, this client pattern can be found there as well.

Table 5: Client base of small and large service firms according to type of region
(share of firms in %)

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

4.2 Innovative activity

In the survey, manufacturing firms were asked about their own innovation activities, while service firms were considered to play an important knowledge contributing function for manufacturing firms (Koschatzky 1999; Muller/Zenker 1998). Therefore they were not only asked to evaluate their own innovative activity, but their *contribution to industrial innovations* as well. 72.6 % of the small and 69.6 % of the large business-related service firms supported innovations at their industrial clients. This kind of activity does not seem to depend on firm size. Size differences, although statistically insignificant, can be found with respect to the kind of innovations which had been supported. Large firms were more engaged in process innovation (44.3 % resp. 34.7 % of the small firms), compared to a higher engagement of small firms in market development (30.5 % resp. 21.5 % of the large firms). This can be explained by differences in average employment figures among the four service industries. Engineering services, which might be closely related to process innovation, are in general much larger (median 26 employees) than consultancy/market research (median 3 employees). According to the service firms, their main function was the supply of knowledge to industrial clients: 65.3 % of the small and 63.3 % of the large firms mentioned knowledge supply as most important function. Cost reduction, flexibility gains and the reduction in capacity bottlenecks were given the next ranks. In this contribution to manufacturing innovation, small and large service firms do not discriminate.

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

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

Manufacturing firms

Kind of activity (1) (share of firms in %)	SF (n=173)	LF (n=225)
only product innovation	30.6	11.6
only process innovation	6.4	4.0
both product and process innovation	63.0	84.4
Total	100.0	100.0
χ^2	0.000	

Service Firms

Kind of activity (2) (share of firms in %)	SF (n=95)	LF (n=79)	χ^2
new service	61.1	63.3	0.762
improved service	56.8	62.0	0.489
new/improved processes for service	67.0	60.8	0.392

(1) Measured according to the devotion of R&D expenditures

(2) Share of firms which implemented this kind of innovation

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

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

(share of firms in %)

Share of R&D personnel in manufacturing firms

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

Share of innovation expenditures in service firms

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

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

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

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

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

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

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

As can be seen from the χ^2 significance values, for most of the obstacles significant distinctions can be made between small and large firms, but a clear pattern relating innovation obstacles to size groups could not be found. For small firms, the recruitment of personnel, especially for production and marketing, seems to be a slightly greater problem than for large firms. On the other hand, the availability of R&D personnel is less a problem in small firms than in the larger ones. This difference in the problem assessment might be explained by the fact that small firms usually employ only a few persons engaged in R&D, so that they face less problems in hiring respective people because of the small absolute amount of vacancies. In production and marketing, where also small firms have a higher absolute demand, wage competition might favour large firms. It is interesting to note that (statistically significant at the 5 % level) small firms seem to have much less problems in organising the innovation process. For 62.1 % of the small firms which answered this question this is not seen as a problem. Whether this self assessment is realistic cannot be answered by the figures. The greater problems for large firms might depend on the more complex innovation processes there in which product and process innovation are more closely related than in the small firms (cf. Table 6). The co-operation with research institutes is not a major obstacle to innovation, and small and large firms differ only slightly in their assessment (statistically insignificant). Stronger differences can be found in assessing the access opportunities to external knowledge. Small firms have a slight disadvantage over large firms, be it because of limited search capabilities or because of limited knowledge processing facilities. This aspect will be raised again later on.

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

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

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

4.3 Information exchange

Information is an essential basis for knowledge. They are the relevant medium for knowledge creation and knowledge formalisation. Information consist of a flow of news which can be fractionised into single parts ("bits"), be added to the knowledge base and by this alter it (Nonaka 1994: 14-15). For the innovativeness of a firm it is crucial to have access to recent information and knowledge and to channel information flows within the firm in an efficient manner. In section 2 it was argued that a decentralised information handling favours creativity and innovation. The *kind of co-ordination activities for innovation* gives an indication about how the gatekeeper function is organised. As can be seen from Table 11, innovation activities in small manufacturing firms are predominantly centrally co-ordinated (94.7 % of all small firms), while in nearly 40 % of the large firms a decentralised co-ordination strategy is applied. This behaviour is almost independent of the kind of the regional environment. Only in rural areas of the sample more large firms favour a centralised co-ordination (71.1 % compared to an average of 62.7 %). It might be attributed to differences in the regional industrial mix according to which the machinery industry is overrepresented in the rural areas (35.6 % of the large firms vs. 28.4 % on average), while the plastics industry is underrepresented (6.7 % compared to 17.3 % on average). The different gatekeeping activity in small and large firms might have influenced the more negative assessment of small firms concerning their access to external knowledge. When information transfer and related activities are monopolised, the knowledge base and innovative potential of a firm highly depend on the absorptive capacity of the gatekeeper. In cases where this capacity is low it could have negative effects on the learning and knowledge building abilities of the firm. Due to their size, small manufacturing firms suffer more on inefficient centralised gatekeeping than large manufacturing firms which have, according to the figures in Table 11, also other options in organising information processing processes.

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

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

It is not only important for innovation by whom information is distributed and how, but also which information sources are used. In this respect the following table should answer the question whether there are clear differences between small and large firms in accessing *external information sources*. For manufacturing firms, a distinction is possible between information relevant for product innovation and for process innovation (cf. Table 12). The two most important information sources for product innovation are customers and exhibitions. While with customers learning by using processes and related information flows play the major role, it is a selective and autonomous information search when information is picked up at exhibitions. For these two sources, small and large firms act in a similar way. Major differences can be found with respect to competitors, suppliers and research institutes. All three sources are much more rated to be important by large firms. In the case of competitors this might have something to do with trust and diversification. Large firms with a broader product spectrum and a lesser dependence on only a few strategic products have more freedom in entering in information exchange with competitors than small firms. The knowledge base and absorptive capacity of a firm is related to its ability in co-operating with research institutes (Rosenberg 1990; Hicks 1995). In our sample many more large firms rate research institutes to be an important information source than small firms (significant at the 1 % level). Technical services are the last important information source, both for small and large firms. With respect to process information, the order of the different information sources varies compared to product innovation, and also the distinctions between small and large firms are more pronounced. Literature seems to be an important stimulus for process innovation, and much more for the large firms. Here firms are able to search and select by their own and are not dependent on other partners. The second most information source are exhibitions, fairly equally rated by small and large firms. The first interactive information flow, that with suppliers, ranks at position three. Here, as well as in accessing information from competitors, research institutes and technical services, large firms assess these sources significantly more often to be important than small firms. These differences have their reason in the fact that small firms are less engaged in process innovation than large firms and do therefore not make use of all these information sources. It can be concluded from the table that the information spectrum of large firms is more diversified than that of small firms, because more large firms rated the given sources as to be important.

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

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

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

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

Table 13: Importance of external information sources for small and large service firms
(share of firms in %)

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

(1) Difference to 100 %: source does not matter

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

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

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

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

4.4 Knowledge exchange by networking

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

The manufacturing firms of the sample were asked with which partners they co-operate in innovation processes beyond the usual business relations. These relationships were grouped into vertical co-operations (with customers and suppliers), horizontal co-operations (with other firms and research institutes) and co-operations with service companies as a special case of knowledge support. *Vertical innovation networks* were rated to be most important by the firms. 71.7 % of the small and 78.2 % of the large firms found this type of relationship to be of great importance for innovation support (cf. Table 15). For the total sample as well as for the three types of region, small and large firms do not discriminate. Due to its production based character, vertical innovation networking mostly reflects already existing business relations which are exploited for innovation purposes. Since they fulfil a viable function for the firm, the collaborative activity does not differ significantly between small and large firms and is also independent of the type of region.[18] Also the spatial range of these networks does not vary significantly between the two types of firms. Large firms show a slightly higher interregional orientation, while small firms co-operate a little bit more with partners from the same federal state. This pattern is also not affected by the type of region in which a firm is located.

Table 15: Importance and spatial range of vertical networking by small and large manufacturing firms according to type of region
(share of firms in %)

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

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

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

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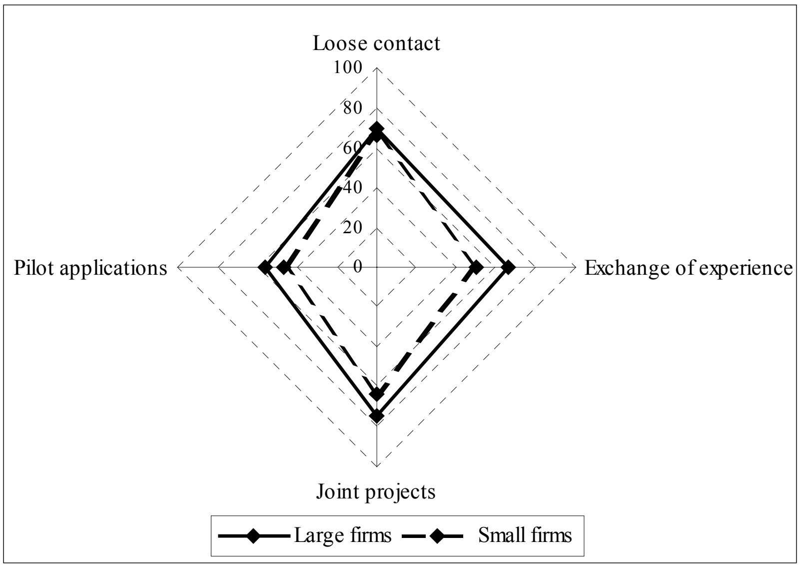
18 Using the same database but including data from Saxony, Fritsch (1999: 12) found out for vertical cooperations "...that not only the propensity to have at least one cooperative relationship but also the number of cooperative relationships increases with size." This is indirectly supported by our results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

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



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

Table 16: Importance and spatial range of horizontal networking by small and large manufacturing firms according to type of region

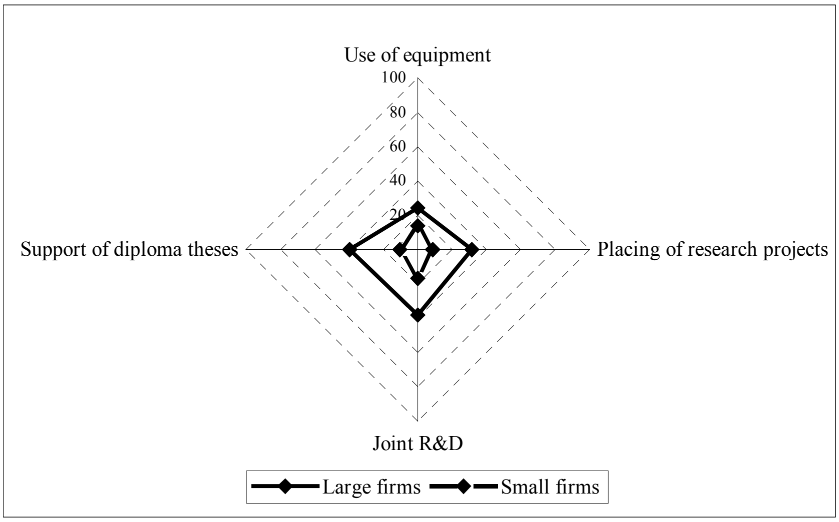
(share of firms in %)

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

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

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

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



Compared to vertical networks where no regional differentiation was found, the importance rating for horizontal networks also discriminates between the types of regions. Especially in central regions large and also small firms seem to establish more horizontal relations than in the two other types of region. This might be partly attributed to the larger supply of possible co-operation partners, because compared to the total sample a slightly higher share of small and large firms maintain regional relationships (16.0 % and 24.6 % resp. 12.7 % and 22.7 % for the total sample). On the other hand, also the shares of interregional networking are higher compared to the average figures. So the higher activity in horizontal networking of small and large firms located in central regions seem to be a characteristic behaviour for this type of region.[19] With respect to the already mentioned spatial range of horizontal co-operations it can be clearly stated that large firms are more actively engaged in both regional and interregional networking. While in central and intermediate regions the differences are not pronounced enough to be statistically significant, they are in rural regions and in the total sample. Especially in the rural areas of the sample only a few of small firms have interregional collaborative relationships, while relatively more large firms are engaged in both regional and interregional interaction compared with the total figures. The figures do not provide an explanation for this collaborative behaviour, but it can at least be concluded that horizontal networking activities differ slightly with respect to the type of the regional environment of the firm.

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

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

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

Table 17: Networking with service companies by small and large manufacturing firms according to type of region
(share of firms in %)

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

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

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

(share of firms in %)

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

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

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

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

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

Table 20: Discrimination measures for manufacturing and service firms

Variables Manufacturing	Dimensions 1	2	Variables Services	Dimensions 1	2
REGION	0.027	0.201	REGION	0.010	0.051
REG_VERT	0.105	**0.642**	COOP_SERV	**0.540**	0.118
INTREG_VERT	0.145	**0.506**	COOP_RESEAR	**0.334**	0.176
REG_HOR	**0.323**	0.072	CLIENT_RANGE	**0.578**	**0.335**
INTREG_HOR	**0.387**	0.035	REG_VERTINFO	**0.297**	**0.501**
REG_SERV	0.151	0.002	REG_HORINFO	0.198	**0.380**
INTREG_SERV	**0.336**	0.053	REG_OTHERINFO	0.248	0.226
COOP_RESEAR	**0.260**	0.055	TURNOV_RANGE	0.099	**0.267**
TURNOV_RANGE	0.133	0.145	SIZE	0.023	0.000
COORD_INNO	0.168	0.165			
SIZE	**0.351**	0.192			

It can be seen that for the manufacturing firms size (SIZE) is a discriminating variable in a way that large firms are more strongly engaged in horizontal networking (both regionally and interregionally; REG_HOR, INTREG_HOR), and also in interregional co-operations with service firms (INTREG_SERV) and in co-operations with research institutes (COOP_RESEAR). Small firms, on the other hand, are more regionally oriented, both with respect to co-operation behaviour and markets. The type of region in which the firms are located (REGION) discriminates more on the second dimension which points to the importance of vertical networking. In this respect, firm size plays only a minor role compared to the first dimension. In the plot of the two dimensions decentral innovation co-ordination is much closer linked to large then to small firms. For the service firms, size (SIZE) as well as the type of region (REGION) are not discriminating. Therefore a clear distinction between small and large service firms and their collaborative behaviour is not possible. Nevertheless, the plots show that service firms which often co-operate with other services co-operate also quite often with research institutes. Those ones which mainly use vertical information sources from within their region also have a high share of industrial clients from the same region. All in all, the homogeneity analysis confirms the results already derived by descriptive statistics that the networking behaviour differs especially between small and large manufacturing firms. The discrimination measures make also clear that for service firms the firm size (as defined in this paper) is a much less discriminating factor in information exchange and innovation co-operation than for manufacturing firms.

4.5 Assessment of the region

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

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

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

The "innovation climate" is quasi a summary of the different regional factors affecting the innovative activities of firms. The ratings of large firms are less bad than those of the small firms, but for both firm types negative ratings prevail. A deeper look into the ratings for the different types of region reveals a slightly different picture (cf. Table 22). The central regions are best assessed compared to intermediate and rural areas, especially by large firms which gave more good than bad ratings. But also the small firms assigned their highest score for a good innovation climate to the central regions. In the comparison between intermediate and rural regions, the innovation conditions seem to be better in the rural areas. Here the bad ratings are lower and large firms gave a more positive assessment than in the intermediate regions. Also for these results it has to be pointed out that they reflect a tendency and are (besides the different shares for the "medium" rating) statistically insignificant. Significant, although only at the 10 % level, are the differences between small and large manufacturing firms in the intermediate regions.

Table 22: Assessment of the regional innovation climate by small and large manufacturing firms according to types of region
(share of firms in %)

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

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

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

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

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

5. Summary and Conclusions

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Based on the findings of this empirical analysis, the conclusion seems justified that small firms more strongly depend on regional information and knowledge sources for their innovative activity than larger firms.[20] This paper could not address the differences between small and large firms in their innovative success. Therefore the question arises how the stronger regional embeddedness influences the innovative and economic performance of small firms. If it is influenced positively, there seems no need to support small firms in their innovative activity by region specific innovation policy measures. If they face problems because of their stronger dependence on regional networking, innovation policy support seems justified, especially with respect to the reduction of disadvantages compared to large firms.

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

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

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

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

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

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

References

ACS, Z.J. and AUDRETSCH, D.B. (1990) *Innovation and Small Firms*. Cambridge/Mass.: MIT Press.

ARNOLD, E. and THURIAUX, B. (1997) *Supporting Companies' Technological Capabilities*. Brighton: Technopolis Ltd.

AYDALOT, P. (Ed.) (1986) Milieux Innovateurs en Europe. Paris: GREMI.

BACKHAUS, A. and SEIDEL,O. (1998) Die Bedeutung der Region für den Innovationsprozeß, *Raumforschung und Raumordnung*, 56, pp. 264-276.

BACKHAUS, A. and SEIDEL, O. (1997) Innovationen und Kooperationsbeziehungen von Industriebetrieben, Forschungseinrichtungen und unternehmensnahen Dienstleistern: Die Region Hannover-Braunschweig-Göttingen im interregionalen Vergleich, *Hannoversche Geographische Arbeitsmaterialien, No. 19-1997*. Hannover: Universität Hannover.

BARKHAM, R., GUDGIN, G., HART, M. and HANVEY, E. (1996) *The Determinants of Small Firm Growth. An Inter-Regional Study in the United Kingdom 1986-90*. London: Jessica Kingsley Publ.

BELLINI, N. (1998) *Services to Industry in the Framework of Regional and Local Industrial Policy*, Paper prepared for the OECD Conference on "Up-Grading Knowledge and Diffusing Technology to Small Firms: Building Competitive Regional Environments, Modena, 28-29 May 1998 (mimeo).

BIRCH, D.L. (1987) Job Creation in America. How our Smallest Companies Put the Most People to Work. New York: The Free Press.

CAMAGNI, R. (Ed.)(1991) *Innovation Networks. Spatial Perspectives*. London, New York: Belhaven Press.

CAMAGNI, R. and CAPELLO, R. (1997) Innovation and Performance of SMEs in Italy: The Relevance of Spatial Aspects. *Paper presented at the International Conference on Innovation and Performance of SMEs, Cambridge*, 17 March 1997.

CAPELLO, R. (1999) Spatial Transfer of Knowledge in High Technology Milieux: Learning Versus Collective Learning Processes, *Regional Studies*, 33, pp. 353-365.

CAPPELLIN, R. and NIJKAMP, P. (1990) The Role of Space in Technological Change, R. CAPPELLIN and P. NIJKAMP (Eds.) *The Spatial Context of Technological Development*, pp. 1-13. Aldershot: Avebury.

CIMOLI, M. and DOSI, G. (1996) Technological paradigms, patterns of learning and development: an introductory roadmap, DOPFER, K. (Ed.) *The Global Dimension of Economic Evolution. Knowledge Variety and Diffusion in Economic Growth and Development*, pp. 63-88. Heidelberg: Physica-Verlag.

COFFEY, W.J. and POLÈSE, M. (1987) Trade and location of producer services: A Canadian perspective, *Environment and Planning A*, 19, pp. 697-711.

COHEN, W. (1995) Empirical Studies of Innovative Activity, STONEMAN, P. (Ed.) Handbook of the Economics of Technological Change, pp. 182-264. Oxford: Blackwell.

COHEN, W. and LEVINTHAL, D. A. (1990) Absorptive capacity. A new perspective on learning and innovation, *Administrative Science Quarterly*, 35, pp.128-152.

COOMBS, R. and HULL, R. (1998) 'Knowledge management practices' and path-dependency in innovation, *Research Policy*, 27, pp. 237-253.

COWAN, R. and FORAY, D. (1997) The Economics of Codification and the Diffusion of Knowledge, *Industrial and Corporate Change*, 6, pp. 595-622.

DEBRESSON, C. and AMESSE, F. (1991) Networks of innovators. A review and introduction to the issue, *Research Policy*, 20, pp. 363-379.

DOSI, G. (1982) Technological paradigms and technological trajectories, *Research* Policy, 11, pp. 147-162.

FELDMAN, M.P. (1994) Knowlegde Complementary and Innovation, *Small Business Economics*, 6, pp. 363-372.

FORAY, D. and LUNDVALL, B.-A. (1996) The Knowledge-Based Economy: from the Economics of Knowledge to the Learning Economy, ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT (Ed.) Employment and Growth in the Knowledge-based Economy, pp. 11-32. Paris: OECD.

FREEMAN, C. (1982) *The Economics of Industrial Innovation,* 2nd edn. London: Pinter.

FRISCH, A.J. (1993) *Unternehmensgröße und Innovation. Die schumpeterianische Diskussion und ihre Alternativen*. Frankfurt: Campus-Verlag.

FRITSCH, M. (1999) Co-operation in regional innovation systems, *Freiberger Working Papers*, 10/1999. Freiberg: TU Bergakademie.

FRITSCH, M. and MESCHEDE, M. (1998) Product innovation, process innovation, and size, *Freiberger Working Papers*, 98/13. Freiberg: TU Bergakademie.

HICKS, D. (1995) Published Papers, Tacit Competencies and Corporate Management of the Public/Private Character of Knowledge, *Industrial and Corporate Change*, 4, pp. 401-424.

KEEBLE D. (1997) Small Firms, Innovation and Regional Development in Britain in the 1990s, *Regional Studies,* 31, pp. 281-293.

KEEBLE, D. and WILKINSON, F. (1999) Collective Learning and Knowledge Development in the Evolution of Regional Clusters of High Technology SMEs in Europe, *Regional Studies*, 33, pp. 295-303.

KLEIN WOOLTHUIS, R., SCHIPPER, D. and STOR, M. (1998) How Entrepreneurial Networks Can Succeed: Case from the Region of Twente, DURING, W. and OAKEY, R. (Eds.) *New Technology-Based Firms in the 1990s*, Volume IV, pp. 112-124. London: Paul Chapman Publ.

KOSCHATZKY, K. (1999) Innovation Networks of Industry and Business-Related Services – Relations between Innovation Intensity of Firms and Regional Inter-Firm Co-operation, *European Planning Studies*, 7, pp. 737-757.

KOSCHATZKY, K. (1998) Firm Innovation and Region: The Role of Space in Innovation Processes, *International Journal of Innovation Management*, 2, pp. 383-408.

KOSCHATZKY, K. (1997) Entwicklungs- und Innovationspotentiale von unternehmensnahen Dienstleistungsbetrieben in Baden. Ergebnisse einer Unternehmensbefragung, *Arbeitspapier Regionalforschung*, No. 10. Karlsruhe: Fraunhofer ISI.

KOSCHATZKY, K. and TRAXEL, H. (1997) Entwicklungs- und Innovationspotentiale der Industrie in Baden. Erste Ergebnisse einer Unternehmensbefragung, *Arbeitspapier Regionalforschung*, No. 5. Karlsruhe: Fraunhofer ISI.

KOSCHATZKY, K. and ZENKER, A. (1999) Innovative Regionen in Ostdeutschland – Merkmale, Defizite, Potentiale, *Arbeitspapier Regionalforschung*, Nr. 17. Karlsruhe: Fraunhofer Institute ISI.

LARANJA, M. (1998) Entrepreneurial Innovation Networks: Small Firms' Contribution to Collective Innovation Efforts, DURING, W. and OAKEY, R. (Eds.) *New* Technology-*Based Firms in the 1990s*, Volume IV, pp. 62-70. London: Paul Chapman Publ.

LAWSON, C. and LORENZ, E. (1999) Collective Learning, Tacit Knowledge and Regional Innovative Capacity, *Regional Studies*, 33, pp. 305-317.

LE Bars, A., MANGEMATIN, V. and NESTA, L. (1998) Innovation in SME's: The Missing Link, HIGH-TECHNOLOGY SMALL FIRMS CONFERENCE The 6th Annual International Conference at the University of Twente, the Netherlands. Proceedings, Vol. 1, pp. 307-324. Twente: University of Twente.

LICHT, G., KUKUK, M., KUHLMANN, S., HIPP, CH., MÜNT, G., SMID, M. and HESS, D. (1996) *Innovationstätigkeit im Dienstleistungssektor. Empirische Analyse der Erhebung 1995*. Mannheim, Karlsruhe: ZEW, ISI.

LUNDVALL, B.-A. (1988) Innovation as an interactive process: From user-producer interaction to the national system of innovation, DOSI, G., FREEMAN, CH., NELSON, R., SILVERBERG, G. and SOETE, L. (Eds.) *Technical Change and Economic Theory*, pp. 349-369. London: Pinter.

MEYER-KRAHMER, F. (1985) Innovation Behaviour and Regional Indigenous Potential, *Regional Studies*, 19, pp. 523-534.

MILES, I., KASTRINOS, N., FLANAGAN, K., BILDEBEEK, R., DEN HERTOG, P., HUNTINK, W. and BOUMAN, M. (1994) *Knowledge Intensive Business Services: Their Roles as Users, Carriers and Sources of Innovation*. Manchester: PREST.

MULLER, E. and ZENKER, A. (1998) Analysis of Innovation-oriented Networking between R&D Intensive Small Firms and Knowledge Intensive Business Services, HIGH-TECHNOLOGY SMALL FIRMS CONFERENCE The 6th Annual International Conference at the University of Twente, the Netherlands. Proceedings, Vol. 1, pp. 175-203. Twente: University of Twente.

NELSON, R. and WINTER, S.G. (1982) *An Evolutionary Theory of Economic Change*. Cambridge: Harvard University Press.

NONAKA, I. (1994) A Dynamic Theory of Organizational Knowledge Creation, *Organization Science*, 5, pp. 14-37.

NONAKA, I. and TAKEUCHI, H. (1995) *The Knowledge-Creating Company. How Japanese Companies Create the Dynamics of Innovation*. New York: Oxford University Press.

PAVITT, K., TOWNSEND, J. and ROBSON, M. (1987) The size distribution of innovating firms in the UK: 1945-1983, *Journal of Industrial Economics*, 35, 297-316.

PFIRRMANN, O. (1994) Die Bestimmung regionaler Innovationsdisparitäten, *Raumforschung und Raumordnung*, 52, pp. 203-211.

PIORE, M.J. and SABEL, C.F. (1984) *The Second Industrial Divide. Possibilities for Prosperity*. New York: Basic Books.

POWELL, W.W. (1990) Neither market nor hierarchy. Network forms of organization, STAW, B.M. and CUMMINGS, L.L. (Eds.) *Research in Organizational Behavior*, Vol. 12, pp. 295-336. Greenwich: JAI Press.

PYKE, F., BECATTINI, G. and SENGENBERGER, W. (1990) *Industrial districts and inter-firm co-operation in Italy*. Geneva: International Institute for Labour Studies.

REID, S. and GARNSEY, E. (1998) How Do Small Companies Learn? Organisational Learning & Knowledge Management in the High-Tech Small Firm, HIGH-TECHNOLOGY SMALL FIRMS CONFERENCE The 6th Annual International Conference at the University of Twente, the Netherlands. Proceedings, Vol. 1, pp. 391-401. Twente: University of Twente.

RITTER, T. (1998) *Innovationserfolg durch Netzwerkkompetenz. Effektives Management von Unternehmensnetzwerken*. Wiesbaden: Gabler Verlag.

ROSENBERG, N. (1990) Why do firms do basic research (with their own money)?, *Research Policy*, 19, pp. 165-174.

ROTHWELL, R. (1989) Small firms, innovation and industrial change, *Small Business Economics*, 1, pp. 51-64.

SAVIOTTI, P.P. (1998) On the dynamics of appropriability, of tacit and of codified knowledge, *Research Policy*, 26, pp. 843-856.

SCHAMP, E.W. (1986) Industriestandort und Wirtschaftsdienste im ländlichen Raum. Zum Reichweitenmuster der Dienstleistungsnachfrage von Industrieunternehmen in Niedersachsen, *Berichte zur deutschen Landeskunde*, 60, pp. 201-226.

SCHERER, F.M. (1980) *Industrial Market Structure and Economic Performance*, 2nd edition. Chicago: Rand McNally College Publ.

SCHUMPETER, J.A. (1942) *Capitalism, Socialism and Democracy*. New York [quoted from the German version, 4th edition, München: Francke 1975].

SCHUMPETER, J.A. (1911) *Theorie der wirtschaftlichen Entwicklung*. München [quoted from the 8th edition, Berlin: DunckerHumblot 1993]

SCOTT, A.J. (1995) The Geographic Foundations of Industrial Performance, *Competion and Change,* 1, pp. 51-66.

SENGENBERGER, W. and PYKE, F. (1992) Industrial districts and local economic regeneration. Research and policy issues, PYKE, F. and SENGENBERGER, W. (Eds.) *Industrial districts and local economic regeneration*, pp. 3-30. Geneva: International Institute for Labour Studies.

SPENDER, J.-C. (1996) Making Knowledge the Basis of a Dynamic Theory of the Firm, *Strategic Management Journal*, 17, pp. 45-62.

STERNBERG, R. (1998) Innovierende Industrieunternehmen und ihre Einbindung in intraregionale versus interregionale Netzwerke, *Raumforschung und Raumordnung*, 56, pp. 288-298.

STORPER, M. (1997) *The Regional World. Territorial Development in a Global Economy*. Guilford Press, New York.

STORPER, M. (1995) The Resurgence of Regional Economies, Ten Years Later: The Region as a Nexus of Untraded Interdependencies, *European Urban and Regional Studies,* 2, pp. 191-221.

STRAMBACH, S. (1995) *Wissensintensive unternehmensorientierte Dienstleistungen. Netzwerke und Interaktion. Am Beispiel des Rhein-Neckar-Raumes*. Münster: Lit-Verlag.

TETHER, B.S. (1998) Small and large firms: sources of unequal innovations?, *Research Policy*, 27, pp. 725-745.

TETHER, B.S., SMITH, I.J. and THWAITES, A.T. (1997) Smaller enterprises and innovation in the UK: the SPRU Innovations Database revisited, *Research Policy,* 26, pp. 19-32.

WOOD, P. (1995) Business Services, the Management of Change and Regional Development in the UK: A Corporate Client Perspective, *Working Paper Series*, 23. Cambridge: University of Cambridge.

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References

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Knowledge, Innovation Processes and Regions*

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1 Introduction

The expanding field of economic literature devoted to knowledge production and diffusion strongly emphasises that knowledge is increasingly becoming a crucial resource for growth. Moreover, the issues of knowledge and innovation appear as intimately inter-related, underlining their decisive influence for the competitiveness of firms and countries, but also for the development and prosperity of regions. In fact, and this is only a paradox at first glance, despite (and even to a certain extent, due to) its intangible nature knowledge is not ideas floating in a purely abstract vacuum but is rooted in the economic reality, and is thus, at least partially, linked to territories. This paper aims at highlighting the complex relations between knowledge, innovation and regions. In the first section, a brief theoretical overview provides the key conceptual elements which allow the mechanisms of knowledge creation and diffusion and their implications for innovation and regional development to be questioned. The second section of the paper offers an illustration of how knowledge exchanges between different categories of actors may take place. The proposed typology displays some stylised facts related notably to the spatial patterns of innovation interactions. Finally, the concluding part raises several issues which can be considered from the researcher's as well as from the policy-maker's points of view.

2 From knowledge to regions: a theoretical overview

This first section is devoted to the theoretical aspects of the interrelations between knowledge, innovation and regions. At first, the difference between knowledge and information is established, which is completed by the distinction between tacit and

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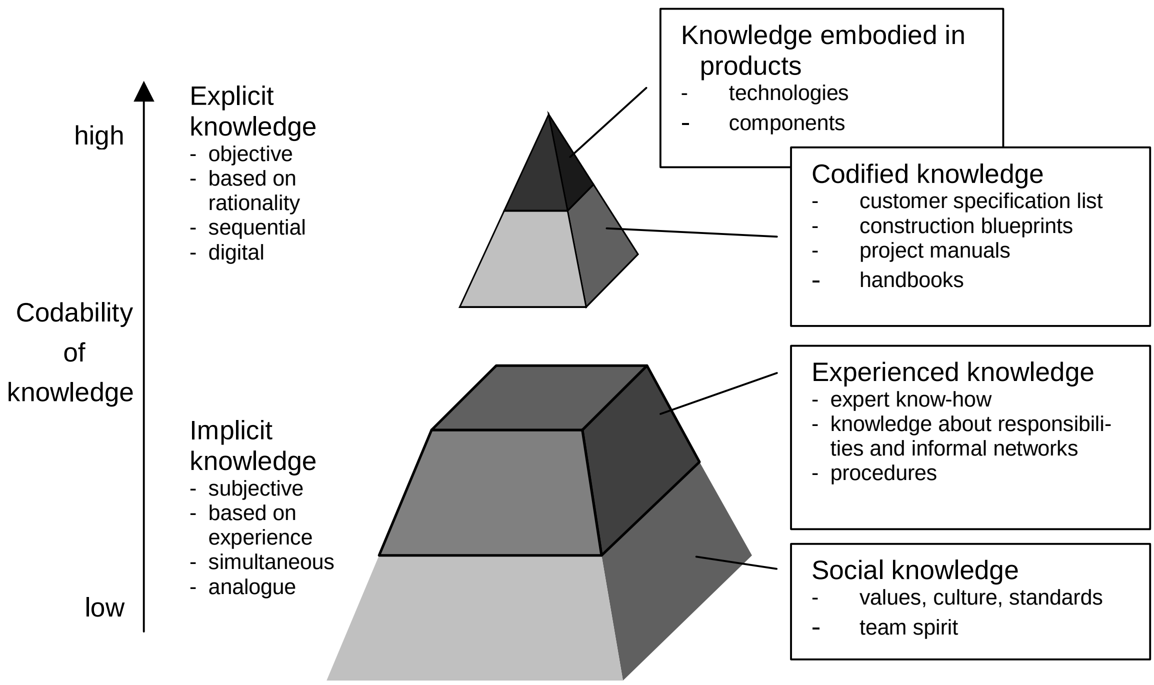
codified knowledge. This leads to a consideration of innovation, in line with the evolutionary approach of innovation, as a cycle associating tacit and codified knowledge within firms and between firms and further actors. Finally, the issues of knowledge sharing and innovation interactions on a regional level are addressed.

Dealing with knowledge implies a critical attempt to define its nature. In this respect, it seems particularly important to stress that knowledge is more than a sum of information. Nonaka (1994) underlines the necessity to distinguish clearly between "information" and "knowledge", although they are sometimes used as synonyms. In this respect, information can be considered as a flow of messages or meanings *which might add to*, *restructure* or *modify* knowledge. Information is thus a necessary and inseparable *medium* for establishing and formalising knowledge. More precisely, one may refer to the distinction provided by Laborit (1974), between: (i) circulating information, (i.e. routinised and repetitive information); and (ii) structuring information, (i.e. information liable to provoke or to favour an adaptation or a transformation and leading to non-routinised decisions). This distinction (cf. Ancori 1983) reviews in fact two visions of communication: the *Shannonian* approach (in which information is reduced to the status of signals, and communication consists of the transmission of these signals) and the *Batesonian* one. In this latest approach, informational flows which lead to "alterations" of the system are introduced in the analysis. Considering for instance a firm, its aptitude to organise its informational flows and to "extract them from/combine them with" its informational stock can be seen as the expression of its **knowledge-base**. This perspective allows the establishment of the distinction between information and knowledge. At the same time, it highlights the economic importance of knowledge, and consequently of learning. As Cooke (1998: 8) put it: "*Knowledge plays a fundamental role: the constitution of a firm is mediated by the knowledge possessed by the founder or 'creative agent' and developed by learning. Firms learn from their own experience, but also from other firms they work with and with whom they share information, knowledge and technologies*."

The economic understanding of knowledge relates primarily to the process of knowledge creation and diffusion within the economy. To grasp this process, it is necessary to consider the issues of codability and codification of knowledge. The distinction between tacit and codified knowledge has been established by Polanyi (1966). Whereas **codified knowledge** is easily transmittable in a formal and systematic language (comprising words, figures, etc.), **tacit knowledge** always has an implicit or individual related character (strongly based on personal experience) which makes its formalisation and exchange difficult. The "knowledge pyramid" provides a possible representation (among others) of the distinction between tacit and codified knowledge (cf. figure 1). Nevertheless, it is important to keep in mind that these two forms complement rather than substitute each other. In fact, they tend to co-evolve: the process of codification generates new tacit knowledge. For instance, the ability of an individual to understand or interpret the codes in which knowledge is articulated is itself based on tacit knowledge, which can only be acquired through practice and experience. "*Any organization that dynamically deals with a changing environment ought not only to process information efficiently, but also create information and knowledge*", asserts Nonaka (1994: 14). This circulation of knowledge implies its transformation along two dimensions (explicit/tacit - individual/social). Focussing on firms and on innovation activities, the knowledge-base of a firm can be interpreted as a combination of *tacit* (or implicit) and of *codified* (or explicit) knowledge. The expansion of a firm's knowledge base can be realised by the exploitation of internal search capacities or by the acquisition of external knowledge (cf. Saviotti 1998). In this respect, a firm's expansion depends on the "absorptive capacities" it develops (cf. Cohen and Levinthal 1989). To sum up, knowledge constitutes a pre-condition for understanding (new) information; and to create (additional) information. Consequently, knowledge is intimately interrelated to innovation processes.

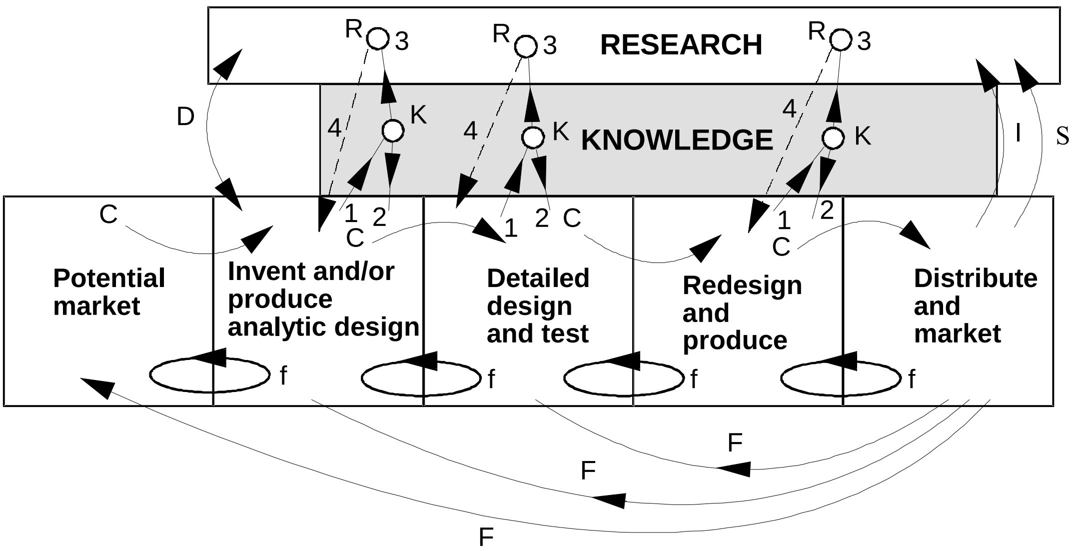
Figure 1: The pyramid of knowledge



Adapted from: Gassmann (1997: 152)

The phenomenon of innovation can be conceived as an evolutionary process based on knowledge. This vision corresponds to the approach adopted by evolutionary economics (cf. Nelson and Winter 1974, 1975, 1977). The central role played by knowledge for innovation is ideally depicted by Kline and Rosenberg (1986) in their "**chain-linked model**". This model can be interpreted on different levels: while the (traditional) linear model features only one single level, the "chain-linked model" comprises five of them (cf. figure 2). The first level consists of the central chain which - extending from the "conception" to the "distribution" of innovation - can be seen as the integration of the linear model. The second level is constituted of the feed-back loops associating phases of the central chain: each stage is linked to the preceding one, and the last (marketing and distribution) to all the other phases. The third level links the central chain of innovation to research[21] which constitutes a kind of "knowledge-stock" likely to stimulate each step of the innovation process (and not only its beginning, in contrast to the linear model). The last levels are less frequent and feature situations where respectively: (i) dramatic scientific shifts generate radical innovations; and (ii) innovations support the expansion of scientific knowledge.

Figure 2: The chain-linked model



C = Central chain-of-innovation
f = Feedback loops
F = Particularly important feedback
K-R = Links through knowledge to research and return paths. If problem solved at node K, link 3 to R not activated. Return from research (link 4) is problematic - therefore dashed line.
D = Direct link to and from research from problems in invention and design.
I = Support of scientific research by instruments, machines, tools, and procedures of technology.
S = Support of research in sciences underlying product area to gain information directly and by monitoring outside work. The information obtained may apply anywhere along the chain.

Source: Kline and Rosenberg (1986: 290)

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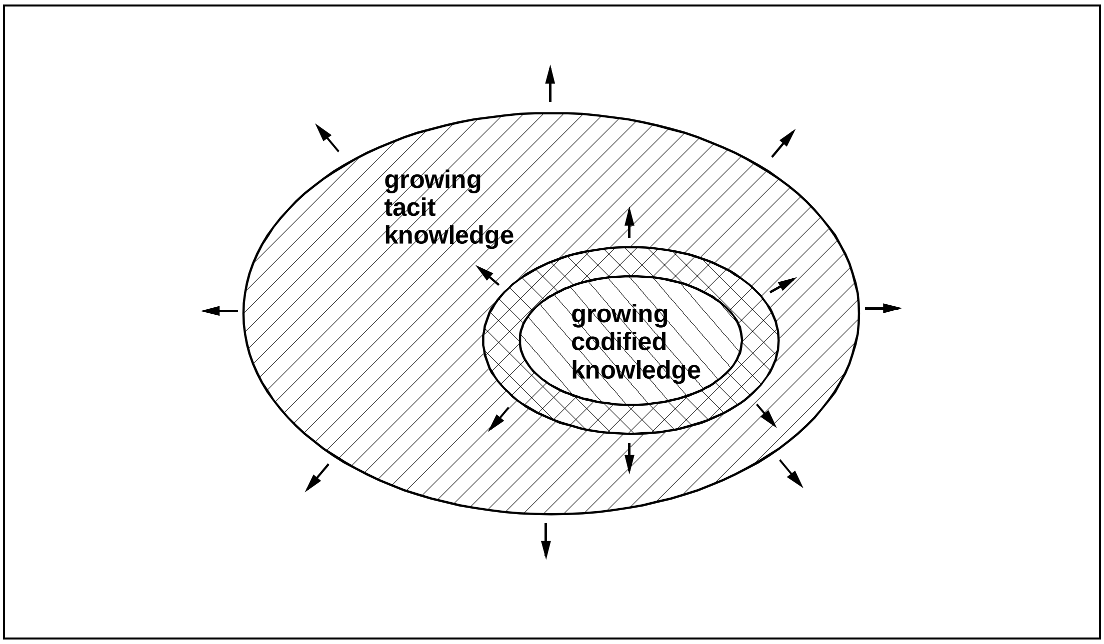
21 The term *research* encompasses internal and external activities.

The phenomenon of innovation should be understood as a **cycle involving interaction between tacit and codified knowledge**. To make the link with the approach adopted by evolutionary economics, it is possible to assert that: (i) firms are organisations which apply different inputs, one of the most relevant for innovation being *information*; (ii) information is *accumulated in* and *processed by* the knowledge base of the firm; and (iii) *knowledge accumulation* and *knowledge processing* by firms results from learning. From a dynamic perspective, knowledge can be seen as expanding by associating in different forms, tacit and codified knowledge.[22] On the one hand, the codification of tacit knowledge allows an availability of knowledge which increases with time. On the other hand, the dynamic expansion of codified knowledge generates the apparition of new areas of tacit knowledge (cf. figure 3).

Figure 3: A context of expanding knowledge



Source: Muller *et al.* (1998: 6)

Three further observations may be relevant before introducing the regional dimension in the analysis of the relations between knowledge and innovation. Firstly, the above developed conception of the knowledge base of the firm authorises (and furthermore implies) the existence of **shared learning effects**. Shared learning effects correspond to situations where learning occurs simultaneously within and outside a given organisation, for instance, when learning takes place in two firms at the same time. It can quite easily be assumed that shared learning effects may influence the innovativeness of firms. The second observation concerns **the growing possibilities**

22 For a detailed analysis of knowledge creation, transformation and diffusion within firms, see Nonaka (1994).

of using new means of codification in the production of knowledge, notably (but not exclusively) due to the dramatic development of information and communication technologies (ICT). These new means of codification affect notably: (i) the generation of new knowledge by firms; (ii) the storing of and access to top knowledge within firms; and (iii) the exchange between firms and further actors. Moreover, these three are strongly inter-related and mutually reinforcing. Finally, considering that the development of a firm's knowledge base (through learning) determines its competencies (and thus its innovativeness), it appears that the **learning process is path dependent**. In fact, the development of competencies by a firm is path dependent in the sense that: (i) a firm learning consists of the combination of "knowledge items" taking different forms (for instance tacit and codified) which implies having been previously acquired or generated ; (ii) this combination refers to an application, i.e. a further step in the process. This remark seems valid even if one considers particular cases in which, for instance, organisational forgetting is a necessary step of the learning process.

Regional learning directed towards innovation is not simply the acquisition of information by firms or groups of firms located within a specific territorial unit defined as a region. It may seem more judicious to consider regional learning as a process by which information available (inside and outside the region) to regional actors becomes usable knowledge for firms located in the region. In this respect, the **role and impact of innovation systems** can be examined by distinguishing mainly two levels: the national and the regional one. Systems may be defined in this context as "*complexes of elements or components, which mutually condition and constrain one another, so that the whole complex works together, with some reasonably clearly defined overall function*" (Edquist 1997: 13). In the continuation of Freeman (1987) and Lundvall (1988; 1992) abundant literature can be found related to national innovation systems (NIS). The regional innovation system (RIS) approach (cf. Cooke *et al.* 1996; Cooke 1998) encompasses the concepts of "industrial district", "innovative milieu" and "regional learning" to the greatest extent. It allows a summary of the arguments in favour of an influence of the regional environment on firms' innovation capacities.[23] RIS can be perceived as a transposition of NIS on the regional level. From both regional and national perspectives, the system of innovation is constituted by elements and relationships interacting in the production, diffusion and use of new knowledge. Thus, it provides a set of arguments highlighting why and how certain regions (and *a fortiori* some countries) are more innovative than others.

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23 An alternative perception, which can be found in the literature but is not retained here, should be briefly evoked. In fact, it is possible to define a region from an economic perspective, for instance with the help of the approach in terms of clusters (in the sense of industrial clusters given by Porter 1990). From this point of view, the industrial cluster may be seen as the sum of all the economic actors contributing directly to the dominant production process of the considered region.

In fact, considering innovative regions, the previously evoked circulation and combination of knowledge is achieved by two main (non–exclusive) methods: (i) the activity and mobility of skilled personnel; and (ii) the development of formal and informal relations of co-operation among actors. In both cases, the ability to transfer knowledge within the region (and to a certain extent the aptitude to catch up with knowledge from outside the region) will depend on a common language and on a shared knowledge base. In this respect, as Keeble and Wilkinson (1999: 299) put it : "*Tacit knowledge* (...) *is specific to organizational and geographic locations and this increases its internal circulation but impedes its external accessibility.*" In other words, localised innovation networks favour an efficient circulation of codified knowledge since the structure of the interactions makes different segments of specific tacit forms of knowledge compatible. More generally, referring to the arguments developed by Lawson and Lorenz (1999), the processes underlying regional collective learning can be examined along three central ideas. Firstly, the overall attitude towards innovation within a region, which relies on the concept of **regional innovation culture**. A lack of innovation culture has as a consequence developed regional inertia, meaning that firms face resistance when trying to introduce, to use and to diffuse new knowledge[24]. Secondly, the resources potentially available within a region in terms of knowledge bases and possible knowledge combination constitute the **regional innovation potential**. As exposed previously, learning, notably with respect to innovation, is a path dependent and cumulative process. The search for and access to new knowledge which becomes incorporated into the regional firm's routines in an incremental manner enables the introduction of innovations (*i.e.* mostly incremental and exceptionally radical innovations). Finally, the willingness of regional actors to be open to knowledge sharing and their ability to exchange ideas on the issue of innovation constitute the aptitude to build up **regional innovation networks**. The existence of a "common language" or, more generally, of a business and regionally rooted culture explains that such networks may resolve the problems of co-ordination/competition which inevitably arise when knowledge becomes shared on innovation issues.

Considering the **policy implications of regional learning** in terms of innovation support, it seems clear nowadays that the nature and frequency of interactions between actors, notably in the form of networks, influence regional development (cf. for instance Braczyk *et al.* 1998). Nevertheless, and this probably constitutes one of the main policy challenges for European regions, no unique way to foster regional innovation capacities and to ensure some competitive advantage can be established. In this context, the multiplication of innovation-related initiatives, notably initiated by the European Union, can be interpreted as a willingness to promote the conditions for sustained knowledge-based economic development on a regional level (for

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24 To a certain extent, it is possible here to make the link with the GREMI (*Groupe de Recherche Européen sur les Milieux Innovateurs*) approach related to "innovative milieux" (cf. for instance Perrin 1990; Maillat and Perrin 1992).

an introduction and overview of regional innovation-related initiatives supported by the European Union, cf. for instance Landabaso, 1997, and Larédo 1995). Learning is the key component of those policy tools. In fact, such initiatives may be considered as a form of social engineering, since they aim at the establishment and development of what Landabaso *et al.* (1999) call the "social capital" of a region. "*The more a region (or a company) is in a position to learn (identify, understand and exploit knowledge* [...]*) the more capable, and possibly willing, it becomes to build on and increase its demand and capacity to use further new knowledge*." (Landabaso *et al.* 1999: 6). Considering the issue of regional competitive advantages, localised innovation networks (which are rooted in the region, even if those networks include actors from "outside", which can be desirable and useful) appear as even more decisive than the skills of the regional labour force (since highly skilled personnel may "escape" from the regional system). In fact, for a region, the establishment and development of a "social capital" is a way to master capabilities which cannot simply be transferred or easily replicated elsewhere. In this respect, the co-existence (within a country, a continent or even in a globalized world) of various types of regional environment, corresponding to different innovation-related infrastructural qualities, implies specific functional organisation of knowledge-related activities. Nevertheless, this does not necessarily imply that regional inequalities in terms of innovation infrastructure cannot be successfully compensated for, refuting the belief in "territorial fatality" (Muller 1999a).

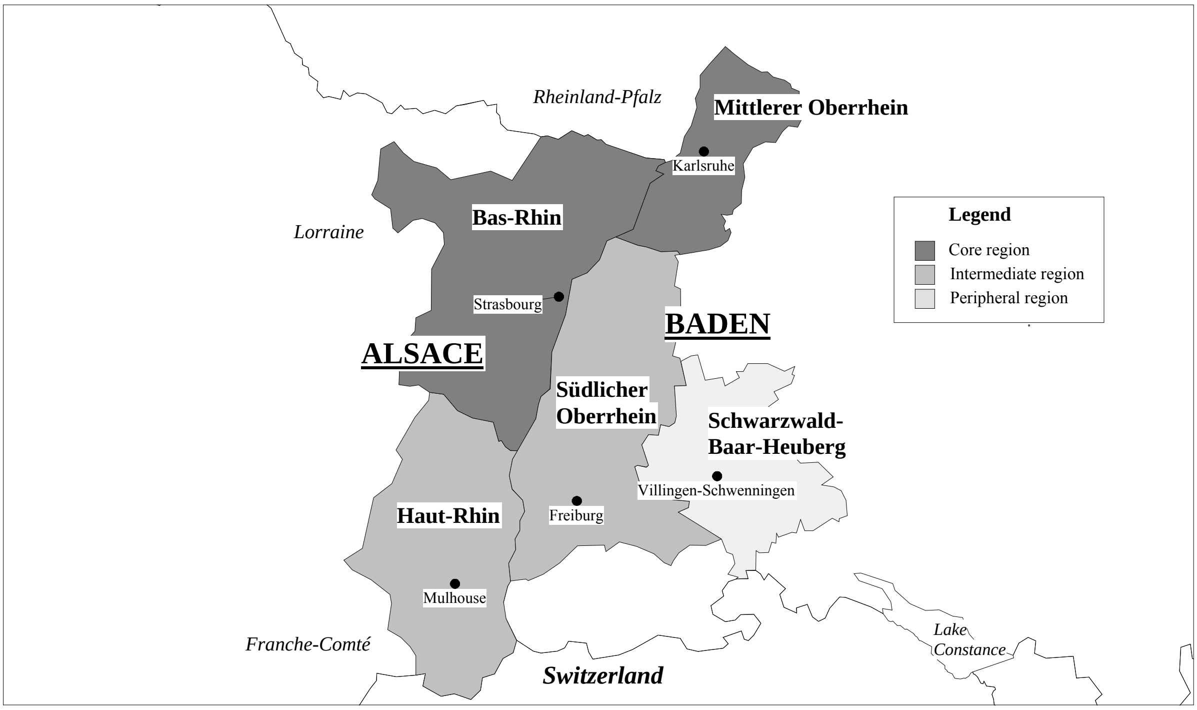
3 An illustration of the influence of spatial patterns on knowledge interactions

A comprehensive theory-oriented literature can be found concerning the links between knowledge and innovation on a regional level; nevertheless these reflections are only supported by parceled and heterogeneous empirical studies. This second section of the paper provides an illustration of knowledge interactions and of their spatial patterns. This example is extracted from a broader body of empirical investigation dealing with regional innovation potential and focusing notably on the examination of interlinkages between three types of actors: (i) manufacturing firms (and in particular SMEs); (ii) knowledge-intensive business service firms (KIBS); and (iii) universities and research institution labs (also called institutions of technical infrastructure or ITI).[25] The illustration below corresponds to a part of the sur-

[25] This operation entitled "Analysis of regional innovation potential from a European perspective" (1994-1998) was granted by the *Deutsche Forschungsgemeinschaft* (DFG, the German Research Council) and designed conjointly by three research teams. The joint research project involved the Department of Economic Geography at the University of Hannover, the Faculty of Economics and Business Administration of the Technical University Bergakademie Freiberg and the Fraunhofer Institute for Systems and Innovation Research (FhG ISI) in Karlsruhe. A recent special is-

vey performed for the border regions of Alsace and Baden. In terms of forms of knowledge involved, this area is particularly interesting for the analysis, since it corresponds to territories which belong to two different national innovation systems, and contains five (administrative) sub-units presenting different resources in terms of innovation–related infrastructures (cf. figure 4). The aim here is not to display detailed results specific to this area, but to try to benefit from the empirical results accumulated in order to go one step further in the reflection about knowledge, innovation processes and regions.[26] More precisely, the consequences in terms of innovation and the spatial patterns of knowledge interactions between different categories of actors are considered.

Figure 4: The surveyed regions



Source: Muller (1999b: 85)

The typology of innovation interactions proposed hereby as an illustration is entitled "the wheel of knowledge interactions" (cf. figure 5). It aims at featuring knowledge exchanges encompassing:

(i) manufacturing SMEs;

(ii) KIBS;

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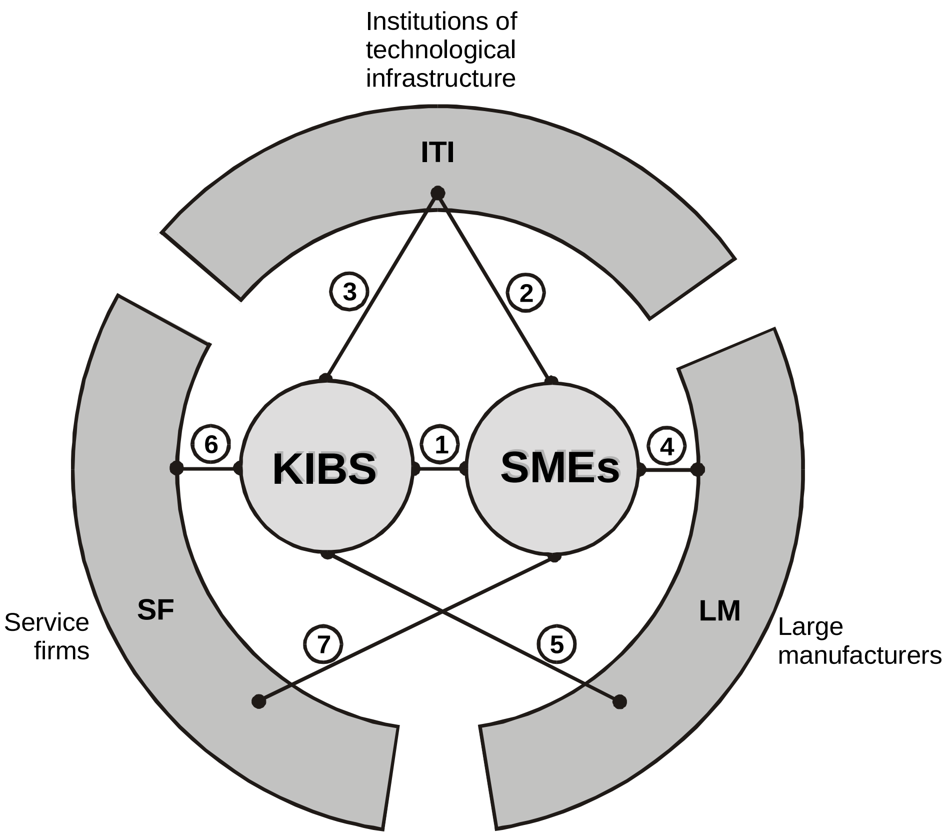
sue of the review *Raumordnung und Raumforschung* (RuR 4, 1998) presents different aspects of the methodology and of the results of the overall project.

26 Detailed empirical results dealing with the case of Alsace and Baden can be found in Koschatzky (1997), Muller (1997), Muller and Zenker (1998), Héraud and Muller (1998), Muller (1999b), Koschatzky (1999).

(iii) institutions of technological infrastructure (ITI);
(iv) large manufacturers (*i.e.* not small and medium-sized firms); and
(v) further service firms (*i.e.* non-KIBS).

A set of approximately 40 personal interviews performed in Alsace and Baden contributed to the establishment of this typology (cf. Muller 1999b: 154-159).[27] The issues of the role and impact of KIBS and ITI are the object of further attention in the present literature: see notably Strambach concerning KIBS and Héraud & Bureth (already referred to in this reader) for analysis related to ITI. The "wheel of knowledge" constitutes a basic representation displaying in a speculative manner some stylised facts about knowledge exchanges. Seven types of interactions or "links" are schematically depicted according to (i) the type of knowledge involved; (ii) the spatial patterns of the considered interactions; and (iii) the influence in terms of firms' innovations.

Figure 5: The wheel of knowledge interactions involving KIBS and SMEs



Source: Muller (1999b: 151)

[27] The interviews, performed during the first semester of 1997, dealt with SMEs, KIBS, research labs and regional innovation-support organisations identified mainly on the basis of a postal survey. The aim was to gain additional qualitative information supplying the mainly quantitative character of the overall investigation (cf. Muller 1999b: 77-138).

(1) **Links between SMEs and KIBS**. This relation is characterised by the mutual impact of interaction between SMEs and KIBS on their respective innovation capacities. Considering empirical results (cf. Muller 1999b: 139-147), it can be assumed that: (i) when knowledge flows from SMEs to KIBS the knowledge transmitted is mainly of a tacit nature and proximity plays an important role; and (ii) when knowledge flows from KIBS to SMEs, proximity appears to be less important because the transmitted knowledge is mainly codified.

(2) **Links between SMEs and ITI**. The direct links between SMEs and ITI have as their main function to support and reinforce SMEs' innovation potential. It can be assumed that knowledge exchanges are most often of a codified nature. In this context, proximity between SMEs and ITI is probably not neutral (particularly due to knowledge transmission-related costs), but is nevertheless also not determinant: the specificity of the knowledge required is in fact the main selection factor.

(3) **Links between KIBS and ITI**. In general, the same basic assumptions can be advanced as for the relations, which are more common, between SMEs and ITI. One may even suppose that the need for (highly specialised) codified knowledge determines the links between KIBS and ITI and that, as a consequence, proximity only has little or no impact on those knowledge exchanges.

(4) **Links between SMEs and large manufacturers**. It is possible to speculate on the nature of the knowledge exchanges between SMEs and large manufacturers by comparing two cases schematically. The first case relates to innovations corresponding to the adoption by an SME of new techniques developed by large manufacturers. In this situation, the knowledge transmitted (for instance embodied in equipment) can be seen rather as codified than tacit and proximity as exerting little or no influence on the relation. The second case relates to specific development (of products, of processes, ...) performed by an SME in order to satisfy the requirements of a large manufacturing client. This corresponds for instance typically to sub-contracting situations. In comparison to the first case considered, it can be assumed that tacit knowledge potentially plays a greater role in the transmission of knowledge (from the SME to the large manufacturer) and that proximity favours the exchange of knowledge to a certain extent.

(5) **Links between KIBS and large manufacturers**. Three typical situations can be used to depict these relationships. The first situation is the adoption by a KIBS of artefacts produced by large manufacturers. The adoption induces associated organisational change (such as, for instance, related equipment in the case of information technologies). In such a situation, knowledge exchanges can be seen as mainly codified (strongly embodied in the artefacts) and relatively insensible to proximity effects. The second situation relates to knowledge exchanges taking the form of support (for instance managerial consultancy) provided by KIBS to large manufacturers. Such support constitutes a potential source of (internal) innovation for KIBS. It can be interpreted as the application

of knowledge which is partly tacit and partly codified. In this case, it is also realistic to consider that it only plays a marginal role. The third situation depicts KIBS resulting from the outsourcing of a specific activity initiated by a large manufacturer. In comparison to the two previous forms of relations, this type of interaction is characterised rather by the circulation of specific tacit knowledge and by the importance given to proximity between the partners.

(6) **Links between KIBS and service firms**. Service firms represent one of the most important groups of customers for KIBS. The effects of relations with (non-KIBS) service firms on KIBS' innovation capacities rely mainly on the concept of new services or on the evolution of existing ones (in order to fulfil service firms' emerging or changing needs). These relations can mainly be considered as a process of knowledge codification: (i) which takes place in the client firms; (ii) which is based on KIBS accumulated tacit knowledge; and (iii) for which proximity is rather unimportant.

(7) **Links between SMEs and service firms**. In contrast to the interactions involving KIBS, the knowledge exchanges which take place between SMEs and service firms correspond rather to routine services and thus have a relatively small impact on SMEs' innovation capacities. The type of knowledge involved and the role of proximity depends strongly on: (i) the degree of standardisation of the activity associating SMEs and service firms; and (ii) the importance of elements like trust for the service relation. Schematically, highly standardised services (typically based on the application of codified knowledge and by which the question of proximity is only related to cost effects) can be compared to more specific services (which imply a greater proportion of tacit knowledge and for which proximity is at least potentially important due to the necessity of a trusting relationship between the SME and the service firm).

4 Conclusion: Research and policy agenda

When trying to answer the question "what shall we do in the future to better understand the relations between knowledge, innovation processes and regions?", it seems important to proceed along three main axes: (i) the concepts on which forthcoming analyses will be based; (ii) the tools which may be useful for performing these analyses and (iii) the policies required for supporting knowledge development, notably on a regional level. New concepts are needed to respond to the challenging and complex issues raised by the drastic expansion of the place of knowledge in economic activities. It can reasonably be considered that only a reinforced movement of interdisciplinary reflections (associating notably epistemology, sociology and psychology to economics) may allow new concepts to flourish. Nevertheless, new concepts need to be accompanied by new tools, destined notably to improve measuring in a satisfactory manner, and thus to better understand the multiplicity of phenomena related to knowledge creation and diffusion. In this respect, investigation instruments such as multifactor analysis, neuronal networks and fuzzy indicators seem worth examining. Finally, new challenges call for new policies: a knowledge-ruled economy offers new perspectives for innovation-based regional development. In the European context especially, due to the double pressure of a reinforced need for regional convergence within the European Union and of the emergence of requirements linked to the possible expansion of the Union eastwords and southwords, regional development policies appear more decisive than ever for the future.

5 Bibliography

ANCORI, B. (1983): Communication, information et pouvoir, LICHNEROWICZ, A./PERROUX, F./GADOFFRE, G. (Eds): *Information et communication*. Maloine:Verlag, pp. 59-84.

BRACZYK, H.J./COOKE, P./HEIDENREICH, M. (1998) (Eds): *Regional Innovation Systems - The Role of Governance in a Globalized World*. London: UCL Press.

COHEN, W./LEVINTHAL, D. (1989): Innovation and Learning, the Two Faces of R&D, *Economic Journal*. 99, pp. 569-596.

COOKE, P. (1998): Origins of the concept, BRACZYK, H.J./COOKE, P./HEIDENREICH, M. (1998) (Eds): *Regional Innovation Systems - The Role of Governance in a Globalized World*. London: UCL Press, pp. 2-25.

COOKE, P./BOEKHOLT, P./SCHALL, N./SCHIENSTOCK, G. (1996): *Regional Innovation Systems: Concepts, Analysis and Typology*. Paper presented during the EU-RESTPOR Conference "Global Comparison of Regional RTD and Innovation Strategies for Development and Cohesion". Brussels, 19-21 September.

EDQUIST, C. (Ed.) (1997): *Systems of Innovation. Technologies, Institutions and Organizations*. London: Pinter Publishers.

FREEMAN, C. (1987): *Technology Policy and Economic Performance: Lessons from Japan*. London: Pinter Publishers.

GASSMANN, O. (1997): *Internationales F&E-Management*. München: Oldenbourg Verlag.

HÉRAUD, J.-A./MULLER, E. (1998): *The Impact of Universities and Research Institutions Labs on the Creation and Diffusion of Innovation-Relevant Knowledge: the Case of the Upper-Rhine Valley*. Paper presented at the 38th Congress of the European Regional Science Association, August 28-31 1998, Vienna.

KEEBLE, D./WILKINSON, F. (1999): Collective learning and knowledge development in the evolution of regional clusters of high technology SMEs in Europe, *Regional Studies*. 33, pp. 295-303.

KLINE, S./ROSENBERG, N. (1986): An Overview of Innovation, LANDAU, R./ROSENBERG, N. (Eds.) (1986) *The Positive Sum Strategy: Harnessing Technology for Economic Growth*. Washington D.C.: National Academy Press, pp. 275-305.

KOSCHATZKY, K. (1997): *Entwicklungs- und Innovationspotentiale der Industrie in Baden*. Erste Ergebnisse einer Unternehmensbefragung. Karlsruhe: Fraunhofer-ISI (Arbeitspapier Regionalforschung Nr. 5).

KOSCHATZKY, K. (1999): Innovation Networks of Industry and Business-Related Services – Relations Between Innovation Intensity of Firms and Regional Inter-Firm Cooperation, *European Planning Studies*, pp. 737-757.

LABORIT, H. (1974): *La nouvelle grille*. Paris: Laffont.

LANDABASO, M. (1997): The promotion of innovation in regional policy: proposals for a regional innovation strategy, *Entrepreneurship & Regional Development,* 9, pp. 1-24.

LANDABASO, M./OUGHTON, C./MORGAN, K. (1999): *Learning regions in Europe: theory, policy and practice through the RIS experience*. Paper presented at the 3rd international conference on technology and innovation policy: assessment, commercialisation and application of science and technology and the management of knowledge. Austin, USA: August 30 - September 2, 1999.

LARÉDO, P. (1995): *A preliminary characterization of RITTS*. Paper presented at the workshop Regional Innovation and Technology Transfer Strategies and Infrastructures. Luxembourg: May 31, 1995.

LAWSON, C./LORENZ, E. (1999): Collective learning, tacit knowledge and regional innovation capacities, *Regional Studies,* 33, pp. 305-317.

LUNDVALL, B. A. (1988): Innovation as an Interactive Process: From User-Producer Interaction to the National System of Innovation. DOSI, G./FREEMAN, C./NELSON, R./SILVERBERG, G./SOETE, L. (Eds) (1988) *Technical Change and Economic Theory*. London: Pinter Publishers, pp. 349-369.

LUNDVALL, B.A. (Ed.)(1992): *National System of Innovation. Towards a Theory of Innovation and Interactive Learning*. London: Pinter Publishers.

MAILLAT, D./PERRIN, J.-C. (Eds.) (1992): *Entreprises innovatrices et développement territorial*. Neuchâtel: EDES.

MULLER, E. (1997): *Entwicklungs- und Innovationspotentiale der Industrie im Elsaß*. Karlsruhe: Fraunhofer-ISI (Arbeitspapier Regionalforschung Nr. 8).

MULLER, E. (1999a): *There is No Territorial Fatality! (or How Innovation Interactions between KIBS and SMEs May Modify the Development Patterns of Peripheral Regions).* Paper presented at the 39th ERSA (European Regional Science Association) Congress. Dublin: August 23-27, 1999.

MULLER, E. (1999b): *Innovation Interactions Between Knowledge-Intensive Business Services and Small and Medium-sized Enterprises – Analysis in Terms of Evolution, Knowledge and Territories*. Ph.D. dissertation, Faculté des Sciences Économiques et de Gestion. Strasbourg: Université Louis Pasteur.

MULLER, E./ZENKER, A. (1998): *Analysis of Innovation-oriented Networking Between R&D Intensive Small Firms and Knowledge Intensive Business Services - Empirical Evidence from France and Germany,* Proceedings of the High-Technology Small Firm Conference. Twente: University of Twente, pp. 175-203.

MULLER, E./ZENKER, A./MEYER-KRAHMER, F. (1998): *The Consequences of a Growing Codification of Knowledge on the Evolution Capacities of European Firms and Regions*. Karlsruhe: Working document FhG ISI.

NELSON, R./WINTER, S. (1974): Neoclassical vs Evolutionary Theories of Economic Growth. Critique and Prospectus, *Economic Journal,* December, pp. 886-905.

NELSON, R./WINTER, S. (1975): Growth Theory from an Evolutionary Perspective: The Differential Productivity Puzzle, *The American Economic Review,* 65, pp. 338-344.

NELSON, R./WINTER, S. (1977): In Search of a Useful Theory of Innovation, *Research Policy,* 6, pp. 36-76.

NONAKA, I. (1994): A Dynamic Theory of Organizational Knowledge Creation, *Organization Science,* 5, pp. 14-37.

PERRIN, J.-C. (1990): Organisation industrielle: La composante territoriale, *Revue d'Economie Industrielle*, 51, pp. 276-303.

POLANYI, M. (1966): *The Tacit Dimension*. New York: Doubleday.

PORTER, M. (1990): *The Competitive Advantage of Nations*. London: Macmillan.

SAVIOTTI, P. P. (1998): On the dynamics of appropriability, of tacit and of codified knowledge, *Research Policy*, 26, pp. 843-856.

Title

Knowledge-intensive Business Services (KIBS) and Regional Innovation Capacities

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References

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Introduction

The aim of the paper is to examine the links between the activities of knowledge-intensive business services (KIBS), the impact on innovation capacities of small and medium-sized manufacturing firms and the consequences in terms of unequal regional evolution patterns. Adopting an evolutionary perspective of innovation, the analysis tries to synthesise different approaches in order to highlight some aspects of the spatial repercussions of the production and diffusion of knowledge by KIBS. Empirical evidences is gained, based on the examination of firm samples corresponding to SMEs and KIBS located on five French and German regions. The core of the investigation consists of the three following key hypotheses:

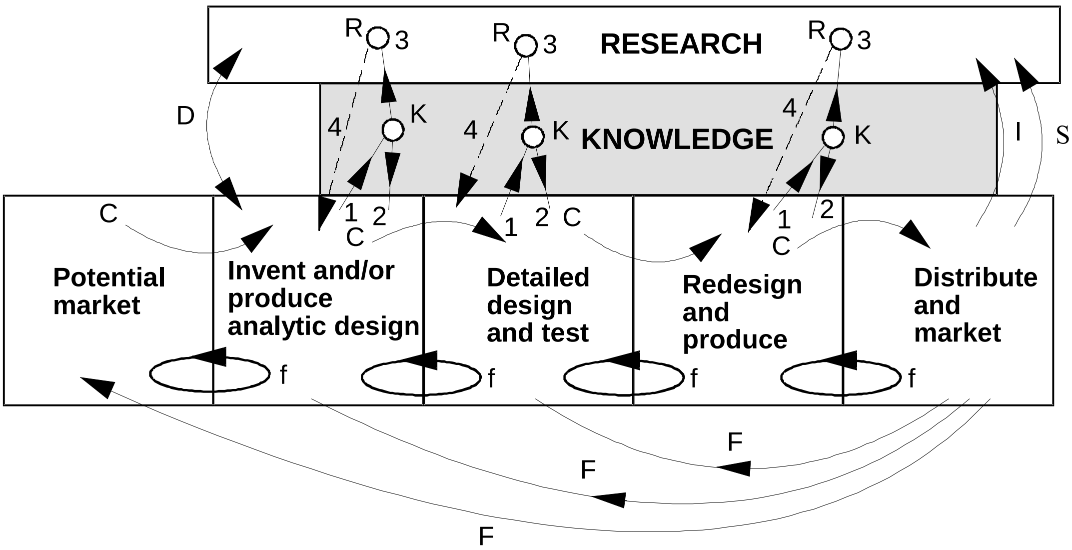
- Interactions between KIBS and SMEs have an impact on their respective innovation capacities.
- The location of SMEs and KIBS influences their behavioural patterns (*i.e.* their propensity to interact, their knowledge-related activities and their innovation capacities).
- At local level, the evolution patterns of SMEs and KIBS are influenced by their composition in structural terms (size, type of activity).

I. Innovation systems, KIBS and regions: a theoretical framework

1.1 Innovation: a knowledge-based process taking place within systems

Innovation constitutes a process. This perception of technical and managerial changes taking place within and between firms allows a systemic understanding of what innovation is. In fact, this phenomenon can be conceived as an evolutionary process based on knowledge and corresponds to the approach adopted by *neo-schumpeterian* or evolutionary economics (*cf.* notably Nelson and Winter, 1974, 1975, 1977 and Freeman, 1982). The central role played by knowledge for innovation is ideally depicted by Kline and Rosenberg (1986) in their "**chain-linked model**". This model can be interpreted in terms of different levels: while the (traditional) linear model features only one single level, the "chain-linked model" comprises five of them (*cf.* figure 1). The first level consists of the central chain which - extending from the "conception" to the "distribution" of innovation - can be seen as the integration of the linear model. The second level is constituted by the feed-back loops associating different phases of the central chain: each stage is linked to the preceding one, and the last (marketing and distribution) to all the other phases. The third level links the central chain of innovation to research which constitutes a kind of "knowledge-stock" likely to stimulate each step of the innovation process (and not only its start, contrary to the linear model). The last levels are less frequent and feature situations where respectively: (i) dramatic scientific shifts generate radical innovations; and (ii) innovations support the expansion of scientific knowledge. Consequently, it is possible to understand the phenomenon of innovation as a **cycle involving interaction between tacit and codified knowledge**. Linking this with the approach adopted by evolutionary economics, it is possible to assert that: (i) firms are organisations which apply different inputs, one of the most relevant for innovation being *information*; (ii) information is *accumulated in* and *processed by* the knowledge base of the firm; and (iii) *knowledge accumulation* and *knowledge processing* by firms results from learning. From a dynamic perspective, knowledge can be seen as expanding by associating under different forms, tacit and codified knowledge (for a detailed analysis of knowledge creation, transformation and diffusion within firms, see Nonaka, 1994). In other words, for instance the generation of new codified knowledge implies the apparition of new tacit knowledge.

Figure 1: The chain-linked model



C = Central chain-of-innovation
f = Feedback loops
F = Particularly important feedback
K-R = Links through knowledge to research and return paths. If problem solved at node K, link 3 to R not activated. Return from research (link 4) is problematic - therefore dashed line.
D = Direct link to and from research from problems in invention and design.
I = Support of scientific research by instruments, machines, tools, and procedures of technology.
S = Support of research in sciences underlying product area to gain information directly and by monitoring outside work. The information obtained may apply anywhere along the chain.

Source: Kline and Rosenberg (1986), p. 290

Single firms do not only develop their knowledge base by internal efforts, but also use external knowledge sources. As a consequence, the knowledge cycles leading to innovation result, at least partly, from interactions between different categories of actors. These categories of actors in turn may be considered as forming systems of innovation. Systems may be defined in this respect as "*complexes of elements or components, which mutually condition and constrain one another, so that the whole complex works together, with some reasonably clearly defined overall function*" (Edquist, 1997, p. 13). In fact, the analyses considering the **role and impact of innovation systems**, distinguishes mainly two levels: the national and the regional one. In the continuation of Freeman (1987) and Lundvall (1988 and 1992) abundant literature can be found related to national innovation systems (NIS). The regional innovation system (RIS) approach (*cf.* Cooke *et al.* 1996; Cooke 1998) encompasses the concepts of "industrial district", "innovative milieu" and "regional learning" to the greatest extent. It allows a synthesis of the arguments in favour of an influence of the regional environment on firms' innovation capacities. RIS can be perceived as a transposition of NIS at the regional level, referring to sub-national characteristics. To sum up, from both regional and national perspectives, the system of innovation is constituted by elements and relationships interacting in the production, diffusion and use of new knowledge. Thus, it provides a set of arguments highlighting why and how certain regions (and *a fortiori* some countries) are more innovative than others.

As a consequence, considering the role knowledge-intensive business services (KIBS) may play with regards to innovation, three points should deserve a particular attention. Firstly, innovation appears as a knowledge-based process and knowledge processing constitutes per definition the main activity of KIBS. Secondly, according to the evolutionary approach, innovation takes place not only in manufacturing firms, but also in services, and *a fortiori* in KIBS. Moreover, KIBS correspond to a dual position: at the same tine, they may support innovation in other firms and be the place of (internal) innovation. Finally, evolutionary economics underline that innovation is not the result of isolated research efforts but are rather the consequence of interactions influenced by systems which may have a territorial component, such as NIS and RIS. Consequently, the spatial location of KIBS and the spread of their interactions may affect the innovation capacities of such systems. In other words, keeping in mind the issue of the potential impact of KIBS on regional innovation capacities, the following questions must be addressed: (i) What is the nature of KIBS? and (ii) What is the meaning of KIBS' activities in terms of knowledge production and diffusion?

1.2 What are KIBS?

KIBS may be seen as consultancy firms (in a broad meaning), more generally "*knowledge intensive business services (KIBS) can be described as firms perform-*

ing, mainly for other firms, services encompassing a high intellectual value-added" (Muller, 1999, p. 2). Nevertheless, this general definition does not reflect the diversity of KIBS' forms and activities.

In this respect, it is worthwhile to turn to Miles *et al.* (1994) who identify two main KIBS categories, quoted KIBS I and KIBS II (*cf.* table 1). The authors establish a separation between (i) "traditional professional services" seen as liable to be intensive users of new technology (such as marketing, advertising and so on) and (ii) "new technology-based KIBS" (such as software design and other computer-related activities). To a certain extent, these categories overlap the distinction which is commonly employed (*cf.* for instance Koschatzky and Zenker, 1999) between (i) advisory services (such as legal activities, book-keeping and auditing activities, market research, business and management activities) and (ii) technical services (such as computer related activities, engineering and architectural activities, technical testing and analysis).

Table 1: The two main categories of KIBS

KIBS I: Traditional Professional Services, liable to be intensive users of new technology

- Marketing/advertising;
- Training (other than in new technologies);
- Design (other than that involving new technologies);
- Some Financial services (e.g. securities and stock-market-related activities);
- Office services (other than those involving new office equipment, and excluding 'physical' services like cleaning);
- Building services (e.g. architecture; surveying; construction engineering);
- Management consultancy (other than that involving new technology);
- Accounting and bookkeeping;
- Legal services;
- Environmental services (not involving new technology, e.g. environmental law, and not based on old technology, e.g. elementary waste disposal services).

KIBS II: New Technology-Based KIBS

- Computer networks/telematics;
- Some Telecommunications (especially new business services);
- Software;
- Other Computer-related services - e.g. Facilities Management;
- Training in new technologies;
- Design involving new technologies;
- Office services involving new office equipment;
- Building services (centrally involving new IT equipment such as Building Energy Management Systems);
- Management Consultancy involving new technology;
- Technical engineering;
- Environmental services involving new technology;
- R&D Consultancy and 'high-tech boutiques'.

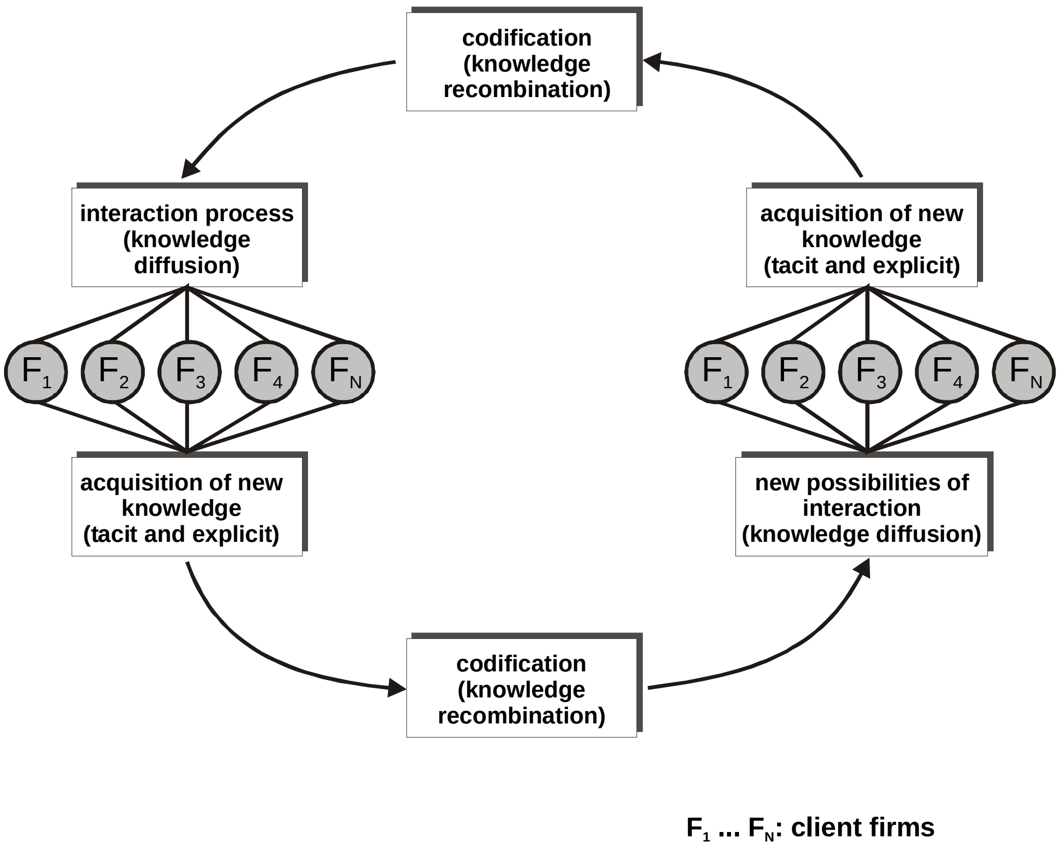
Source: Miles et al. (1994), pp. 19-20

Additionally to their economic activity, it is also possible to characterise KIBS according to the nature of the functions they fulfil for their clients. Three main common features can be underlined (i) the knowledge-intensity of the service provided by KIBS for their clients which distinguishes them from other types of services, (ii) the function of consulting (which could be also expressed as problem-solving function), and (iii) the strongly interactive or client-related character of the service provided. This specificity of the functions fulfilled by KIBS for their clients allows to grasp how knowledge is produced and diffused by KIBS.

1.3 The production and diffusion of knowledge by KIBS

Focussing on the service provided by KIBS, it is possible (referring to Strambach, 2000) to present a knowledge cycle - involving KIBS and their clients - distinguishing three main stages in the process of knowledge production and diffusion by KIBS: i) the acquisition of new knowledge, ii) a stage of knowledge recombination, and iii) the transfer of knowledge towards the client firm (*cf.* figure 2).

Figure 2: Knowledge production and diffusion as a result of KIBS activities



Adapted from Strambach (2000)

The acquisition of new knowledge takes place in contact with the client firms. This interaction-based generation of knowledge consists mainly in learning by trying to solve problems on behalf of the client firms. During the second stage, a recombination of the knowledge acquired previously is performed. This takes the form of a partial codification of the acquired knowledge, which in turn favours the mastering of this "new created knowledge". To a certain extent, as underlined by Strambach (2000), this allows KIBS to create their own market. Finally, the application of this knowledge under the form of new or enhanced services constitutes a partial transfer of knowledge from the KIBS to its client firms. As one may observe, the diffusion of knowledge is interrelated with new possibilities for interaction and knowledge generation and form (at least potentially) a loop.

From a systemic point of view, the knowledge cycle allows to understand that the contribution of KIBS to innovation systems may be twofold, corresponding to (i) a direct contribution (*i.e.* the innovation activities of KIBS as suppliers of knowledge); and (ii) an indirect contribution (*i.e.* the impact on innovation activities of KIBS clients). This twofold contribution leads to consider the possibility of a virtuous innovation circle linking KIBS and SMEs.

1.4 A virtuous innovation circle linking KIBS and SMEs?

SMEs trying to innovate are confronted with several obstacles. For instance, in the frame of an empirical study, Kleinknecht (1989, p. 219) provides a list of possible problems which small manufacturing firms might experience in the innovation process. As a result, it appears that the most important limiting factors for SMEs are: (i) capital scarcity; (ii) lacking management qualification; as well as (iii) difficulties to obtain technical information and know-how required for innovation projects. This list of obstacles indicates clearly that, in terms of innovation capacity, **SMEs are confronted with specific limitations related to knowledge**. Additionally, as Bughin and Jacques (1994, pp. 654-655) underline, failure to innovate is not only related to "bad luck" but seems to be linked to the inability of firms to respect what these authors call "key managerial principles". These "key principles" consist of: (i) efficiency of marketing and R&D; (ii) synergies between marketing and R&D; (iii) communication skills, (iv) managerial and organisational excellence; and (v) the protection of the innovation. In other words, it is suggested that **internal R&D alone (if any) is not sufficient in most of the cases**. The innovation-related effort, therefore, also consists of the access to external informational resources (*i.e.* primarily the network(s) in which the SME is embedded). This capacity to combine external and internal sources may be interpreted as an improvement of "absorptive capacities" (in the meaning given by Cohen and Levinthal, 1989).

This leads to consider KIBS as potentially playing a role of co-innovators for SMEs. In this respect, the concept of complementary innovation assets developed by Teece (1986) is helpful for characterising, from the point of view of SMEs, innovation-related interactions with KIBS. In fact, services provided by KIBS to SMEs, consist of highly interactive processes in which KIBS perform a continuous adaptation to the needs of their clients. KIBS' activities constitute one element of SMEs' environment (in terms of information network or of scientific and technical information system), however, **KIBS represent more for SMEs than just a simple information source**. As underlined by Strambach (1998, p. 4): "*The purchase of knowledge-intensive services is not the same as the purchase of a standardized product or service. The exchange of knowledge products is associated with uncertainties and information asymmetries stemming from the special features of knowledge* (...)". Gadrey (1994) distinguishes three important types of functions KIBS can assume for their clients: (i) the detection and analysis of problems; (ii) the (abstract) establishment of a diagnosis; and (iii) the (concrete) participation to the problem-solving process. As a consequence, focusing on SMEs and referring to the concept **of complementary innovation assets** suggested by Teece (1986), it seems worthwhile to consider the three following functions: (i) KIBS constitute an information source for their clients, (ii) KIBS assume a "bridge" or interface function between the environment and their clients, (iii) KIBS reinforce or catalyse evolution and innovation capacity of their clients. Consequently, it can be assumed that **SMEs interacting with KIBS are in a situation of activation of complementary innovation assets**. Going one step further, it can be suggested that KIBS play a role of co-innovators or even of "midwives" for SMEs (*cf.* von Einem and Helmstädter 1994, p. 2). Indeed, if innovation activities are not reduced to the sole R&D but encompass other dimensions of the firm (management of human resources, marketing strategy, investment financing, legal protections, etc.), a broader conception of innovation interactions can be considered. Consequently, the hypothesis can be suggested that, comparatively to SMEs not interacting with KIBS, interacting SMEs: (i) spend more of their resources on R&D, (ii) show a higher propensity to co-operate with research organisation (or more generally with Institutions of Technological Infrastructure or ITI[28]) and, as a result, (iii) are more able to be innovative. To summarise the potential impact of KIBS on SMEs' innovation capacities (and referring notably to the models of co-produced innovation proposed by Gallouj, 1994) one may speak of **innovation co-production**.

Nevertheless, the impact of KIBS on SMEs' innovation capacities constitutes only one side of the story. In fact, KIBS may also benefit from their interactions with SMEs in terms of ability to innovate. In particular, since the development of KIBS' knowledge base is intimately related to the activity they perform for their clients, it seems logical that their innovation capacities are influenced through those interactions. Focussing on the interactions between SMEs and KIBS, the following can be suggested: interactions with SMEs contribute to the innovation capacities of KIBS.

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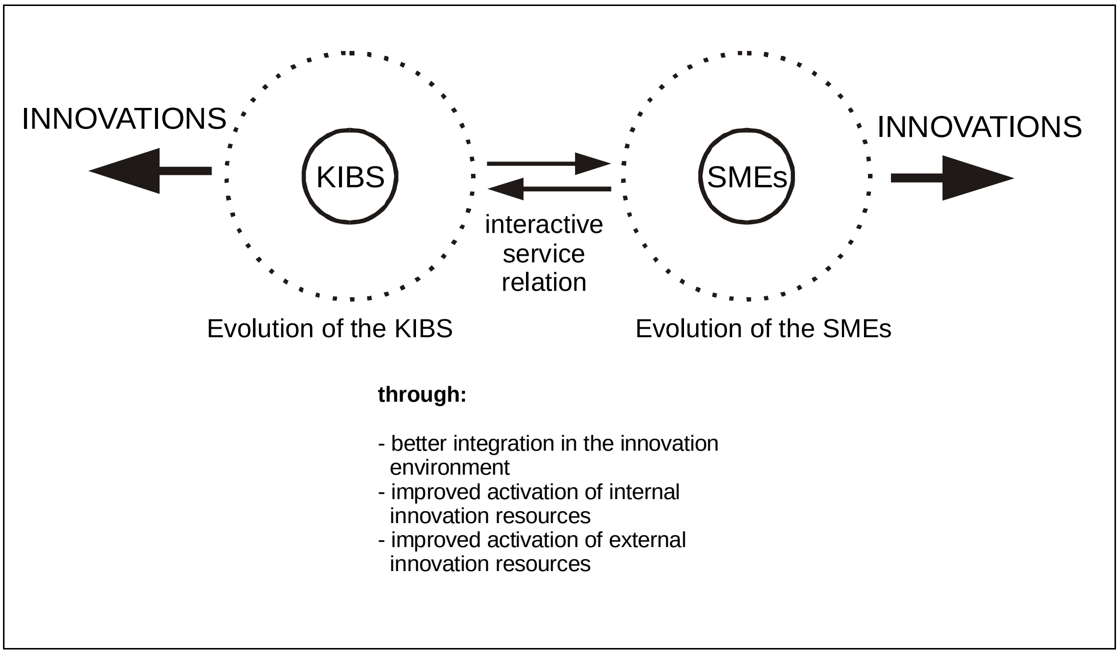
[28] For a presentation of the concept of Institutions of Technological Infrastructure (ITI), see Koschatzky and Héraud (1996).

This contribution corresponds potentially to: (i) an improved activation of internal innovation resources (such as R&D expenses).; (ii) an improved activation of external innovation resources (such as interactions with ITI); and (iii) a better integration in the innovation environment leading to a higher propensity to innovate. As a consequence, considering SMEs and KIBS together, the hypothesis of a virtuous circle (*cf.* figure 3), can be expressed. In other words and to summarise: "*it can be argued that* ***interacting KIBS and SMEs mutually contribute to their respective innovation capacities, in a similar but not identical way****. This mutual contribution is based on a "core sequence" which can be approximated with three "sub-sequences": (i) the interaction itself; (ii) the resulting knowledge base expansion; and (iii) the ensuing evolution of the firm. These three constituents of the whole phenomenon should not be seen in a linear perspective but as potentially interlinked in a "knowledge-based loop" thanks to feed-back effects*." (Muller 1999, p. 144).

Figure 3: The virtuous circle associating KIBS and SMEs

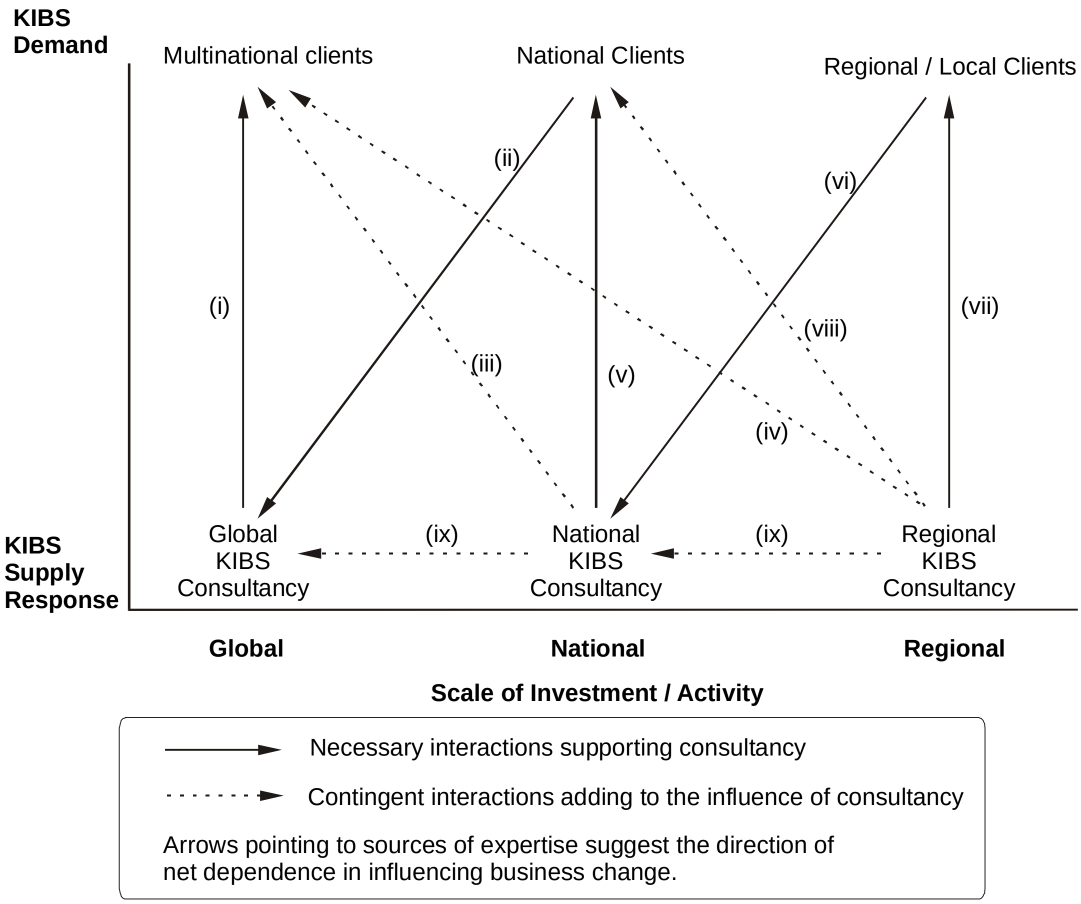


Adapted from Muller (1999, pp. 48 and 55)

1.5 Are KIBS influencing regional innovation capacities?

Considering international differences in the density of KIBS and their concentration, at sub-national level, in core metropolitan regions it seems particularly worthwhile to address the issue of KIBS and innovation capacities from a spatial perspective. According to the vision , dealing with KIBS demand and supply response, proposed by Wood (1998) the expansion of KIBS leads to a reinforcement of the domination of the core. The model (*cf.* figure 4) features interactions involving KIBS and their clients on different spatial levels. This approach pays particular attention to large enterprises both in consultancy and manufacturing sectors as well as to the role of international and national-scaled interactions. In this perspective, the growing role of KIBS appears to be an opportunity for core regions (in particular big metropolis) and a threat for peripheral regions.

Figure 4: KIBS demand and supply response from a spatial perspective



(i) Global consultancies respond primarily to the requirements of multinational clients and agencies.

(ii) Global consultancies increasingly act as conduits of innovative ideas and methodologies between the global and national scales.

(iii) Successful medium-small nationally-based consultancies may develop internationalisation strategies by serving multinational clients seeking specialist expertise or familiarity with home country conditions.

(iv) Successful regionally-based consultancies may also work for multinational clients operating in their regions on a similar basis to (iii), although their growth more often depends on serving national clients (viii).

(v) Nationally-based consultancies, serving private and government clients within that market, provide the predominant volume of consultancy exchanges across a wide variety of expertise.

(vi) Within national systems of consultancy-client interaction, regionally-based clients seeking consultancy support often depend on nationally-based consultancies.

(vii) Regionally-based consultancies originate largely to serve regional clients, and adapt to these needs on the basis of local exchange and innovativeness.

(viii) Successful regionally-based consultancies most often grow by serving national or even international (iv) clients on the basis of specialist skills or knowledge of local conditions.

(ix) Contingent links may exist between international, national and regionally-based consultancies, either directly through subcontracting or networking relationships, or indirectly as a result of client tendering policy.

Adapted from Wood (1998, pp. 13-14, 21)

Basically, if one refers to what have been detailed previously, KIBS bring knowledge and practice to bear on client activities which their own staff do not possess or would otherwise not be able to implement. These interactions may constitute a "knowledge cycle" concerning KIBS and it has been suggested that SMEs and KIBS may be associated in a virtuous circle of innovation. Nevertheless, from a spatial perspective, since access to the knowledge cycle is not equal everywhere, the knowledge flows may favour regional differences and even generate a reinforcement of regional inequalities. This can be influenced in addition through national specificity in terms of innovation systems. Moreover, the composition of local population of firms in itself (for instance in terms of size and type of activity) may have an impact on the intensity of the knowledge cycle animating KIBS as well as on the degree of "virtue" of the innovation circle potentially linking SMEs and KIBS.

To sum up, addressing the issue of KIBS and regional innovation capacities, it seems worthwhile to examine the three following key hypotheses:

- Interactions between KIBS and SMEs have an impact on their respective innovation capacities
- The location, in national and regional terms, of SMEs and KIBS influences their behavioural patterns (*i.e.* their propensity to interact, their knowledge-related activities and their innovation capacities).
- At local level, the evolution patterns of SMEs and KIBS are influenced by their composition in structural terms (size, type of activity).

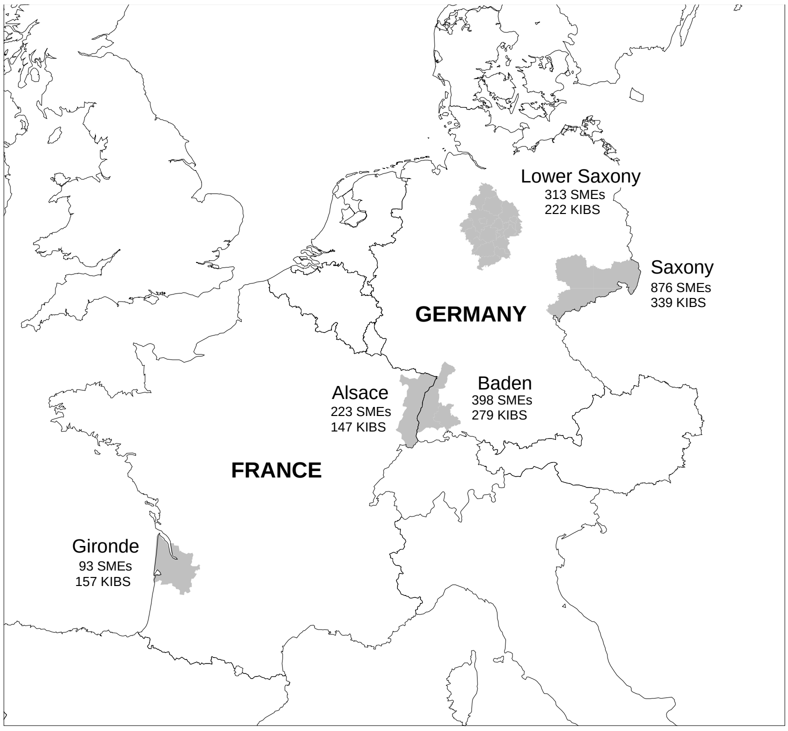
These key hypotheses constitutes the base of the empirical investigation.

II. Methodology

2.1 Surveyed regions and samples

In order to get further insight into the knowledge aspects evoked above and into the role of interactions between SMEs and KIBS for the benefit of their respective innovation activities, the following empirical analysis uses the results of a postal innovation survey in different French and German regions (*cf.* figure 5).

Figure 5: The surveyed regions



Data Base: ERIS (European Regional Innovation Survey)
Software: MapInfo 4.1

Covering innovation and co-operation characteristics of manufacturing and service firms as well as research institutions, the survey has been performed between 1995 and 1997 by the University of Hanover, the University of Cologne, the Technical University Bergakademie Freiberg and the Fraunhofer-Institute for Systems and Innovation Research Karlsruhe on behalf of the German Research Association. France and Germany have been chosen to test the hypotheses developed above because in each country at least two regions have been covered by the survey[29]. Thus, this sample allows to draw conclusions concerning different regional environments in different national innovation systems. Figure 5 indicates the number of manufacturing small and medium-sized enterprises and knowledge-intensive business services analysed in each region.

2.2 Characteristics of the two samples

Tables 2 to 5 give further insight into the structure of the SME and KIBS samples in each region, referring to the respective type of activity in terms of sectoral distribu-

[29] Besides the French and German regions, the metropolitan regions of Stockholm, Barcelona and Vienna as well as South Wales, South Holland and Slovenia have been studied in the frame of this innovation survey.

tion for SMEs and type of activity for KIBS (showing two KIBS I and two KIBS II activities; *cf.* table 1) as well as the distribution in size classes. Table 2 already gives some indications concerning differences in the sectoral structures of the samples. Both French regions have a relatively higher share of sample firms in the food products sector than German firms. A high share of Girondian firms are active in the wood / paper and the basic metals sectors; 43.0 % of the sample firms belong to these two sectors of activity. Besides food products, Alsatian sample firms are to a high extent active in basic metals. On the contrary, German sample firms are underrepresented in the food products sector and – with the exception of Saxony – also in the textiles production. Baden firms are mainly active in basic metals, electrical machinery and apparatus and machinery and equipment whereas the sectoral focus of Lower Saxonian firms are in chemicals and machinery and equipment. The sample of Saxonian firms has no 'peak', i.e. no sector with more than 20 % of firms, the main sectors being basic metals, machinery and equipment and chemicals.

Concerning the type of activity of KIBS, every region has a share of more than 25 % of sample firms in the technical and engineering branches. Alsace and Saxony even have more than 40 % of sample firms in this sector. Gironde has another focus in legal, accounting and tax consulting whereas Baden is the "leading" region in computer related consultancy activities. Concerning business, management and marketing activities, all five regions have a relatively homogenous share of firms, varying between 24 and 31 %.

Switching to tables 4 and 5 that present the distribution of sample firms in size classes, one can conclude that more than 60 % of the SME sample consists of firms with less than 50 employees. Especially Lower Saxony shows a share of large firms (100 to 500 employees) which lies above the average whereas especially Gironde is characterised by a high amount of firms with less than 20 employees (*cf.* table 4).

Table 2: Characteristics of the SME sample: Sector of activity (share of firms)

Region	Sector of activity (%)						
	Food products	Textiles	Wood, paper	Chemicals	Basic metals	Machinery and equipment	Electrical machinery and apparatus
Alsace	23.1	6.8	13.6	14.5	19.0	10.4	12.7
Baden	3.8	6.3	16.7	11.9	21.2	19.4	20.7
Gironde	16.1	6.5	22.6	15.1	20.4	9.7	9.7
Lower Saxony	5.8	3.2	18.1	24.8	12.9	21.6	13.5
Saxony	8.3	10.6	15.5	17.6	18.9	17.6	11.5
Total	**9.1**	**7.8**	**16.3**	**17.1**	**18.5**	**17.4**	**13.8**

Table 3: Characteristics of the KIBS sample: Type of activity (share of firms)

Region	Type of activity (%)			
	Computer related consultancy and activities	Legal, accounting and tax consultancy	Business, management and marketing consultancy activities	Architectural, engineering and technical activities
Alsace	16.3	16.3	25.2	42.2
Baden	27.2	16.1	24.7	31.9
Gironde	14.0	31.8	28.0	26.1
Lower Saxony	22.1	8.1	30.2	39.6
Saxony	13.3	15.3	26.0	45.4
Total	**18.9**	**16.5**	**26.7**	**37.9**

Table 4: Characteristics of the SME sample: Size classes (share of firms)

Region	Size classes (%)				
	less than 20 employees	20 to 49 employees	50 to 99 employees	100 to 199 employees	200 to 499 employees
Alsace	30.5	37.7	15.7	7.6	8.5
Baden	28.4	31.4	19.1	9.8	11.3
Gironde	46.2	30.1	11.8	7.5	4.3
Lower Saxony	16.3	28.8	21.1	18.8	15.0
Saxony	35.0	30.6	17.1	9.9	7.3
Total	**30.6**	**31.3**	**17.8**	**11.0**	**9.4**

Table 5: Characteristics of the KIBS sample: Size classes (share of firms)

Region	Size classes (%)				
	less than 3 employees	3 to 4 employees	5 to 9 employees	10 to 19 employees	20 and more employees
Alsace	28.7	28.0	25.2	7.7	10.5
Baden	22.0	20.1	25.6	17.9	14.3
Gironde	35.9	24.1	22.8	8.3	9.0
Lower Saxony	13.4	20.4	19.9	19.4	26.9
Saxony	43.8	14.2	16.0	12.1	13.9
Total	**29.6**	**19.9**	**21.2**	**13.9**	**15.4**

A similar tendency can be reported for KIBS (*cf.* table 5). More than 70 % of the sample firms have less than 10 employees, the highest share of firms has one or two employees. Especially the Saxonian KIBS sample is characterised by a high amount of very large firms; Lower Saxony has the "leading position" concerning KIBS with more than 20 employees.

2.3 The variables used for the analysis

Having described some general characteristics of the samples, table 6 presents the variables used for the empirical analysis. The choice of the variables refers to the conceptual model and the research hypotheses developed in section 1.5 with respect to the innovation capacities of mutually interacting manufacturing SMEs and KIBS, to interregional differences and similarities and to the impact of structural characteristics on firms' evolution patterns.

While the "interaction variables" are conceived as dummies distinguishing interacting firms from non-interacting ones, the level of R&D and innovation expenses respectively identifies 'high tech' firms that spent more than 8 % of their turnover for research and development (manufacturing SMEs) or innovation activities (KIBS). Following the conception of absorptive capacity, R&D is considered here as internal knowledge determinant whereas the acquisition of knowledge generated in research and transfer institutions is considered as external knowledge factor. Thus, the variable "interaction with ITI" distinguishes firms that maintain interaction with institutions of the technological infrastructure from those firms that do not interact with this kind of actor. Firms' innovation and development success is measured by the introduction of innovations and their increase in size, both measured within the three-year-period foregoing the inquiry. Concerning structural characteristics of the firms, their size (in classes, *cf.* tables 4 and 5), the kind of their activities (*cf.* tables 2 and 3) and the region in which they are located (*cf.* figure 5) are indicated.

Table 6: The variables used for the analysis

Target groups / Indicators	Manufacturing SMEs	KIBS
Mutual interaction activities	• Interactions with knowledge-intensive business services (KIBS)	• Interactions with innovative small and medium sized enterprises (SMEs)
Internal and external knowledge determinants	• Level of internal research and development (RDINT) • Interactions with institutions of technological infrastructure (ITI)	• Level of internal research and development (RDINT) • Interactions with institutions of technological infrastructure (ITI)
Indicator of firms' innovation performance and development	• Introduction of innovations in precedent three years (INNOV) • Increase of number of employees in precedent three years (GROWTH)	• Introduction of internal innovations in precedent three years (INNOV) • Increase of number of employees in precedent three years (GROWTH)
Structural characteristics of the firm	• Location of the firm (REGION) • Size of the firm (SIZE) • Sector of activity (ACTIVITY)	• Location of the firm (REGION) • Size of the firm (SIZE) • Type of activity (ACTIVITY)

The empirical analysis consists of three steps that complete each other and give an integral insight into the activities of both actor groups in the different sample regions. The analysis starts with a comparison of interacting and non-interacting firms considering their innovation performance, their co-operation patterns with ITI and their internal R&D activities. This first step is performed with the help of crosstables and χ^2-tests. This bivariate overview is followed by a multivariate analysis which aims at detecting patterns of variable categories and may give first indications concerning different innovation characteristics in the analysed regions. This part of the investigation is based on multiple correspondence analyses (MCA) which is a powerful tool to detect associations between variable categories. Considering non-linear relationships between variables, the module plots associated categories in close neighbourhood which is a first link of homogeneity between them. Finally, the analysis traces regional profiles of the characteristics mentioned above in opposing regional characteristics from a SME and a KIBS point of view and tries to interpret the results with respect to the structural characteristics shown in tables 2 to 5.

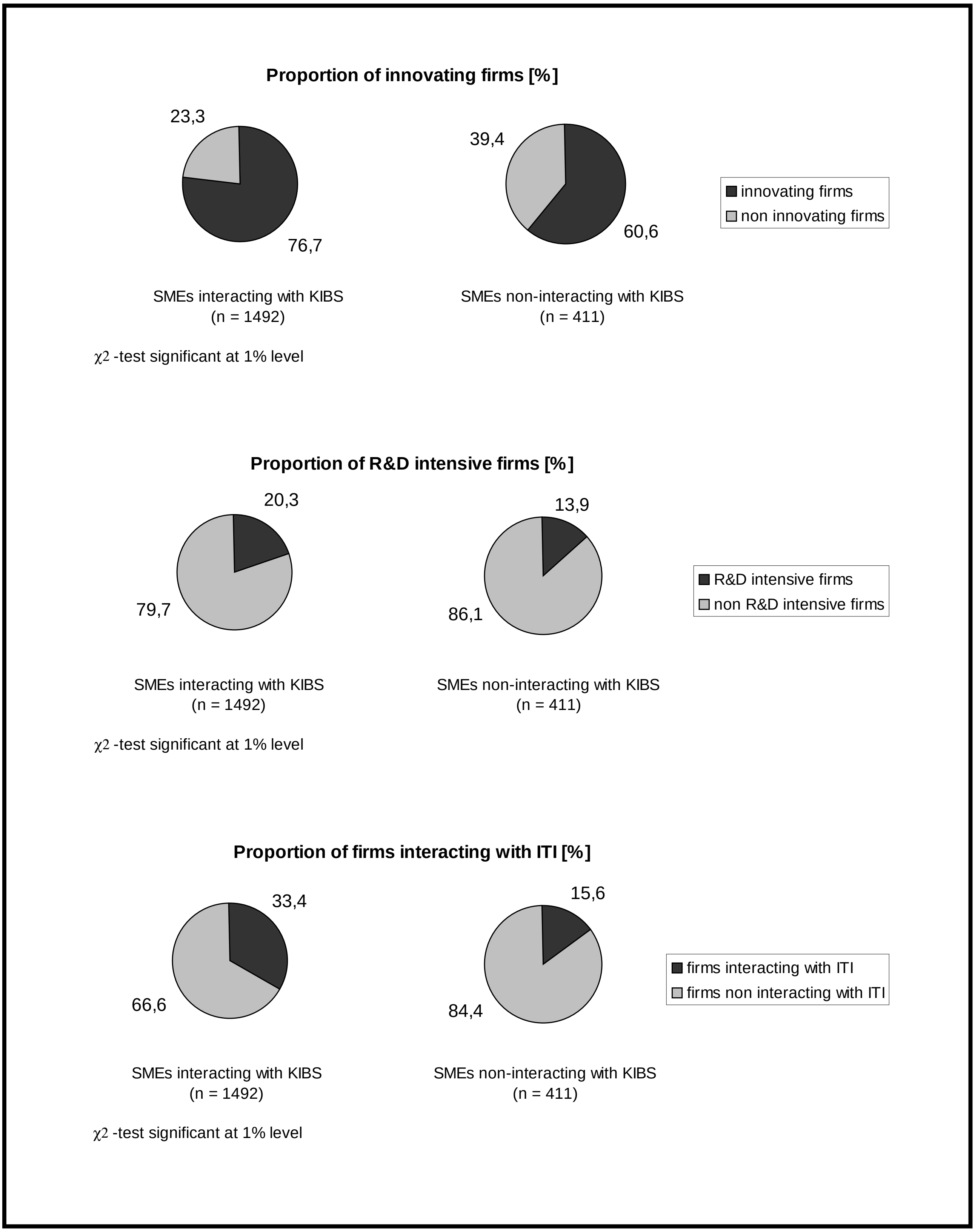
III Empirical results

3.1 The influence of interactions with KIBS on SMEs innovation capacities

The SME sample consists of 1,903 firms, 1,492 of which interacted with KIBS (78.4 %) and 411 (21.6 %) not maintaining such interactions. 1,393 firms introduced innovations during the precedent three years (73.2 % of the whole sample).

Figure 6 shows the performance of innovations, the R&D intensity and co-operations with ITI for interacting and non-interacting manufacturing SMEs. Obviously, the share of firms having introduced innovation during the precedent three years is higher in the case of SMEs maintaining co-operations with KIBS than in the case of non-interacting SMEs. Compared with non-interacting SMEs, a higher share of R&D intensive firms can be found in the group of interacting SMEs and more of them interacted with institutions of technological infrastructure.

Figure 6: **Innovation activities, R&D intensity and co-operation with ITI: Comparison between interacting and non-interacting manufacturing SMEs**

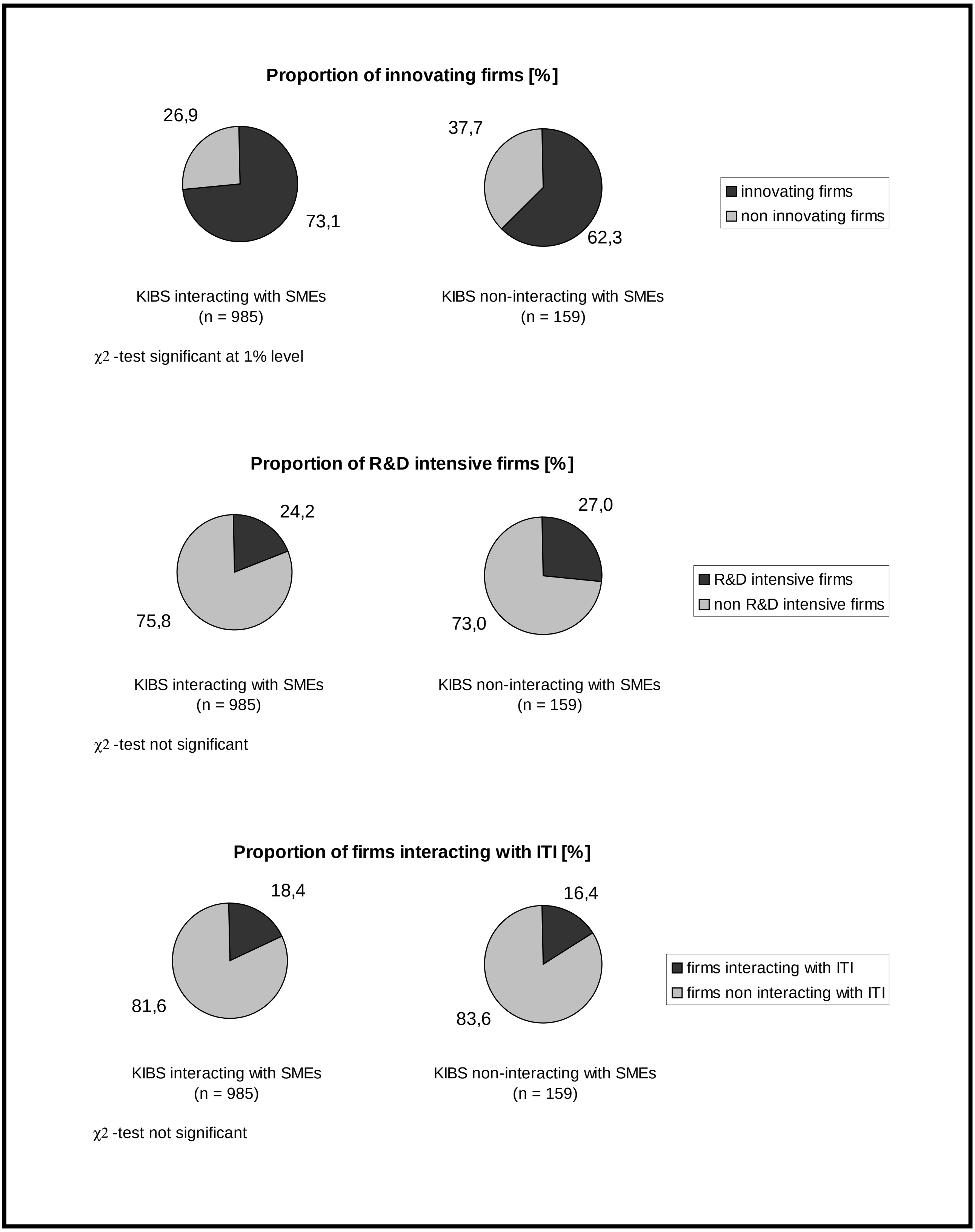


3.2 The influence of interactions with SMEs on KIBS' innovation capacities

985 of the 1,144 KIBS (86.1 %) interacted with SMEs and supported them in their innovation projects whereas 819 firms (71.6 %) introduced internal innovations. 720 sample firms (62.9 %) interacted with SMEs and simultaneously introduced innovations in their own firm. Figure 7 gives an overview for the KIBS sample opposing business services that supported innovation in manufacturing SME clients and non-interacting ones. Interacting KIBS show a higher share of internal innovations than non-interacting ones: 73.1 % of KIBS that interacted with SMEs introduces internal innovations. On the other hand, 62.3 % of non-interacting KIBS implemented internal inventions.

Switching to KIBS that spent more than 8 % of their turnover for innovation activities (281 firms, *i.e.* 24.6 % of the sample), nearly 25 % of them can be described as high-tech firms. However, 27.0 % of non-interacting KIBS belong to the high-tech group. Considering KIBS' interactions with institutions of technological infrastructure, figure 7 shows that 18.4 % of KIBS interacting with innovative SMEs also interacted with research and transfer institutions whereas 16.4 % of non-interacting ones co-operated with ITI.

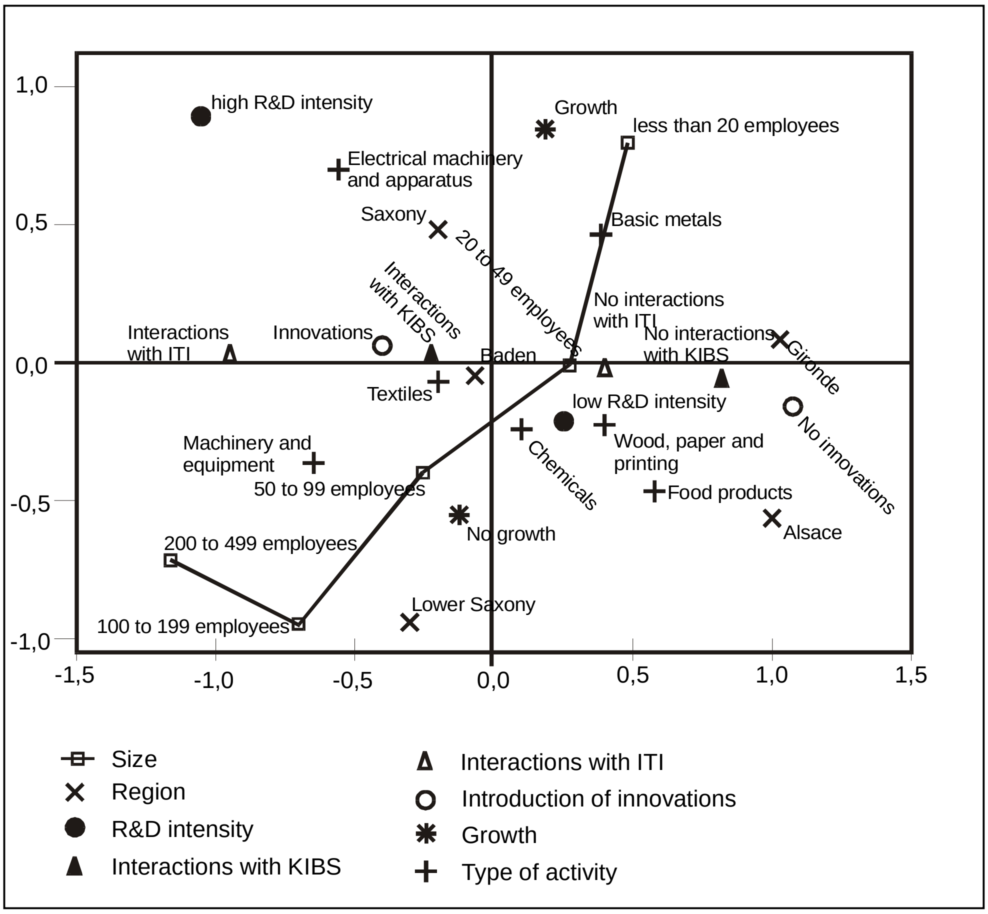
Figure 7: **Innovation activities, R&D intensity and co-operation with ITI: Comparison between interacting and non-interacting KIBS**



3.3 A multivariable analysis of SMEs knowledge and innovation related features

As indicated above, the second step of the analysis consists of a multiple correspondence analysis (or homogeneity analysis) which is presented in figure 9 for the SME sample and in figure 10 for the KIBS group.

Figure 9: Multiple correspondence analysis of the SME sample



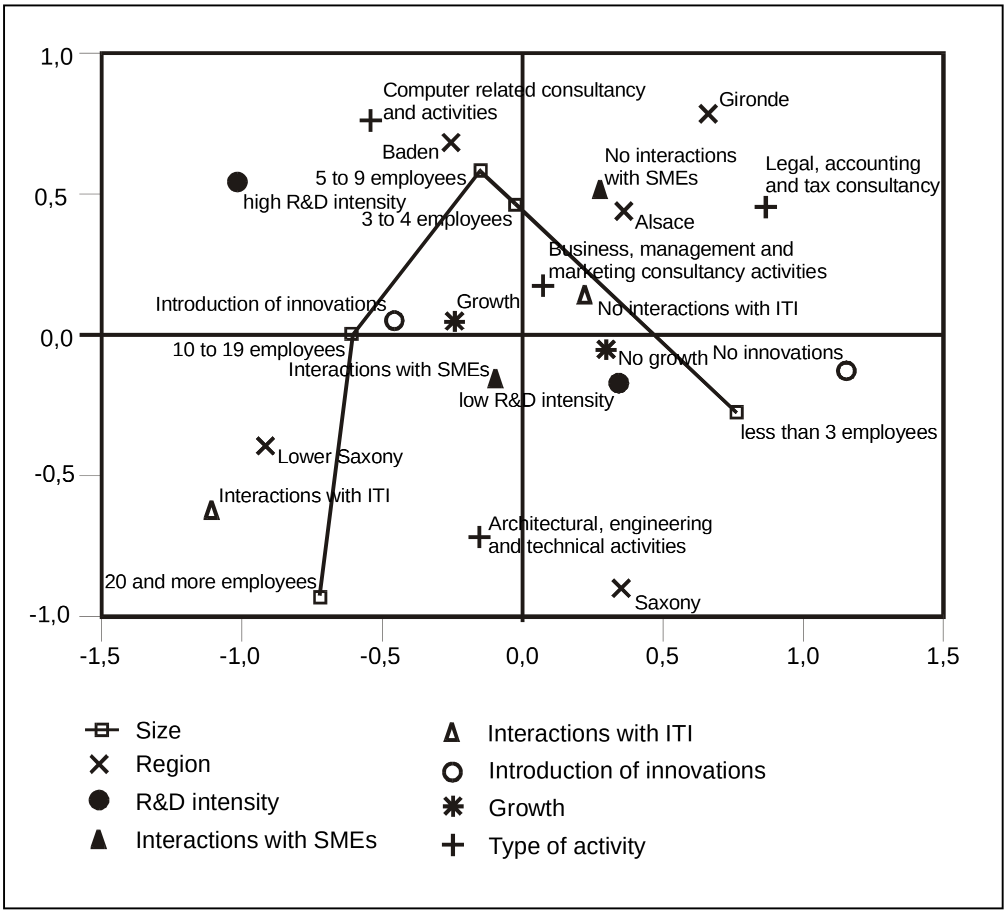
Presenting the projection of the modalities along the first two axes of the graph, figure 9 and the discrimination measures of the different variables (*cf.* appendix) indicate that the performance of innovations, interactions with ITI, size and R&D intensity show a particular contribution to the first dimension. On the contrary, the second dimension is to a large extent influenced by the growth variable, by size and region. Thus, it can be concluded that the first dimension opposes innovative, R&D intensive, co-operating with ITI and large manufacturing SMEs (western part of the graph) to non-innovative SMEs that do not interact with ITI and do not belong to the group of high-tech firms as defined (eastern part). It is rather smaller size classes with less than 50 employees that are plotted here. The second dimension opposes especially growing and non-growing firms and also refers to firms' size: the northern part illustrates growing and rather small firms whereas the southern part is formed by non-growing and larger firms with more than 50 employees. A limited, but perceivable impact is also exercised by the sector of activity and the technology level. This dimension opposes small manufacturing SMEs of the electrical machinery and apparatus as well as the basic metals sectors that could increase their size during the precedent three years to larger and non-growing ones being active in the machinery and equipment as well as the food product, chemicals and wood/ paper/ printing sectors. From a regional point of view, Saxonian and Girondian firms are plotted in the northern part whereas Lower Saxony and Alsace may be found in the southern part of the graph. Baden is plotted very near to the centre.

3.4 A multivariable analysis of KIBS knowledge and innovation related features

Jointly considered with the discrimination measures (*cf.* appendix), the graph for the KIBS sample is in its first dimension mainly constituted by the variables performance of innovations, intensity of innovation-related expenses, size and region whereas the second dimension is to a large extent built by the regional structure and the type of activity. Thus, figure 10 opposes in the first dimension firms that introduced innovations, spent more than 8 % of their turnover for innovation projects and have 5 or more employees (western part). On the contrary, the eastern part presents non-innovating and very small KIBS (less than 3 employees) with lower innovation expenses. On this part, Girondian, Alsatian and Saxonian firms can be found whereas the regions of Lower Saxony and Baden are rather to be found in the western part of the graph. Associations between the interaction and innovation categories are not very obvious.

Mainly opposing the type of activity, location in terms of region and firms' size, the second dimension plots in its northern part computer related consultancies as well as legal, accounting and tax consultancy and business, management and marketing consultancy activities whereas architectural, engineering and technical activities are presented in the southern part. This part also contains the very small and large firms, KIBS with between 3 and 9 employees are shown in the north. Lower Saxony and Baden can be found in the "innovative" (western) part of the graph, Gironde, Alsace and Saxony on the "non-innovating" eastern part.

Figure 10: Multiple correspondence analysis of the KIBS sample

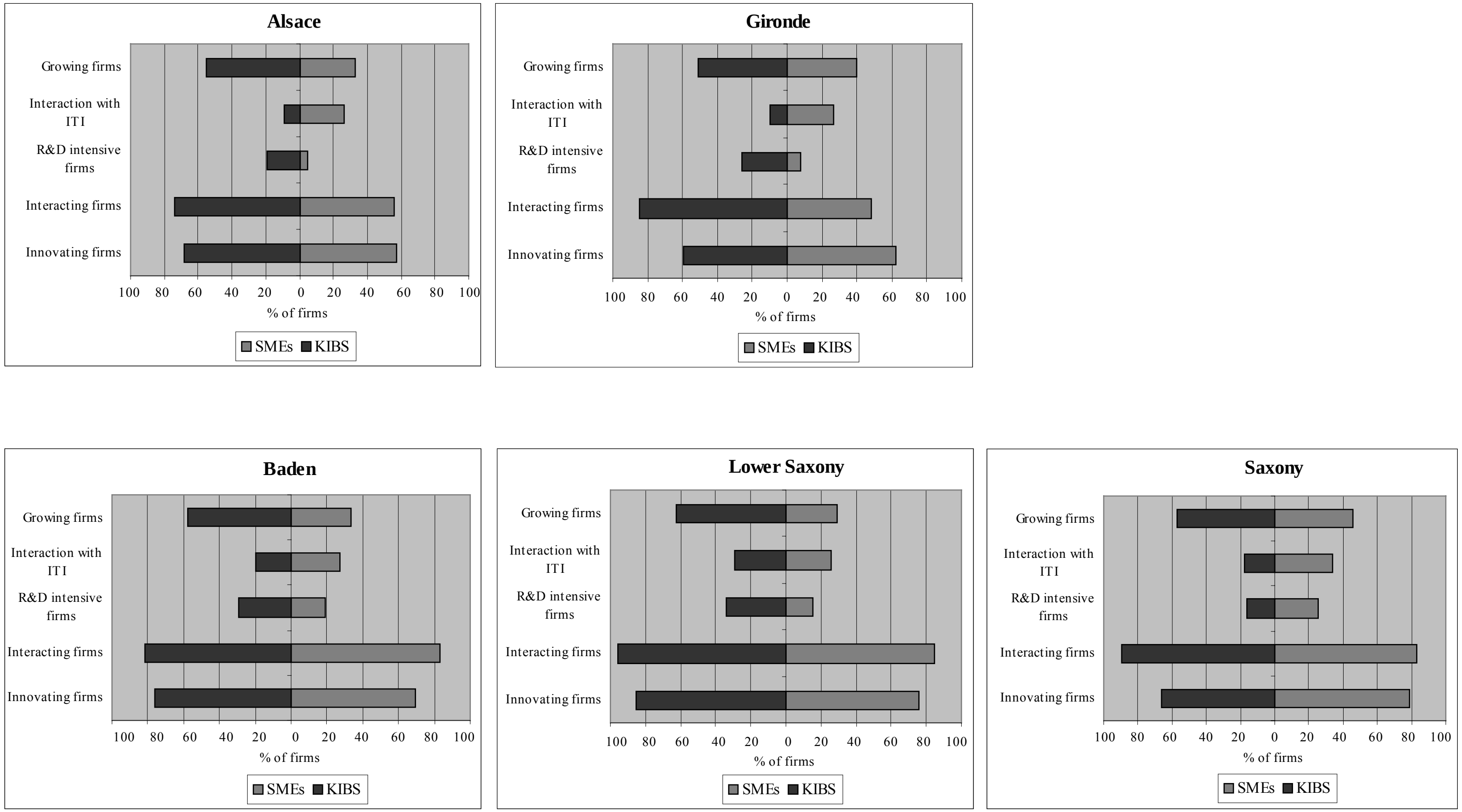


3.5 Some elements of interregional comparisons

Focusing on sample firms' interaction activities, their growth and innovation performance as well as their R&D input, figure 11 aims at comparing the different regions and the sample groups – SMEs and KIBS – within the regions. Figure 11 shows simultaneously interregional similarities within the two different countries and divergences between them. Both in Alsace and Gironde, the share of growing, R&D intensive and interacting KIBS is higher than in the SME sample. The percentage of KIBS that interacted with SMEs is higher in Gironde than in Alsace.

The share of firms that reported interactions with institutions of technological infrastructure is higher in the manufacturing than in the service firm group. In both French regions, a higher share of KIBS can be considered as "high-tech firms": 19.0 % of Alsatian KIBS and 26.1 % of KIBS in Gironde spent 8 % or more of their turnover for innovation activities whereas 4.5 % of Alsatian and 7.5 % of Girondian SMEs reported such a share of expenses devoted to research and development.

Figure 11: Interregional Comparison



German regions show higher shares of interacting and innovating firms than French ones. Compared with Gironde and Alsace, the differences between manufacturing and service firms seem to be lower in the German cases. Generally, a higher share of German firms – especially KIBS – seem to interact with ITI than French firms and with regards to interaction activities between manufacturing SMEs and KIBS, the share of co-operations is higher in Germany than in France.

Conclusion

Considering the main results of the investigation, it is possible to stress the following conclusions. Firstly, the analysis showed clearly that interacting SMEs and KIBS are more oriented towards innovation than non-interacting firms. This supports the hypothesis of a virtuous innovation circle linking SMEs and KIBS, a circle made virtuous through the knowledge generating / processing / diffusing function KIBS may fulfil within innovation systems. As a consequence, it can be assumed that interactions between KIBS and SMEs have an impact on their respective innovation features. Secondly, the interregional comparison have shown that there are indeed regional differences concerning SMEs' and KIBS' innovation and interaction behaviour. Those differences reflect disparities in the generation and diffusion of knowledge by firms. These in turn induce inequalities in terms of innovation capacities and performance. Besides interregional differences, discrepancies could be detected between French and German firms. Thus, it appears that the respective national innovation systems have a perceptible influence on SMEs' and KIBS' propensity to interact, on their knowledge-related activities and more generally on their innovation capacities. Finally, observing the effects of determinants such as size and type of activity on firms' ability to maintain knowledge-intensive interactions, it can be postulated that - at regional level - the evolution patterns of both SMEs and KIBS are partly determined by the structure of the local business sector as a whole.

References

BUGHIN, J./ JACQUES, J. M. (1994): Managerial Efficency and the Schumpeterian Link Between Size, Market Stucture and Innovation Revisited. In: Research Policy. 23. pp. 653-659.

COHEN, W./ LEVINTHAL, D. (1989): Innovation and Learning, the Two Faces of R&D. In: Economic Journal. 99.pp. 569-596.

COOKE, P. (1998): Origins of the concept. In: BRACZYK, H. J.; COOKE, P.; HEIDENREICH (1998) (Eds): Regional Innovation Systems - The Role of Governance in a Globalized World. UCL Press, London. pp. 2-25.

COOKE, P./ BOEKHOLT, P./ SCHALL, N./ SCHIENSTOCK, G. (1996): Regional Innovation Systems: Concepts, Analysis and Typology. Paper presented during the EU-RESTPOR Conference "Global Comparison of Regional RTD and Innovation Strategies for Development and Cohesion". Brussels, 19-21 September.

EDQUIST, C. (Ed.)(1997): Systems of Innovation. Technologies, Institutions and Organizations. Pinter Publishers, London.

FREEMAN, C. (1982): The Economics of Industrial Innovation. Pinter Publishers, London.

FREEMAN, C. (1987): Technology Policy and Economic Performance: Lessons from Japan. Pinter Publishers, London.

GADREY, J. (1994): Les relations de service dans le secteur marchand. In: DE BANDT, J./ GADREY, J. (Eds.) (1994): Relations de service, marchés de services. CNRS Editions. pp. 23-41.

GALLOUJ, F. (1994): Economie de l'innovation dans les services. Editions L'Harmattan, Paris.

KLEINKNECHT, A. (1989): Firm Size and Innovation. Observations in Dutch Manufacturing Industries. SEO Reprint. 53, Amsterdam.

KLINE, S./ ROSENBERG, N. (1986): An Overview of Innovation. In: LANDAU, R./ ROSENBERG, N. (Eds.) (1986): The Positive Sum Strategy: Harnessing Technology for Economic Growth. National Academy Press, Washington D.C. pp. 275-305.

KOSCHATZKY, K./ HÉRAUD, J.-A. (1996): Institutions of Technological Infrastructure. Final report to Eurostat on the project "Feasibility study on the statistical measurement of the Institutions of Technological Infrastructure". ISI, Karlsruhe and BETA (Université Louis Pasteur), Strasbourg.

KOSCHATZKY, K./ ZENKER, A. (1999): The Regional Embeddedness of Small Manufacturing and Service Firms: Regional Networking as Knowledge Source for Innovation. Working Papers Firms and Region. No. R2/1999. ISI,Karlsruhe.

LUNDVALL, B. A. (1988): Innovation as an Interactive Process: From User-Producer Interaction to the National System of Innovation. DOSI, G./ FREEMAN, C./ NELSON, R./ SILVERBERG, G./ SOETE, L. (Eds) (1988): Technical Change and Economic Theory. Pinter Publishers, London. pp. 349-369.

LUNDVALL, B. A. (1992) (Ed.): National System of Innovation. Towards a Theory of Innovation and Interactive Learning. Pinter Publishers, London.

MILES, I./ KASTRINOS, N./ FLANAGAN, K./ BILDEBEEK, R./ DEN HERTOG, P./ HUNTINK, W./ BOUMAN, M. (1994): Knowledge Intensive Business Services: Their Roles as Users, Carriers and Sources of Innovation. PREST, Manchester.

MULLER, E. (1999): Innovation Interactions Between Knowledge-Intensive Business Services and Small and Medium-sized Enterprises – Analysis in Terms of Evolution, Knowledge and Territories. Ph.D. dissertation, Faculté des Sciences Économiques et de Gestion, Université Louis Pasteur, Strasbourg.

NELSON, R./WINTER, S. (1974): Neoclassical vs. Evolutionary Theories of Economic Growth. Critique and Prospectus. In: Economic Journal. December, pp. 886-905.

NELSON, R./WINTER, S. (1975): Growth Theory from an Evolutionary Perspective: The Differential Productivity Puzzle. In: The American Economic Review. 65/2. pp. 338-344.

NELSON, R./WINTER, S. (1977): In Search of a Useful Theory of Innovation. In: Research Policy. 6. pp. 36-76.

NONAKA, I. (1994): A Dynamic Theory of Organizational Knowledge Creation. In: Organization Science. 5/1. pp. 14-37.

STRAMBACH, S. (1998): Knowledge-Intensive Business Services (KIBS) as an Element of Learning Regions - the Case of Baden-Württemberg. Paper presented at the ERSA Conference, August 28-31 1998, Vienna.

STRAMBACH, S. (2000): Innovation Processes and the Role of Knowledge-Intensive Business Services. In: KOSCHATZKY, K./KULICKE, M./ZENKER, A. (2000) (Eds.): Innovation Networks – Concepts and Challenges in the European Perspective. Physica, Heidelberg. *(forthcoming)*

TEECE, D. J. (1986): Profiting from Technological Innovation: Implications for Integration, Collaboration, Licensing and Public Policy. In: Research Policy. 15. pp. 285-305.

VON EINEM, E./ HELMSTÄDTER H. G. (1994): Produktinnovationen in wechselbeziehungen zwischen Industrie und Dienstleistungen. Thesenpapier zum Kolloquium im Rahmen des DFG Schwerpunktprogramms "Technologischer Wandel und Regionalentwicklung in Europa". IfS, Bonn.

WOOD, P. (1998): The Rise of Consultancy and the Prospect for Regions. Paper presented at the 38th Congress of the European Regional Science Association, August 28-31 1998, Vienna.

Appendix

Multiple correspondence analysis: Eigenvalues and discrimination measures for the SME sample

```
Dimension   Eigenvalue
---------   ----------
    1          ,2451
    2          ,1860

Discrimination measures per variable per dimension
==================================================

Variable  Dimension

               1       2

ACTIVITY    ,205    ,170
GROWTH      ,022    ,457
INNOV       ,435    ,011
ITI         ,382    ,000
KIBS        ,182    ,001
RDINT       ,264    ,185
REGION      ,179    ,292
SIZE_5CL    ,292    ,373
```

Multiple correspondence analysis: Eigenvalues and discrimination measures for the KIBS sample

```
Dimension   Eigenvalue
---------   ----------
    1          ,2442
    2          ,1648

Discrimination measures per variable per dimension
==================================================

Variable  Dimension

               1       2

ACTIVITY    ,189    ,346
GROWTH      ,069    ,002
INNOV       ,525    ,006
ITI         ,225    ,085
SMES        ,013    ,042
RDINT       ,339    ,093
REGION      ,294    ,475
SIZE        ,298    ,270
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Title

The Impact of Knowledge Codification on the Evolution Capacities of European Firms and Regions

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References

Draft version, unpublished paper.

Introduction

Modern economies are to an increasing extent shaped by intangible factors. One of the most important contemporary resources consists of **knowledge** whose different facets appear to be of crucial importance for economic processes, in particular for innovation phenomena. Since the amount of codified knowledge is growing and, consequently, the stock of accessible knowledge is increasing, questions referring to the relation between tacit and codified knowledge as well as to the processes of codification, diffusion and accessibility of knowledge have to be raised. These aspects are of special interest for innovation activities that require the combination of available knowledge and the creation of new knowledge with respect to a specific problem to be solved.

Recently, a rich theoretical debate about the different conceptualisations of **knowledge** is taking place (the different knowledge concepts are investigated in detail in COHENDET 1998). Generally speaking, knowledge is a necessary pre-condition to understand and to create new information and is intimately interrelated with innovation processes. Considering the different types of knowledge, implicit (or tacit) and explicit (or codified) knowledge are probably the most relevant for economic analyses. Whereas **codified knowledge** is easily transmittable in a formal and systematic language – comprising words, mathematics, etc. – **tacit knowledge** has always an individual, personal character which makes its formalisation and transfer very difficult. Thus, the **codification of knowledge** implies the 'conversion' of a piece of knowledge and serves as a base for communicating it. Knowledge is acquired and expanded by **learning** processes. Learning may not only occur within one firm, but in the frame of interactions with other firms as well. A firm's **knowledge base** in this context can be described as the collective knowledge this firm uses for its productive purposes. This knowledge base can be expanded by internal search activities or by the acquisition of external knowledge (*cf.* SAVIOTTI 1998).

In its first part, the paper gives a theoretical introduction to the importance of the factor knowledge for the evolution capacity of firms. These reflections link the factor knowledge to firms' innovation processes and their evolution. The second part broadens these views and integrates the environment of innovating firms, focussing especially on networking approaches and the concepts of proximity whereas the third part refers to specific actors that are relevant for innovation projects in industrial firms, especially small and medium enterprises (SMEs), knowledge-intensive business services (KIBS) and institutions of technological infrastructure (ITI). It gives an overview of the specific functions of these actors for innovation activities and the type of knowledge these actors generate and offer to manufacturing SMEs. The research hypotheses resulting from those theoretical parts are summarised in the forth part. They are the base for the empirical part which tries to deliver insight into knowledge and innovation processes in different European firms and regions.

1 Knowledge and Evolution

Referring to the evolutionary approach of the firm, innovation may be assumed as a result of the expansion of individual firms' knowledge base. Thus, the degree of codification of knowledge underlying firms' innovation can be seen as an element of their competencies.

1.1 The Role of Knowledge in the Innovation Process

According to SCHUMPETER (1950), the "**process of creative destruction**" leads to the evolution of capitalist systems. Developing SCHUMPETER's ideas further, the evolutionary, or neo-schumpeterian, vision of innovation constitutes a radical break-up with the orthodox neo-classical approach in the sense that innovation is perceived as **process** (*cf.* for instance NELSON and WINTER 1974, KLINE and ROSENBERG, 1986). The chain-linked model of innovation (*cf.* figure 1) allows the set up of a framework related to the impact of knowledge codification on firms' evolution capacity.

Showing the links between the innovation process, the knowledge stock and research at every step of the central chain of innovation, the model is interaction-based and implicates the dependency of probability and intensity of innovation on the knowledge-base of the firm. Playing an "intermediate" role in the context of research and innovation activities within a firm, growing knowledge and more specifically the growing codification of knowledge, may appear as a factor with a strong positive influence on the innovative capacity of the firm. Moreover, if the "informational nature" of the firm is taken into account, it appears clear that the process of innovation is strongly dependent on its knowledge base. To consider the firm as an "informational complex" (i.e. an information generation and processing system) consists in interpreting it as an **information system** whose units or departments maintain interactive co-operation on the one hand and interactions with its environment on the other hand.[30] In such a vision, information constitutes (one of) the basic resource(s) of the system and plays the role of a production factor for the firm. Thus, as for production factors in general, the efficient exploitation of information is one of the objectives of the firm.[31]

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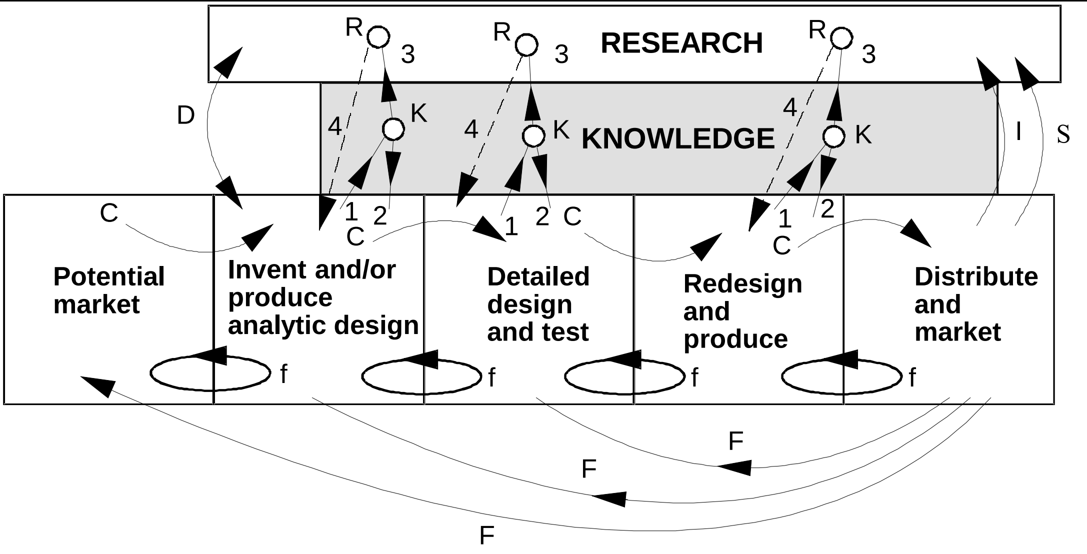
[30] The relationship between information and knowledge is elaborated in detail in COHENDET 1998.

[31] For a review of the firm seen as an information system see for instance DAVIS (1974), LE MOIGNE (1986), MORIN (1986), DJELLAL (1993).

Figure 1: The chain-linked model



C =	Central-chain-of-innovation
f =	Feedback loops
F =	Particularly important feedback
K - R =	Links through knowledge to research and return paths. If problem solved at node K, link 3 to R not activated. Return from research (link 4) is problematic - therefore dashed line.
D =	Direct link to and from research from problems in invention and design.
I =	Support of scientific research by instruments, machines, tools, and procedures of technology.
S =	Support of research in sciences underlying product area to gain information directly and by monitoring outside work. The information obtained may apply anywhere along the chain.

Source: KLINE and ROSENBERG, 1986, p. 290.

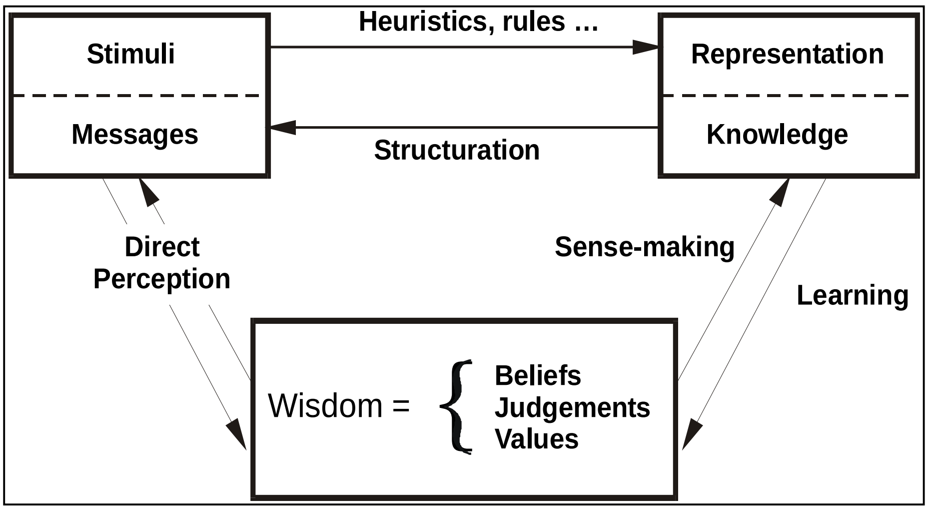
Based on this informational interpretation, an innovative firm can be characterised with the help of two basic elements. The first element corresponds the control of information coming from outside the firm (external information) and from the firm itself (internal information) in order to allow the accumulation, application and evolution of the knowledge base. The second element consists of the generation of innovations itself. This process of innovation is based on the evolution of the knowledge base. These two elements are inter-related: (i) the evolution of the knowledge base of the firm allows the development of innovations and (ii) innovations developed by the firm reinforce its knowledge base. NONAKA's (1994) view concerning knowledge and innovation has to be seen in this context. Asserting that "[any] *organization that dynamically deals with a changing environment ought not only to process information efficiently but also create information and knowledge*", NONAKA (1994, p. 14) underlines that **innovation, as a key form of organisational knowledge creation, should not only be explained in terms of information processing and problem solving, but also as a (cumulative) process in which the firm creates and defines (new) problems and then actively develops (new) knowledge to solve them**.

One of the essential contributions of the evolutionary approach consists of a set of new concepts and of a model of the technical change which expresses at the same time the complexity (in terms of characteristics diversity) and the temporal dynamic of the innovation phenomenon. In this approach, the three following characteristics are notably conferred to innovation. Firstly, the cumulative and interactive character: the importance of accumulation and interaction appears especially by analysing learning effects, for instance under the form of "learning by doing" (ARROW 1962), of "learning by using" (COHEN and LEVINTHAL 1989) and of "learning by interacting" (LUNDVALL 1988). Secondly, the specific character: the specificity of innovation obeys the principle of historical trajectories and integrates the conception of a tacit nature of acquired knowledge. Finally, the institutionalised character which features mainly the role played by the selection environment of innovation (NELSON and WINTER 1975, 1977) and the importance of R&D departments (FREEMAN 1982).

1.2 Innovation Capacities and the Expansion of the Knowledge Base

Considering the "formation of knowledge phenomenon" as an interactive process, it can be assumed that knowledge itself consists of an interactive combination of different components. Put in other words, it means that any **item of knowledge** generated by an entity corresponds to a **representation** resulting from an **interactive process** associating/confronting **messages** (stimuli) and/to the **vision of reference** (or "wisdom") of the concerned entity (*cf.* figure 2).

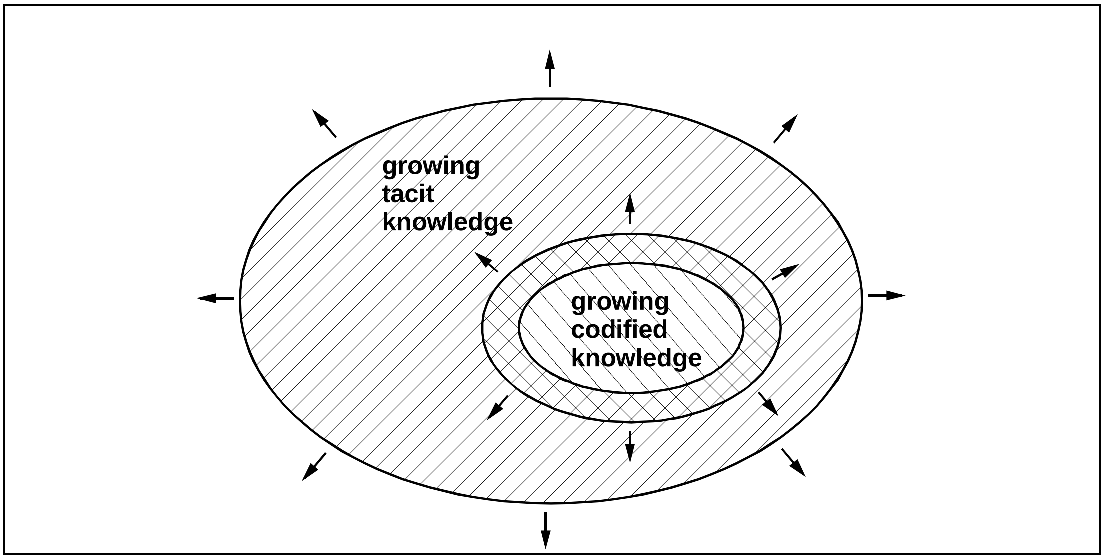
Figure 2: The interactive system of formation of knowledge and the different processes at stake



Source: COHENDET*, 1998, p. 9.*

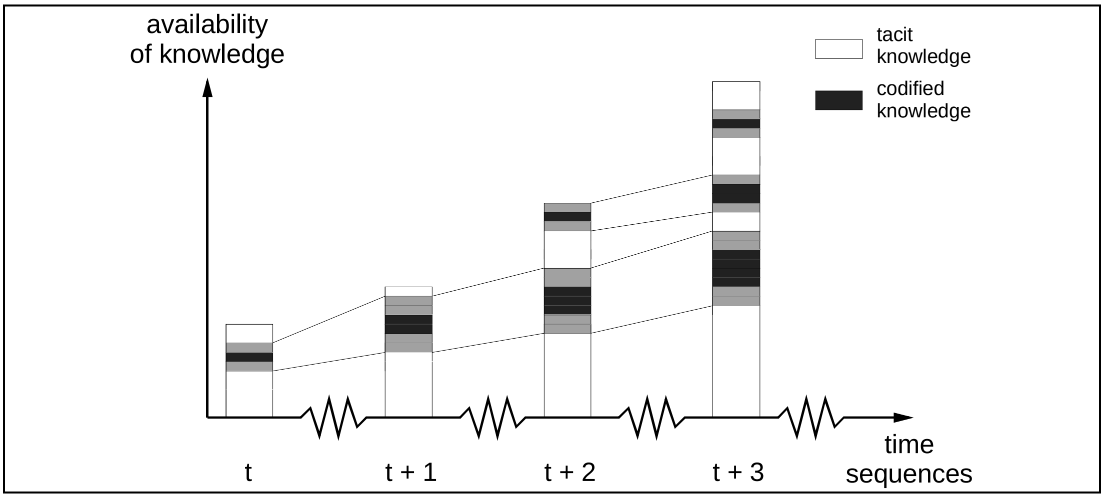
The generation of new knowledge or more generally the expansion of knowledge reveals a non-homogeneity (at least a dichotomy) within the knowledge-base of the firm (*cf.* figure 3).

Figure 3: A context of expanding knowledge



Referring to the contribution of the evolutionary approach in this respect, it is possible to perceive the process of knowledge creation and codification in a cumulative perspective (*cf.* figure 4). In a dynamic view, knowledge is expanding cumulatively associating tacit and codified knowledge since (i) the successive codification of tacit knowledge leads to an increased availability of codified knowledge, and (ii) the expansion of codified knowledge generates new areas of tacit knowledge. This process of knowledge accumulation is bounded by forgetting which opens the way for the development of new activities (JOHNSON 1992, p. 29/30).

Figure 4: The process of codification in a cumulative perspective

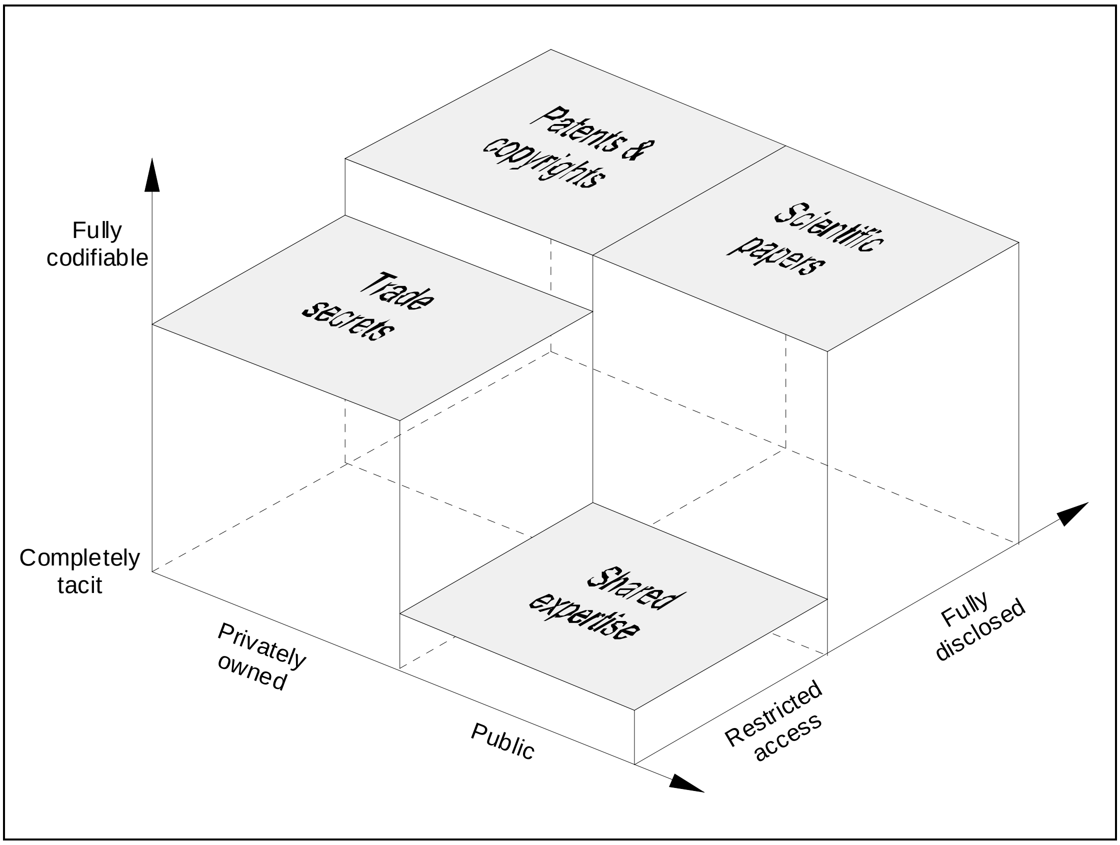


1.3 Codification of Knowledge and Firms' Strategy

Firms' innovation-related competencies may be seen as specific combinations of tacit and codified knowledge. The human capital of a firm nourishes its stock of embodied tacit knowledge whereas knowledge incorporated in documents, databases, procedures, etc. constitutes its stock of codified knowledge. In this respect, the question can be raised in how far such a specific combination of tacit and codified knowledge corresponds to the result of a random process or is the consequence of a knowledge-based strategy.

If a firm codifies its implicit knowledge, it makes knowledge easily accessible within and outside the firm. Thus, the codification process facilitates the acquisition of knowledge and increases the amount of available knowledge. According to DAVID and FORAY (1995, p. 34), tacit knowledge can be defined as "*expertise that particular individuals possess*". Thus, "(...) *supporting the management task of hiring and allocating competence must be the most important function of the information system of the firm.*" (ELIASSON, 1996, p. 4). A further statement is delivered by ELIASSON (1996, p. 13) for the whole economic system: "*With tacit knowledge embodied in human beings or groups of human beings, the allocation of competence through the mobility of human beings becomes the critical function of the economy.*" In short, the skills of employees, their experiences, competencies, their "tacit knowledge" as well as the allocation of this knowledge becomes a factor of major concern for firms: "*The art of disseminating the new competence through the firm therefore is a matter* of organizational technique*, of allocating (”filtering”) people through careers and job assignments. The competitiveness of a business firm almost entirely depends on its ability to create, accumulate, disseminate, and allocate human or team embodied competence. Machine and labor hours have no economic* *value without a dominant competence to guide and control their allocation and use*" (ELIASSON, 1996, pp. 8-9). Furthermore, it has to be mentioned that the status of knowledge may change in parallel to its codification since codification is a prerequisite for communicating and diffusing it. Once diffused, knowledge (for instance incorporated in publications) cannot be classified as being "private" anymore, but it has approached the "public" character. Complementary indications are given by DAVID and FORAY (1995) in their systematic view of the different "knowledge products" which are the result of a combination of the degree of codification, the accessibility to a piece of knowledge and the type of ownership (*cf.* figure 5).

Figure 5: The knowledge-product space

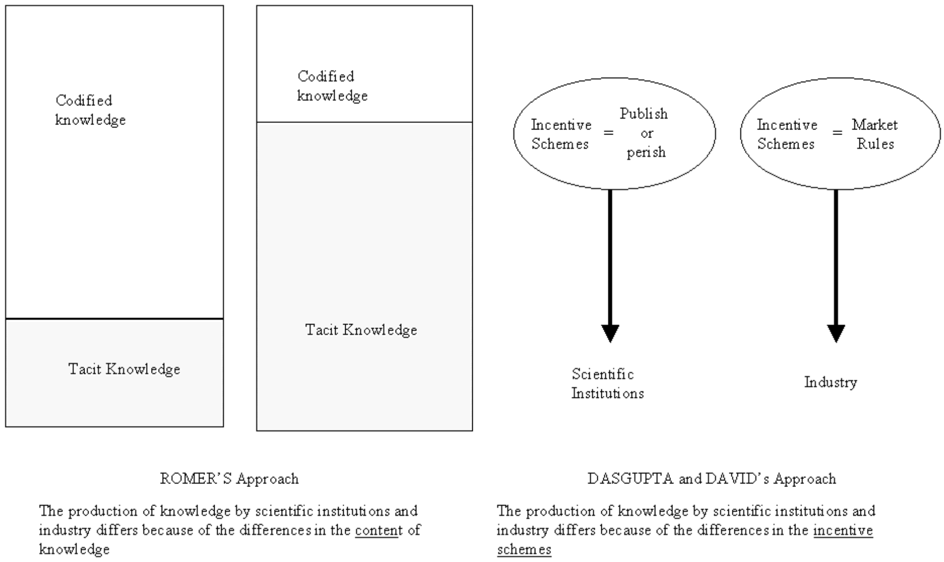


Source: DAVID and FORAY, 1995, p. 33.

HICKS (1995) tries to classify knowledge by ownership in tracing that public knowledge, being created by the release of research results, could to a high degree be associated with universities and the publication of basic research results. On the contrary, private knowledge may be realised through corporate patenting. She also points to the difficulties in differentiating both categories unambiguously; since for instance, results of empirical analysis presented in published papers may be regarded as public knowledge, but nevertheless contain private parts, e.g. concerning the methodology. Researchers still want to keep "secret parts" of the techniques used in order to maintain competitive advantages. On the contrary, the validation of patents depends on their complete disclosure. Thus, the choice of the medium to present research results may be seen in a strategic way: "*In choosing between secrecy and patenting, companies manage the release of their knowledge. Similarly, academics manage the release of their knowledge by choosing how much they disclose.*" (HICKS, 1995, p. 408).

Firms' strategy concerning the composition of their knowledge does not only depend on the pure content of knowledge, but is also influenced by the **institutional setting** (*cf.* COHENDET, 1998). Considering basic and applied research, CALLON (1998) presents two extreme views: ROMER's content-oriented vision describing basic research as strongly codified whereas applied research is rather tacit, and the context-oriented vision by DASGUPTA and DAVID focusing on the institutional setting in which knowledge is produced. This institutional setting and especially incentive schemes and norms explain the specific innovation-related competencies. Since researchers in public institutions have the incentive to publish the results of their work while engineers in private firms are rather invited to acquire and use specific know-how, it may be assumed that the knowledge combination within (public) research institutions and within (private) industrial firms will differ fundamentally (*cf.* figure 6). Thus, with respect to the general environment being responsible for this institutional setting, public institutions appear to produce rather codified knowledge whereas private firms – manufacturing or service firms – are rather focusing on tacit forms of knowledge. **However, the optimal strategy mix between tacit and codified knowledge from the point of view of the individual firm – firm specific competencies – has to be discussed.**

Figure 6: Differences in the production of knowledge



Source: COHENDET, 1998, p. 24.

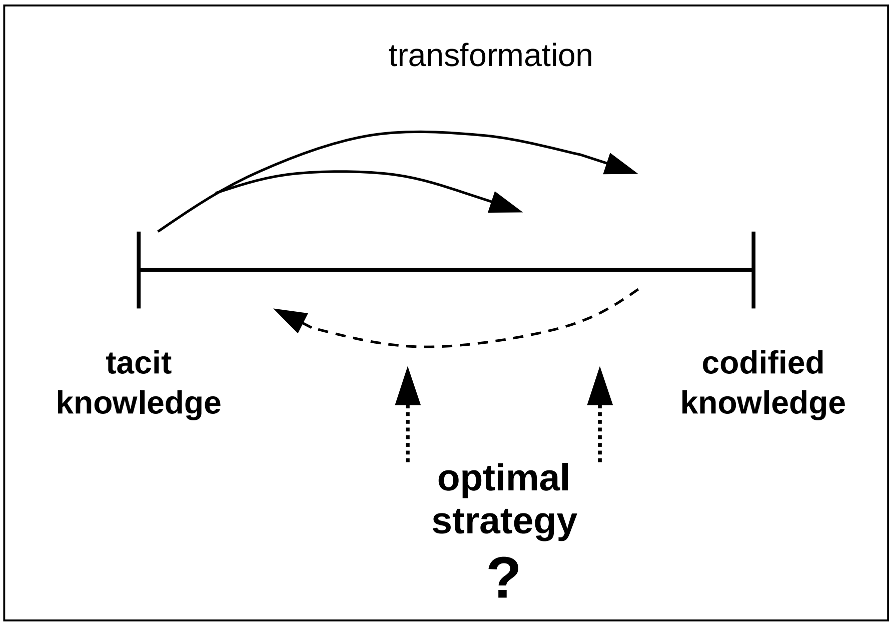
Summarising, it has become apparent that different kinds of (codified) knowledge correspond to different kinds of actors and that the choice of the type of codification may be an important strategic factor for firms. To this respect, the question why firms perform basic research (and by the way, in certain cases publish their results) should be raised. If internal R&D and the creation of knowledge constitute important competitive advantages and if their value decreases with the use by competitors, the deny of access to internal knowledge should be the logical consequence. COHEN and LEVINTHAL (1989) assume that R&D obviously generates innovations and develops firms' ability to identify, assimilate and exploit knowledge from their environment (concept of "absorptive capacity"). These authors suggest that the long run cost of learning may be substantial, because technological knowledge is not a public good[32]. Additionally, most of these costs are limited via the development of a stock of prior knowledge that constitutes the firms' "absorptive capacity", and a significant benefit of R&D consists of its contribution to building and expanding this knowledge base.

In this context, it becomes obvious that R&D activities "still matter" and even "matter more" since knowledge is expanding and is made more available by the increase of its codification. As ROSENBERG (1990, p. 170) put it: "[basic research]

32 Public goods understood in the sense of ARROW (1962).

may be thought of as a ticket of admission to an information network. This network includes a variety of information flows with no particular attempt to distinguish or classify into basic or applied categories." Nevertheless, the optimal strategy mix between tacit and codified knowledge from the point of view of the single firm has to be investigated further (*cf.* figure 7). One may suggest that strategies pursued by firms, in terms of knowledge composition and disclosure, are in most cases mixed strategies. In fact, firms' activities are not based neither exclusively on tacit nor on codified knowledge but rather on a specific composition of both types of knowledge. Since the relationship between tacit and codified knowledge changes in the frame of the transformation process, the combination of knowledge types ensuring innovation-related competencies should be seen as a dynamic process allowing a continuous adaptation to new situations.

Figure 7: A mixed strategy between tacit and codified knowledge



Summarising, these assumptions lead to the first research hypothesis:

H1:	**The combination of tacit and codified knowledge is firm specific and determines its level of competencies. Those competencies in turn determine the capacities of a firm in terms of innovation and economic success.**

2 Knowledge-based Interactions and Territorial Determinants

Completing the theoretical analysis, the spatial dimension cannot be neglected. In this respect, it seems necessary to introduce three key concepts: territory, proximity and networks.

2.1 The Concept of Territory

In fact, one of the main problems in conceptualising the relations between "space" (or territory), knowledge and innovation (*i.e.* the results of knowledge-based interactions between actors, at least partly located in the considered territory) can be traced back to what AUTÈS (1996, p. 15) calls the "*polysémie du mot territoire*". According to AUTÈS, the word "territory" recovers three distinct (and however related) meanings. At first, in a literal meaning, the territory points out the geographical area occupied by humans and their activities. Secondly, in a political meaning, the territory consists in a product of policy (and history) which may be governed as an administrative unit and which is defined by borders. At last, in a symbolical meaning, the territory is populated with "social objects" which express the relationship of humans to the two previous forms of territory. This last meaning corresponds to the (immaterial) dimension of knowledge exchange. It constitutes the "knowledge-territory", which may have a precise spatial inscription in certain cases (for instance a national innovation system[33]) but most often corresponds to an "area with fluent borders". Insisting on the existence of feed-back loops, JULIEN (1996) underlines the importance of the environment for firms as well as of their integration capacity within it. In his point of view, information sharing within an environment leads to shared learning, which in turn accelerates the development of an entrepreneurial spirit and facilitates risky decision-making: "(...) *the stronger a small firm links with a dynamic environment, the more innovative it will be, and the greater its stimulating effect on the environment, through a double loop effect*" (JULIEN, 1996, p. 13).

2.2 The Conceptualisation of Proximity

From a geographical point of view, an important point of the discussion on the relation between proximity and knowledge concentrates on the analysis of knowledge spillovers, which may be interpreted as transformation of organised information (for example generated by universities) in productive capacity (*i.e.* applied by firms). On the one hand, JAFFE (1989, p. 968) assesses that "(...) *there is only weak evidence*

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[33] In the meaning adopted by LUNDVALL, 1988.

that spillovers are facilitated by geographic coincidence of universities and research labs within the state". However, on the other hand ANSELIN, VARGA and ACS (1997, p. 11) investigating geographic spillovers based on concentric rings assume that "(...) *the positive and significant relationship between university research and innovative activity, both directly, as well as indirectly through its impact on private sector R&D.* (...) *the spillovers of university research on innovation extended over a range of 75 miles from the innovating MSA*[34]*, and over a range of 50 miles with respect to private R&D*".

RALLET (1993), focusing on the role of proximity in the development of innovations, provides a critical approach of the concept of proximity between actors. His main argument consists in pointing out the complementarity of different proximity concepts. According to his view, the role of geographical proximity (measurable in kilometres) should be analysed in relation with two other forms of proximity/ distance, *i.e.* the "organisational distance" (measurable in the intensity and number of links existing between actors participating in the innovation process) and the "time distance" (measurable in the actual time needed by actors to meet each other). These two additional forms of proximity/ distance revise the impact of proximity between actors in the frame of innovation processes: "*La contrainte de proximité est d'autant moins évidente que l'on envisage les possibilités offertes par les mobilités conjointes des hommes et des informations*" (RALLET 1993, p. 378). In the general frame of the innovation process, RALLET links the type of knowledge to proximity: If innovation is not exclusively considered as a result of perfectly codifiable and transmissible information, but also derives from knowledge that is partially of tacit nature, proximity rather matters in a socio-cultural than in a pure geographical perspective. The underlying hypothesis is that proximity between actors facilitates interaction and allows a reduction of transaction costs. A possible explanation of this potential influence relates to agglomeration economies effects in the meaning of WEBER (1929). Agglomeration economies can be defined as the sum of the benefits a firm may gain from its location in a given place. COFFEY and POLÈSE (1984) and PECQUEUR (1989) integrate socio-cultural dimensions and thus add a qualitative component to WEBER's approach. Briefly summarised, proximity benefits may be resumed as higher opportunities of face-to-face contacts (in comparison to "distant relationships") and as the exploitation of a common "business culture" (expressed as shared values and references, common language, tacit and complementary knowledge, etc.)[35]. The notion of socio-economical pre-structured area leads to a broader

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[34] MSA: Metropolitan Statistical Area.

[35] Contrary to location theories that consider spatial proximity from a point of view of expenditures, it is understood in terms of learning processes: "*If physical proximity was once valued as a means for reducing costs, today it is valued as a means for enhancing learning capacity; in a world where product life cycles are being rapidly abbreviated, the codification of existing knowledge is forever being tempered by the growth of new knowledge, and the latter always has a strong tacit dimension*." (MORGAN/NAUWELAERS, 1999, p. 8).

acceptation of proximity, not reduced exclusively to geographical coincidence but likely to encompass also cultural and/or behavioural proximity. In this acceptation, proximity influences profoundly knowledge exchanges, especially in the cases where circulating knowledge is at least partly tacit: "*The ability to assimilate and transfer scientific and technological knowledge that is not completely codified, likewise, is greatly affected by the opportunities for direct personal contact among the parties involved*." (DAVID and FORAY, 1995, p. 18).

2.3 Proximity and Networking

Consequently, proximity facilitates the possibilities for direct inter-individual contacts. To this respect, face-to-face contacts are rather influenced by the "time distance" than the pure physical distance. These opportunities are further supported by **cultural proximity** since the communicating actors dispose of the same socio-cultural background and identical codes. Therefore, the categorisation of messages and the building of a common language – a common understanding – is facilitated. Additionally, the institutional setting on national and regional levels shapes rules and regulations, business culture, competition and co-operation. Analysing user-producer interactions between German machinery producers and the North American machine users, GERTLER (1995, p. 22) further investigates the concept of culture and comes to the conclusion that "*Culture is not a static, analytically prior concept, which 'produces' these differences. To a very significant extent, it is the outcome of regulatory forces emanating from a set of socially constructed institutions for the governance of investment and the use of labor*."

Trust is an important pre-requisite for firms' engagement in a network: firms must be sure that the knowledge they bring into the network is treated confidentially and that the introduction of knowledge has a reciprocal character.[36] As GERTLER (1995, p. 5) describes it: "*... relations are social, but are increasingly buttressed by trust. (...), for these innovative production systems to function properly, firms must develop a considerable degree of interdependence on one another (including surrendering proprietary information) but will only do so when a relationship of trust has been established*." In fact, every partner disposes of individual knowledge and exposes parts of this internal knowledge – mainly tacit forms – and thus parts of the individual competitive advantage for the benefit of the whole network. This leads to flexible forms of knowledge and know-how exchanges, to common learning and common experiences and the building of specialised knowledge and experience within the network. Since these "weak ties", *i.e.* relationships without formal contracts, are based on a common understanding of codes and rules, the socio-

[36] Consequently, companies are situated between co-operation and competition: "*Collaboration, for firms, means a trade-off between access to greater resources against the potential loss of valuable proprietary information to competitors*." (Cooke 1998, p. 5).

economic context plays a determining role. Thus, partners characterised by similar framework conditions are rather supposed to fulfil these conditions than partner located in great distances. Common attitudes as well as the advantage of frequent face-to-face contacts may support and foster shared experiences and shared learning. This assumption leads to the following hypothesis:

H2: The absorption of knowledge external to the firm is influenced by its "knowledge environment". As a consequence, it can be assumed that the location of a firm, notably in regional terms, has an impact on its innovation capacities and economic success.

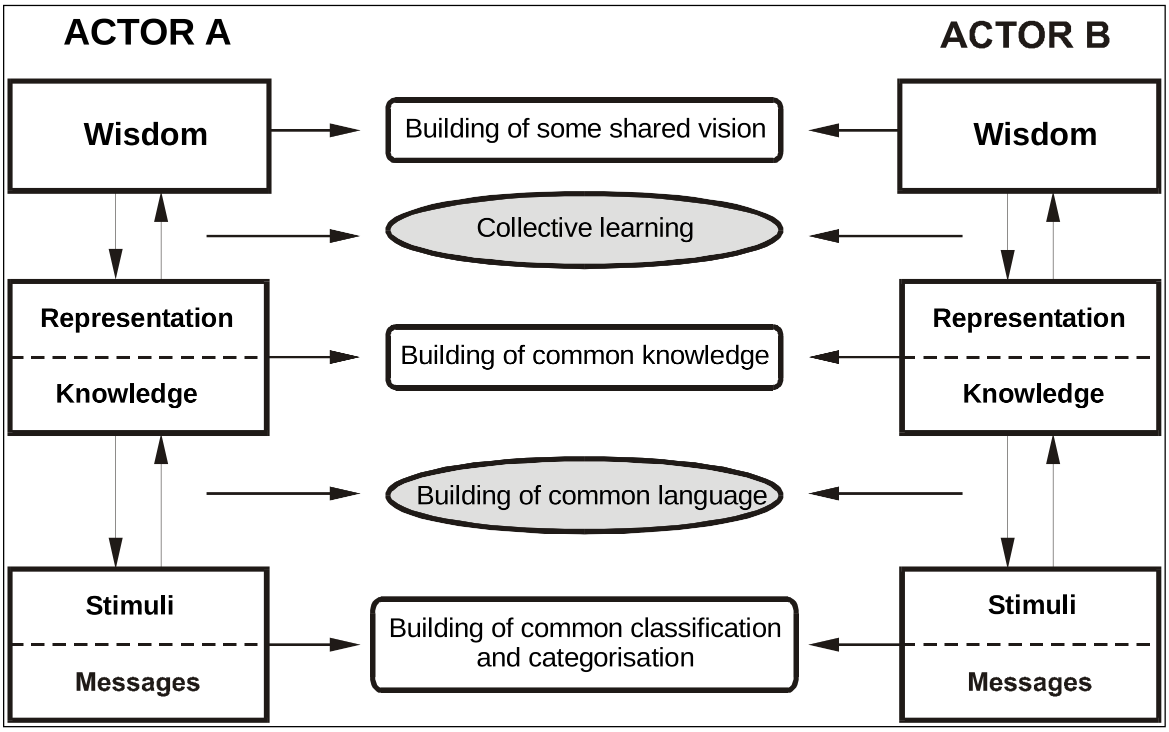
3 Knowledge-based Interactions and Specific Actors

This section focuses on knowledge-related interactions and on the development of the knowledge base of the firm. It is assumed that specific actors, *i.e.* **Knowledge Intensive Business Services** (KIBS) and **Institutions of Technological Infrastructure** (ITI) are liable to play a particular role in the process of knowledge creation and development and more generally to affect the innovation capacities of interacting firms.

3.1 Formation of knowledge and interactions

The following sector focuses on interactions between actors with particular attention on common learning processes and the creation and exchange of knowledge. This simultaneous consideration of several entities or actors (or put in other words, the introduction of a systemic vision) requires the inclusion of knowledge-related processes presented in figure 8. These processes consist mainly in building common classifications and categorisations, common languages, in building a common knowledge base, in collective learning processes and in building shared visions (cf. in detail COHENDET, 1998, pp. 5, 9/10 and 14). More precisely, in the frame of the present investigation, the analysis deals with knowledge-based innovation-related interactions taking place between manufacturing firms and KIBS and/or ITI.

Figure 8: Interactions between actors in the formation of knowledge

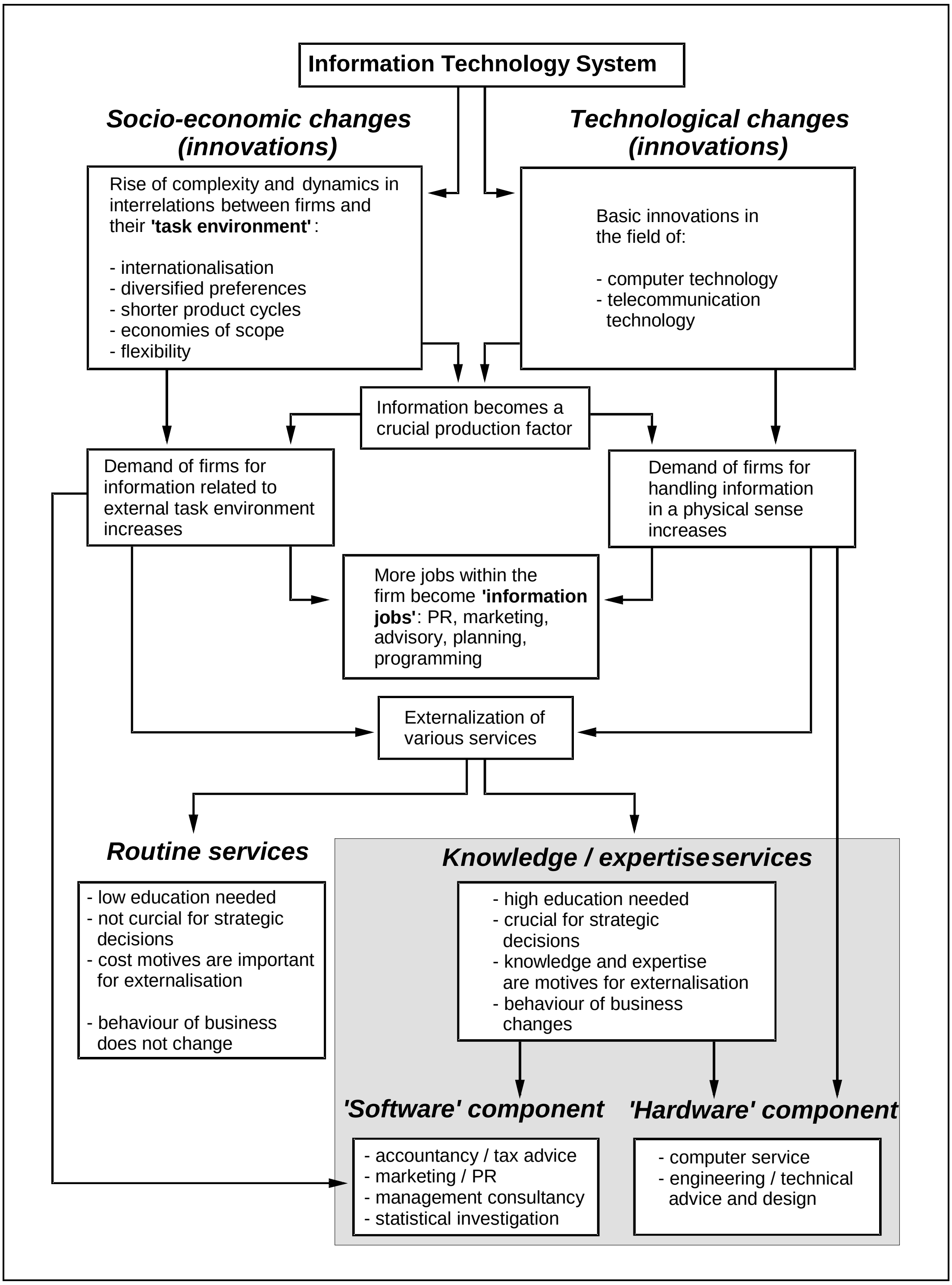


Adapted from C*OHENDET, 1998, p. 9.*

3.2 The Specific Role of KIBS

With a *Schumpeterian* accent, GALLOUJ (1994, p. 154) notices that: "*Les services aux entreprises, et notamment les services de type conseil, sont le lieu d'une importante dynamique de concurrence, et l'on peut dire que le phénomène de destruction créatrice y est à l'oeuvre*". This dynamic perspective can be found in DAVELAAR (1991) as well, who puts in parallel **socio-economic and technological changes** affecting services (*cf.* figure 9). The examination of the consequences for services in general and KIBS in particular leads notably to the differentiation of the hardware and software components of KIBS as a result of an externalisation process of various services.

Figure 9: The place of KIBS in a socio-economic and technological changes perspective



Adapted from D*AVELAAR*, *1991, p. 279.*

The following categories of service firms may be identified as KIBS (subdivided in KIBS I et KIBS II) by MILES *et al.* (1994):

KIBS I: Traditional Professional Services, liable to be intensive users of new technology

- Marketing/advertising;
- Training (other than in new technologies);
- Design (other than that involving new technologies);
- Some financial services (e.g. securities and stock-market-related activities);
- Office services (other than those involving new office equipment, and excluding 'physical' services like cleaning);
- Building services (e.g. architecture; surveying; construction engineering);
- Management consultancy (other than that involving new technology);
- Accounting and bookkeeping;
- Legal services;
- Environmental services (not involving new technology, e.g. environmental law, and not based on old technology, e.g. elementary waste disposal services).

KIBS II: New Technology-Based KIBS

- Computer networks/telematics;
- Some Telecommunications (especially new business services);
- Software;
- Other computer-related services - e.g. Facilities Management;
- Training in new technologies;
- Design involving new technologies;
- Office services involving new office equipment;
- Building services (centrally involving new IT equipment such as Building Energy Management Systems);
- Management consultancy involving new technology;
- Technical engineering;
- Environmental services involving new technology;
- R&D consultancy and 'high-tech boutiques'.

Source: MILES et al., *1994, pp. 19-20.*

GALLOUJ (1992) discusses the role of KIBS in the context of a new technological paradigm based on the importance of organisational and social innovations. As those "immaterial" innovations are implemented with the help of KIBS, additional elements can be gained for their characterisation. *I.e.* KIBS are:

- firms performing services with the help of specialised knowledge and information bases (e.g. accounting, legal consultancy),

- and/or firms performing services (including possibly the provision of material goods as a complement) that constitute an information or knowledge source for their client organisations (e.g. technical engineering),
- and/or whose performing services which constitute intermediary inputs or tools for the information and knowledge generation of the client organisations (e.g. computing related activities).

KIBS activities should not be reduced to a simple transfer of "technology encompassed in capital" (which corresponds to a vision of information liable to constitute "stocks") but consist principally in "organisations encompassed in capital", and even in "information encompassed in the organisation under the form of a system restructuration" (which corresponds in fact to a dynamic vision of information flows and knowledge). KIBS activities constitute one element of the firms' environment, an element which can be represented as a part of their information network. However, KIBS are more than a simple information source. In fact, one may refer to the concept of complementary innovation assets as suggested by TEECE (1986). Since information and knowledge become crucial production factors, KIBS occupy a particular place in the current context of socio-economic and technological changes (as suggested in figure 9). Indeed, due to their particular nature, KIBS' service relations go beyond the dichotomy market/hierarchy. It is possible to summarise this hypothesis as follows. At first, KIBS represent an information source for firms, secondly, they assume a "bridge" or interface function for their clients, and finally, KIBS reinforce or catalyse evolution and innovation capacities of their clients, especially in the case of manufacturing firms. From the point of view of client firms, this hypothesis leads to the concept of KIBS as a form of activation of complementary innovation assets in the sense given by TEECE (1986). DE BANDT and GADREY (1994, p. 13) illustrate this point in observing that "(...) *nombre de travaux, en particulier sur les services aux entreprises, ont fait ressortir la diversité des liens entre industrie et services, les services précédant, accompagnant ou suivant les biens ou, allant encore plus loin, faisant partie de ou produisant des biens*".

Referring to COHENDET (1998) and to the matrix of public and private forms of knowledge (*cf.* figure 10), it can be considered that the competitive advantage of KIBS consists mainly of personal tacit knowledge that they acquire and offer their clients.

Figure 10: Public and private forms of knowledge

		Exclusive	
		YES	**NO**
Rival	**YES**	Personal tacit knowledge	Shared tacit forms of knowledge
	NO	Information codes encrypted messages	Codified statements

Source: COHENDET, 1998, p. 23.

3.3 The Specific Role of ITI

The interactive conception of innovation processes stresses the importance of the generation, accumulation and diffusion of knowledge. To this respect, and particularly in the case of knowledge-based interactions encompassing a scientific dimension, ITI (Institutions of Technological Infrastructure) may play a major role for innovating firms since they (potentially) fulfil three main functions [37]:

Function 1. Managing the knowledge base
ITI aim towards the development of the common knowledge base of the economic system. Starting from the production of scientific and technological knowledge, this function includes the diffusion of knowledge by educating, collecting and distributing technological information (informing) as well as by guaranteeing the accessibility of the knowledge base without discrimination (demonstrating).

Function 2. Improving interactions between enterprises
Information and knowledge is not an easily marketable commodity. ITI overcome the limitations of the market mechanism in order to adjust supply and demand of technological knowledge and of know-how. In doing so, they can either improve market transactions by using the knowledge of the actors of the system, or provide non-market allocative systems by creating incentive structures. The function of intermediation consists of organising meetings, business fairs, exhibitions and of financing interaction costs in order to improve interactions.

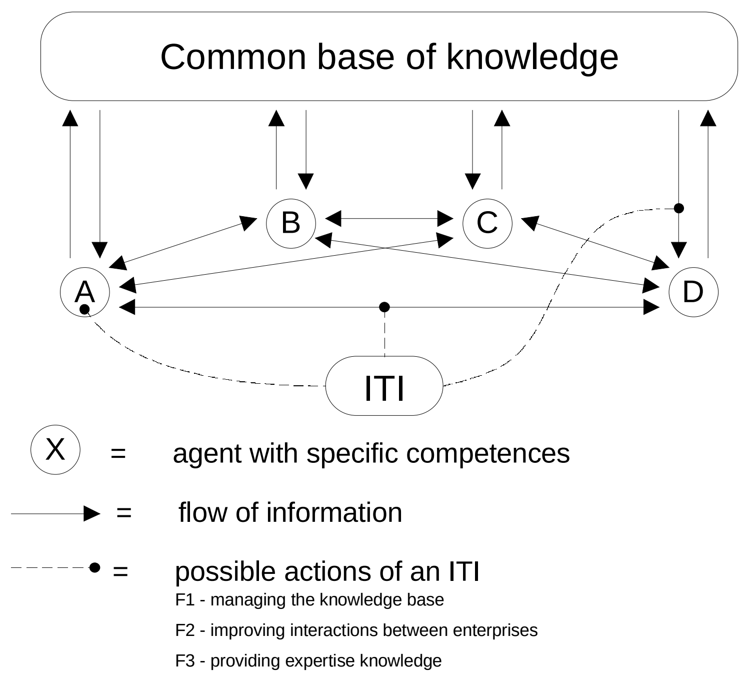
[37] The different functions evoked are referring to the work performed formerly for Eurostat. See "Institutions of Technological Infrastructure", collective report FhG-ISI/BETA performed for the European Commission - Eurostat (under the direction of K. KOSCHATZKY and J.-A. HÉRAUD, 1996). Concerning more precisely universities and research institutions labs and the creation and diffusion of innovation-relevant knowledge see HÉRAUD and MULLER (1998).

Function 3. Providing expertise knowledge

In this case, ITI are in contact with a single actor, focusing on his very specific needs and providing training or consulting. The aim of training can be to reinforce existing skills or to develop new competencies. Individual support may be related to patenting activities (validating, appropriating) or to providing financial grants (financing).

In order to improve the expansion of knowledge and to foster the codification of knowledge, the promotion of links between the science system and the rest of the economy seems to be of special importance. Keeping in mind that firms – and not public actors – are the main actors of R&D as well as of innovation, MEYER-KRAHMER (1997, p. 159) emphasises that "*Economic effects of basic R&D establishments (e.g. universities) could only be expected in a country, if (a) a sufficiently innovative industry exists and (b) efficient links between basic, applied and industrial R&D are established*". Presuming the definition of ITI in a broader sense, their possible activities fully correspond to this vision in terms of "knowledge interactions" between ITI and other actors (mainly firms) as shown in figure 11.

Figure 11: Possible activities of ITI



Adapted from KOSCHATZKY et al.*, 1996, pp. 3-6.*

The argumentation developed above and the reflections related to innovation-related competencies (*cf.* section 1.3) lead to research hypothesis H3. **KIBS, on the one hand, acquire knowledge that is available 'on the market' in codified form, but they develop and adopt it with respect to the special needs of their clients, hence offering services that consist to a considerable extent of tacit knowledge.** Consequently, their amount of tacit knowledge increases with their experience in collaborating with manufacturing firms. On the other hand, most of them being public institutions, ITI's incentive scheme differs from that of private firms. Researchers in universities and research laboratories for instance are requested to publish their results in order to gain and to keep their scientific reputation. Consequently, unlike manufacturing-service relations, networking between manufacturing firms and ITI in the frame of innovation activities implies knowledge flows of a rather codified nature.

H3: KIBS and ITI fulfil different functions when interacting with innovative manufacturing firms. Interactions taking place between KIBS and their clients are mainly of tacit knowledge content whereas knowledge employed in interactions with ITI is mainly of codified nature. As a consequence, it can be assumed that interactions with KIBS and ITI affect firms differently in terms of innovation capacities and economic success.

4 Operationalisation of the Analysis

In order to get further insight into the knowledge aspects evoked above and to test the research hypotheses, the following empirical analysis uses the results of a postal innovation survey in ten European regions (ERIS: European Regional Innovation Survey). Covering innovation and co-operation characteristics of manufacturing and service firms as well as research institutions, the survey has been performed between 1995 and 1997 by the Universities of Hanover, Cologne and Freiberg and the Fraunhofer-Institute for Systems and Innovation Research Karlsruhe on behalf of the German Research Association.

The conceptual model of the empirical analysis is based on the assumption that innovation and competitiveness lead to firms' growth and evolution. Besides structural characteristics such as the size or sector of activity, firms' innovation activity is to a high extent influenced by internal and external knowledge factors and learning, the former comprising research and development and the human capital incorporated in employees. External knowledge is made available by cooperation partners of the innovation networks, notably research institutions such as ITI and knowledge intensive business services.

4.1 Conceptual Model and Key Variables

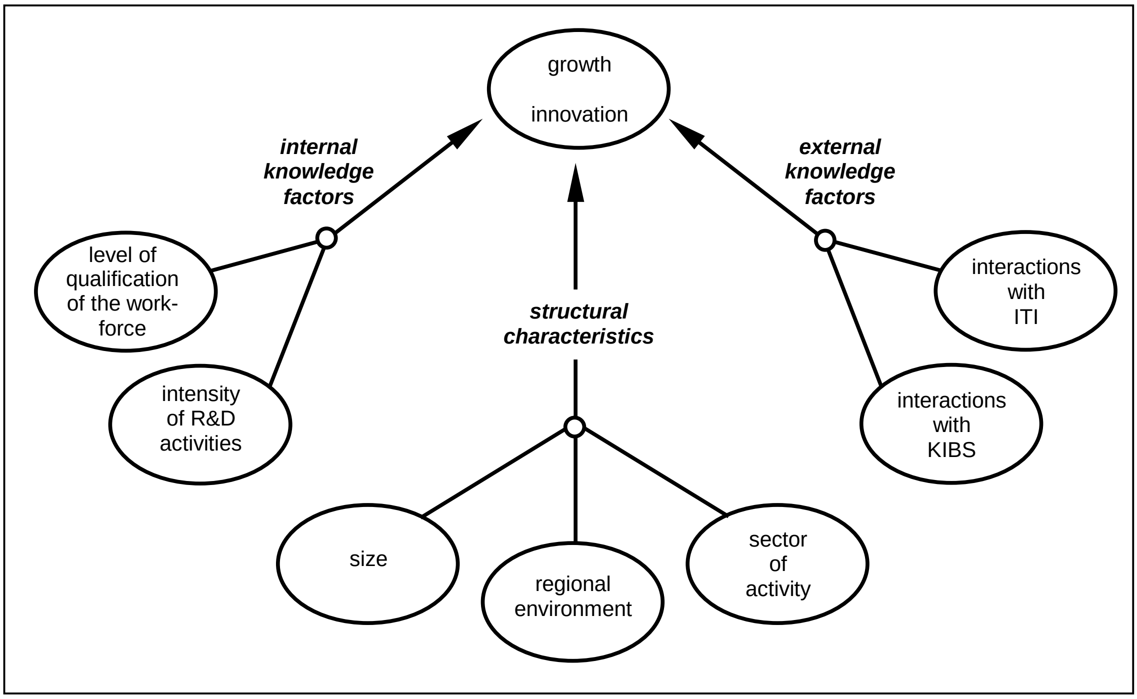
Based on the hypotheses developed in the previous chapters (see below), the impact of structural characteristics, internal and external knowledge factors on innovation and growth of small and medium enterprises[38] in ten European regions will be analysed.

H1:	**The combination of tacit and codified knowledge is firm specific and determines its level of competencies. Those competencies in turn determine the capacities of a firm in terms of innovation and economic success.**
H2:	**The absorption of knowledge external to the firm is influenced by its "knowledge environment". As a consequence, it can be assumed that the location of a firm, notably in regional terms, has an impact on its innovation capacities and economic success.**
H3:	**KIBS and ITI fulfil different functions when interacting with innovative manufacturing firms. Interactions taking place between KIBS and their clients are mainly of tacit knowledge content whereas knowledge employed in interactions with ITI is mainly of codified nature. As a consequence, it can be assumed that interactions with KIBS and ITI affect firms differently in terms of innovation capacities and economic success.**

Firms' structural characteristics comprise their size, the sector of activity and the region in which they are located. Internal knowledge factors are resumed by the qualification level of the employees and the level of research and development in the firms. According to the theoretical reflections, co-operations with KIBS and ITI are considered as knowledge factors external to the firm (*cf.* figure 12).

[38] SMEs are defined as firms with less than 500 employees.

Figure 12: The conceptual model of the investigation



With respect to the conceptual model, the analysis contains the following variables:

Indicator of firms' development and success	• Introduction of innovations (INNOV) • Growth in size (GROWTH)
Structural characteristics of the firm	• Size of the firm (SIZE) • Location (REGION) • Sector of activity (SECTOR)
Internal knowledge determinants	• Level of qualification of the workforce (HUMAN) • Intensity of R&D activities (RDINT)
External knowledge determinants	• Interactions with KIBS (KIBS) • Interactions with ITI (ITI)

4.2 Surveyed Regions and Firm Sample

In the following, some indications concerning the firm sample and the regions of the analysis will be given. Figure 13 presents the regional distribution of the sample whereas tab. 1 gives some details concerning regional sub-samples and response rates. The first line contains the number of questionnaires sent to manufacturing and service firms and the second one describes the number of questionnaires that have been completed and sent back. The third line finally presents the response rates.

Figure 13: The surveyed regions

Software: MapInfo 4.1

Data Source: ERIS (European Regional Innovation Survey), performed by University of Hanover, University of Cologne, Technical University Bergakademie Freiberg, Fraunhofer Institute for Systems and Innovation Research Karlsruhe.

Table 1: Samples and Response Rates in the Case Study Areas
(Number of distributed questionnaires; number of analysed questionnaires (sample); response rate)

Region	Samples and response rates
Alsace	1,753 263 15.0%
Baden	2,715 430 15.8%
Barcelona	2,650 405 15.3%
Gironde	797 101 12.7%
Lower Saxony	1,807 372 20.6%
Saxony	3,767 1,004 26.7%
South Holland	1,894 260 13.7%
South Wales	1,593 280 17.6%
Stockholm	1,902 456 24.0%
Vienna	985 196 19.9%
Total	**19,863** **3,767** **19.0%**

Source: ERIS (European Regional Innovation Survey), performed by University of Hanover, University of Cologne, Technical University Bergakademie Freiberg, Fraunhofer Institute for Systems and Innovation Research Karlsruhe

Table 2: Characteristics of the sample: Sector of activity (number of firms)

Sector of activity / **Region**	Food products	Textiles	Wood, paper	Chemicals	Basic metals	Machinery and equip-ment	Electrical machinery and appara-tus	**Total**
Alsace	51	15	30	32	42	23	28	**221**
Baden	15	25	66	47	84	77	82	**396**
Barcelona	0	0	82	37	72	99	59	**349**
Gironde	15	6	21	14	19	9	9	**93**
Lower Saxony	18	10	56	77	40	67	42	**310**
Saxony	72	92	135	153	164	153	100	**869**
South Holland	19	6	38	34	29	45	25	**196**
South Wales	4	8	30	54	59	48	41	**244**
Stockholm	23	4	96	55	84	85	71	**418**
Vienna	21	12	45	30	20	23	25	**176**
Total	**238**	**178**	**599**	**533**	**613**	**629**	**482**	**3272**

Tables 2 and 3 give further details concerning the manufacturing firms sample. 72.6 % of the sample firms have their main activities in machinery and equipment, basic metals, wood/paper and chemicals. 30.4 % of the sample firms are very small ones with less than 20 employees, 33.6 % have between 20 and 49 employees whereas 36.0 % of the firms have more than 50, but less than 500 employees.

Table 3: Characteristics of the sample: Size classes (number of firms)

Size classes / **Region**	Less than 20 employees	20 to 49 employees	50 to 499 employees	**Total**
Alsace	68	84	71	**223**
Baden	113	125	160	**398**
Barcelona	41	208	117	**366**
Gironde	43	28	22	**93**
Lower Saxony	51	90	172	**313**
Saxony	307	268	301	**876**
South Holland	105	68	73	**246**
South Wales	90	75	80	**245**
Stockholm	185	121	114	**420**
Vienna	20	62	99	**181**
Total	**1,023**	**1,129**	**1,209**	**3,361**

4.3 Statistical Investigation Procedure

Besides basic features, the statistical investigation will mainly focus on **PROBIT based path-modelling**, displaying significant relationships between the different kinds of variables.

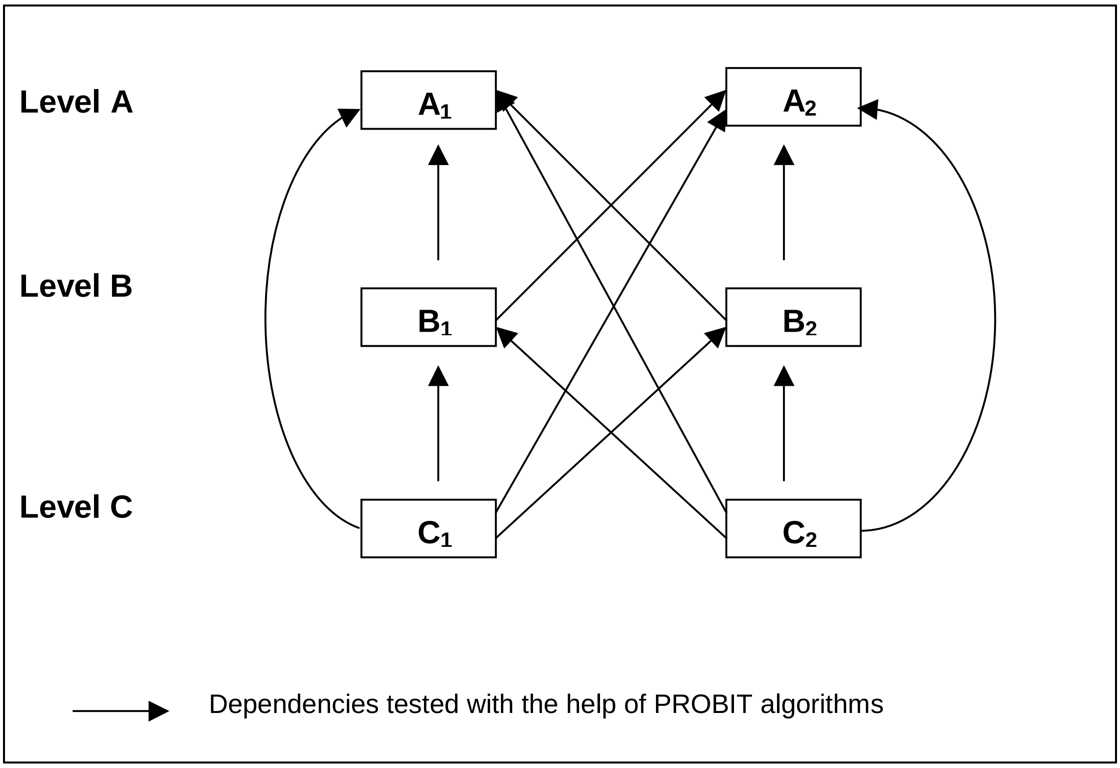
The path-modelling procedure is based on the successive performance of PROBIT algorithms. PROBIT algorithms estimate maximum-likelihood models in order to detect dependencies associating a dependent variable to explanatory (or independent) variables. The general form of the model to be estimated is:

$$\mathbf{Pr\ [E = 1] = \Phi[\beta_0 + \beta_1 A + \beta_2 B + ... + \beta_n X]}$$

with Φ being the cumulative normal distribution, E (dichotomic variable) the dependent variable, A, B and X being the explanatory variables. β_0 is the constant, β_1, β_2 and β_n are the coefficients of the independent variables in the equation.

The path-model is obtained by placing selected variables (according to the conceptual model developed) alternatively in the role: (i) of dependent variable in respect to some variables; or (ii) of independent variable in comparison to others. The set of "paths" resulting from the procedure can be interpreted as a "picture" of the interrelations between the variables. Variables can at the same time be explanatory (or independent) and dependent, depending on their relative position, (*cf.* figure 14).

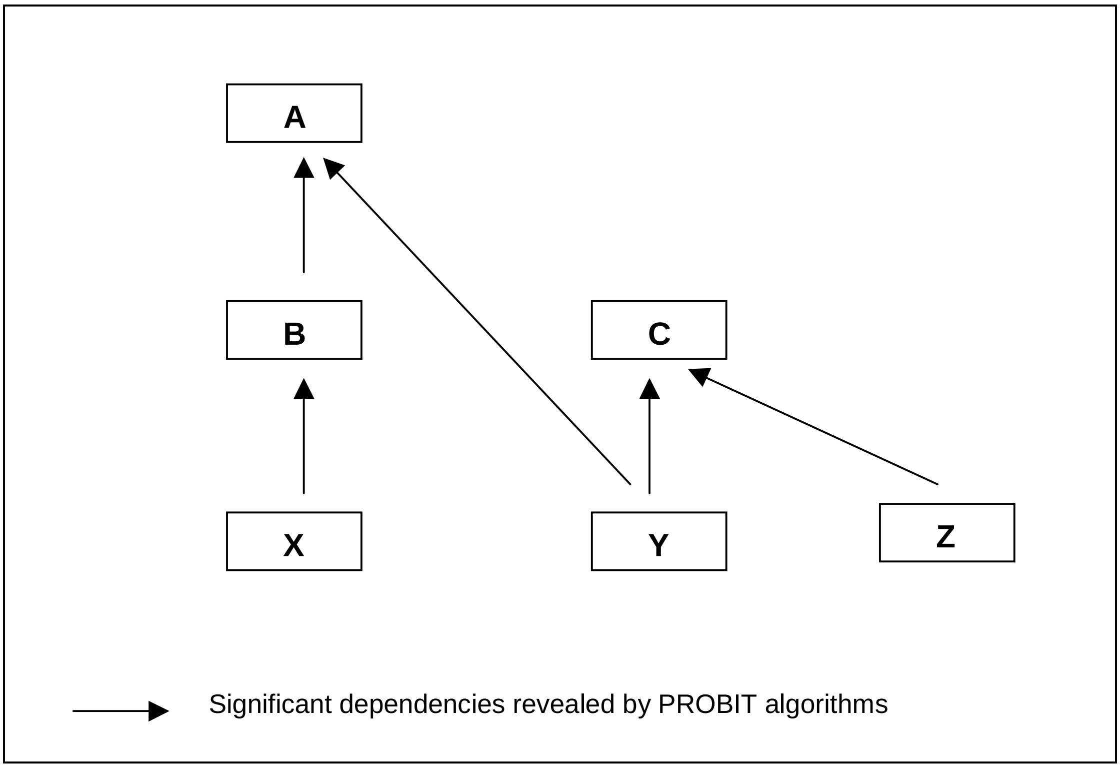
Figure 14: Path modelling – dependent and explanatory variables



The variables corresponding to level A are dependent variables relative to levels B and C.
The variables corresponding to level B are explanatory variables relative to level A and dependent variables relative to level C.
The variables corresponding to level C are explanatory variables relative to the levels A and B.

As a consequence, the identification of significant dependencies allows the interpretation of the revealed "paths" in terms of causality effects, and to distinguish between direct and indirect dependencies (*cf.* figure 15).

Figure 15: Path modelling – direct and indirect dependencies



Variable A depends (in a statistically significant way) directly on variables B and Y and indirectly on variable X.
Variable A does not depend, whether directly or indirectly, on variable Z.

5 Empirical Findings

The empirical analysis consists of two steps the first of which gives an overview of the sample firms concerning the share of innovating and growing firms and the variables describing internal and external knowledge factors. The second step – the PROBIT modelling – aims at gaining indications about causal relationships between knowledge-related variables and the growing/innovating feature. This step of the analysis compares both "success variables" (growth and innovation within a three-year-period) and their dependency on the chosen knowledge-related and structural variables.

5.1 Basic Features

Figure 16 gives a first overview of basic features of the SME sample:

- First of all, considering a three year period, 74.2 % of the firms reported innovation activities whereas 40.4 % of the sample firms have been able to increase their size during this period. It is worthwhile to notice that less than one third (30.5 %) of the firms have simultaneously introduced innovations and shown a sensible growth.
- In 37.7 % of the sample firms, more than 10 % of the employees dispose of a higher degree of qualification such as an university degree. This indicator will be used in further analyses as proxi for firms' knowledge incorporated in their staff.
- The share of firms' expenses for research and development reflects their propensity to use and produce specific problem-solving knowledge. In the sample of manufacturing firms considered, 16.0 % of the firms spent more than 8 % of their turnover for R&D and can therefore be considered as high-tech firms.
- Interactions with external partners are supposed to provide external knowledge for the firm. 60.5 % of the sample firm used this knowledge source in co-operating with knowledge-intensive business services.
- The share of firms co-operating with research institutions is obviously lower; 26.5 % of the firms in the sample used this specific knowledge source.

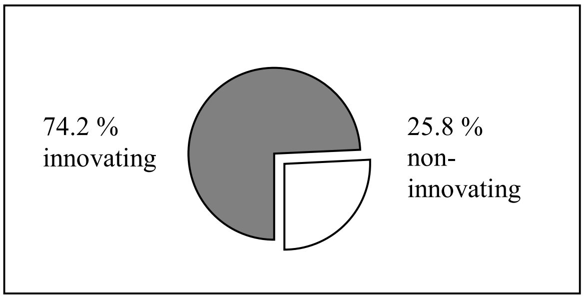
These first results show that less than 50 % of the considered firms have been "successful" in terms of growth increase even though the share of firms that innovated within a three-year-period is much higher. The fact that about one third of the sample firms simultaneously innovated and grew indicates that theses two phenomena are not necessarily inter-related, al least it does not imply that a simple linear causality and time congruency exists.[39] In fact, it can be assumed that innovation leads to firm growth with a certain time-lag. Therefore, both "success indicators" will be treated individually in the following sections.

The sample contains a higher share of firms with more than 10 % of the employees holding a higher education degree than firms belonging to the high-tech sectors. Concerning external knowledge sources, knowledge-intensive business services are chosen for co-operation by 60.5 % of the sample firms whereas a smaller amount of firms co-operated with research institutions. Whether growing and innovating firms used these knowledge sources to a higher extent than their non-growing/non-innovating counterparts, cannot be seen here and will be further investigated.

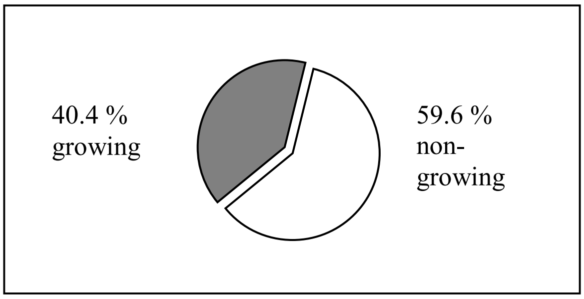
[39] In fact, this proportion is in reality even smaller since like in every firms survey of this kind, a "survivor bias" must be kept in mind: only firms that survived the considered three-years period can be taken into account.

Figure 16: Basic features of the sample

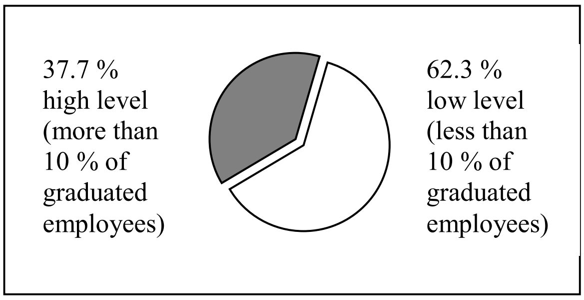
Proportion of innovating firms



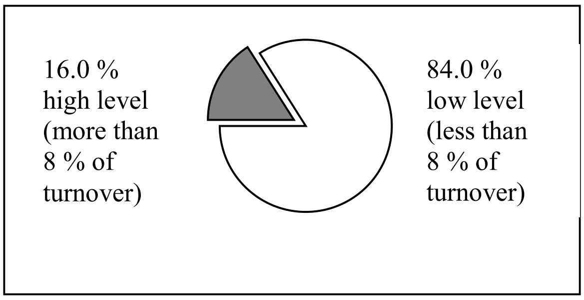
Proportion of growing firms



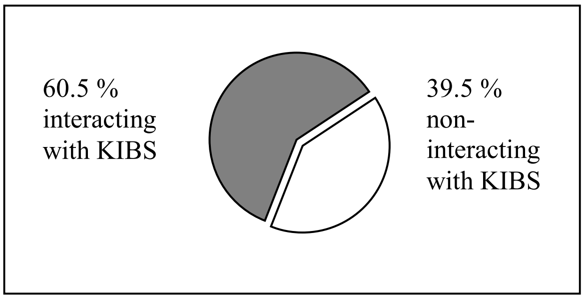
Proportion of firms with a high degree of qualification of the workforce



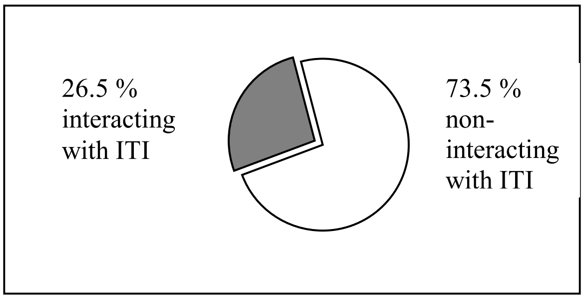
Proportion of firms with high level of investment in R&D



Proportion of firms interacting with KIBS



Proportion of firms interacting with ITI



5.2 Path Modelling: first variable (GROWTH)

According to the conceptual model, the influence of internal and external knowledge-related variables and of structural firm characteristics on firm growth in terms of increase in number of employees is investigated at first. Since structural firm characteristics are supposed not only to influence growth and innovation directly, but also knowledge characteristics of firms, successive PROBIT models have been calculated.

Table 4: Results of the PROBIT analysis

Dependent variables	Variables presenting **significance values < 0,05** according to PROBIT estimates	Variables presenting **significance values > 0,05** according to PROBIT estimates
GROWTH	KIBS - SIZE - REGION - SECTOR	HUMAN - ITI -RDINT
KIBS	SIZE - REGION	SECTOR
HUMAN	SIZE - REGION - SECTOR	
ITI	SIZE - REGION - SECTOR	
RDINT	SIZE - REGION - SECTOR	

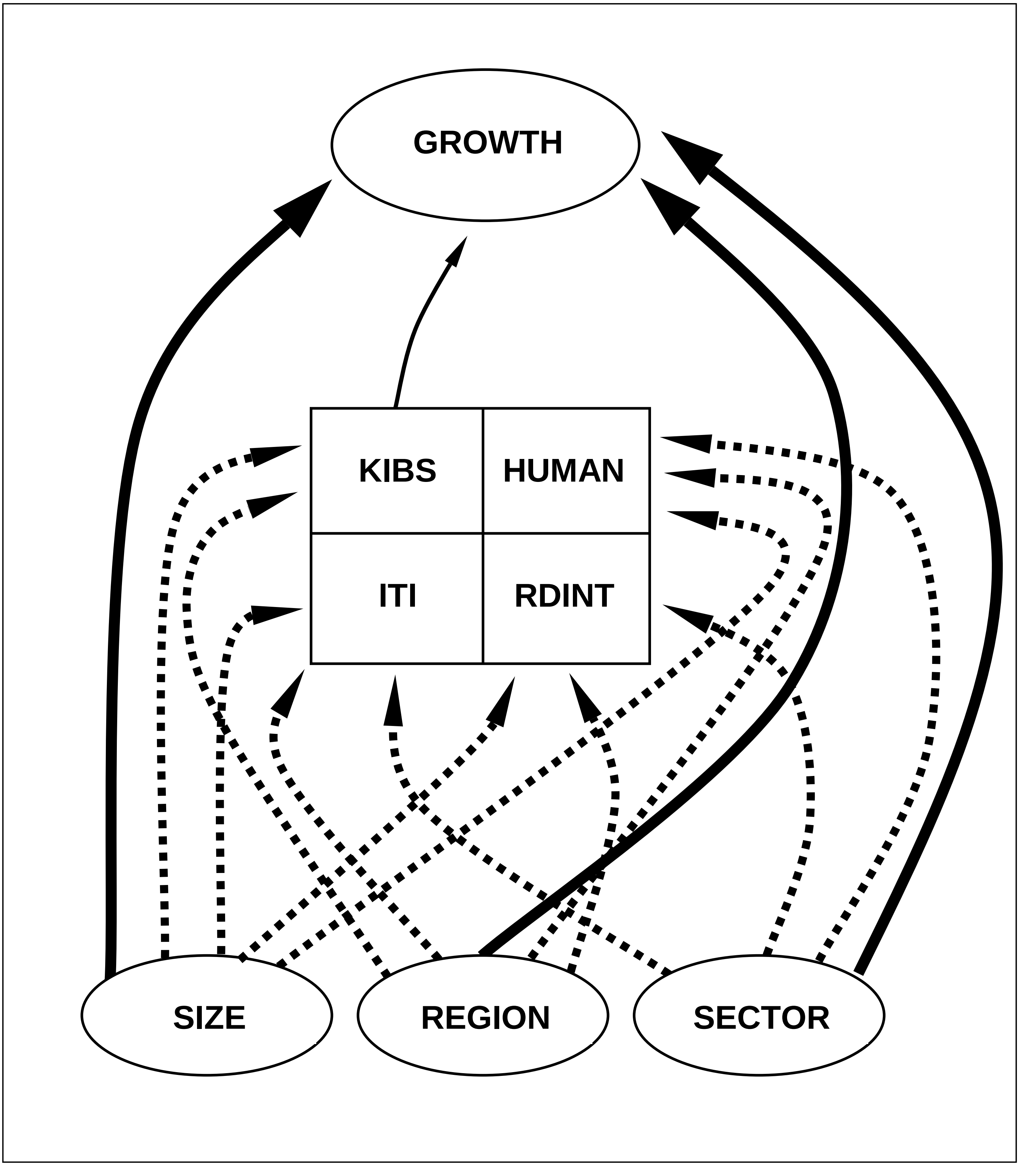
Results are displayed in table 4 and figure 17.[40] Among knowledge-related features, firm growth is influenced by interactions with KIBS in a significant and direct way. Since this variable is highly significant and has a positive sign, it can be concluded that co-operations with knowledge-intensive business services contribute to the evolution and growth of manufacturing small and medium-sized enterprises. In this respect, it is important to underline that the propensity of firms to interact with KIBS is significantly influenced by firms' size and location. Larger firms interact more frequently with KIBS than smaller ones and firms located in German regions are more inclined to use KIBS' services than firms located in any other European region of the sample. Besides interactions with KIBS, the chosen model does not reveal significant direct influences of the other knowledge-related variables. Concerning the structural variables, the influence of firms' size becomes obvious: the smaller the firm, the higher their propensity to grow.[41] Considering Baden as reference region, firms located in Barcelona, Saxony, South Holland, South Wales and Stockholm are characterised through a significant higher propensity to grow whereas firms in Vienna showed a significant lower propensity. Compared to firms in the food sector, firms belonging to the basic metals and to the electrical machin-

[40] *Cf.* also the appendix for detailed PROBIT models.

[41] Compared to small firms with less than 20 employees, larger firms show a highly significant negative influence on growth.

ery and apparatus industries significantly outperform other sectors in terms of growth in size.

Figure 17: First path model (GROWTH)



Concluding, considering growing SMEs (which constitute approximately 40 % of the whole sample), it appears that variables depicting the knowledge-related activities show only minor direct significant influence whereas structural factors are determining.

5.3 Path Modelling: second variable (INNOV)

Table 5 and figure 18 present the results for the dependent variable "introduction of innovations within a three-year-period".[42] The results of the PROBIT show clearly a higher influence of the considered variables on the innovation capacities of the firms comparatively to their inclination to grow.

Table 5: Results of the PROBIT analysis

Dependent variables	Variables presenting **significance values < 0,05** according to PROBIT estimates	Variables presenting **significance values > 0,05** according to PROBIT estimates
INNOV	KIBS - HUMAN - ITI - RDINT - SIZE - REGION - SECTOR	
KIBS	SIZE - REGION	SECTOR
HUMAN	SIZE - REGION - SECTOR	
ITI	SIZE - REGION - SECTOR	
RDINT	SIZE - REGION – SECTOR	

Within the chosen model, all four knowledge-related variables show a significant positive impact on the performance of innovations. Internal and external knowledge sources can be ranked as follows concerning their influence on firms' propensity to innovate: R&D intensity, interactions with ITI, interactions with KIBS and qualification level of the employees. This result shows that both internal as external knowledge factors determine the aptitude of firms to innovate. The structural variables show also a considerable influence on firms' inclination to innovate. Firstly, the proportion of innovating SMEs increases with size. Secondly, considering firms' location in terms of regional environment, Barcelona, Saxony, South Holland, South Wales and Vienna outperform significantly Baden (as a reference region). Finally, firms being active in the machinery and equipment and the electrical machinery and apparatus industries show a significant higher propensity to innovate than those of the other sectors.

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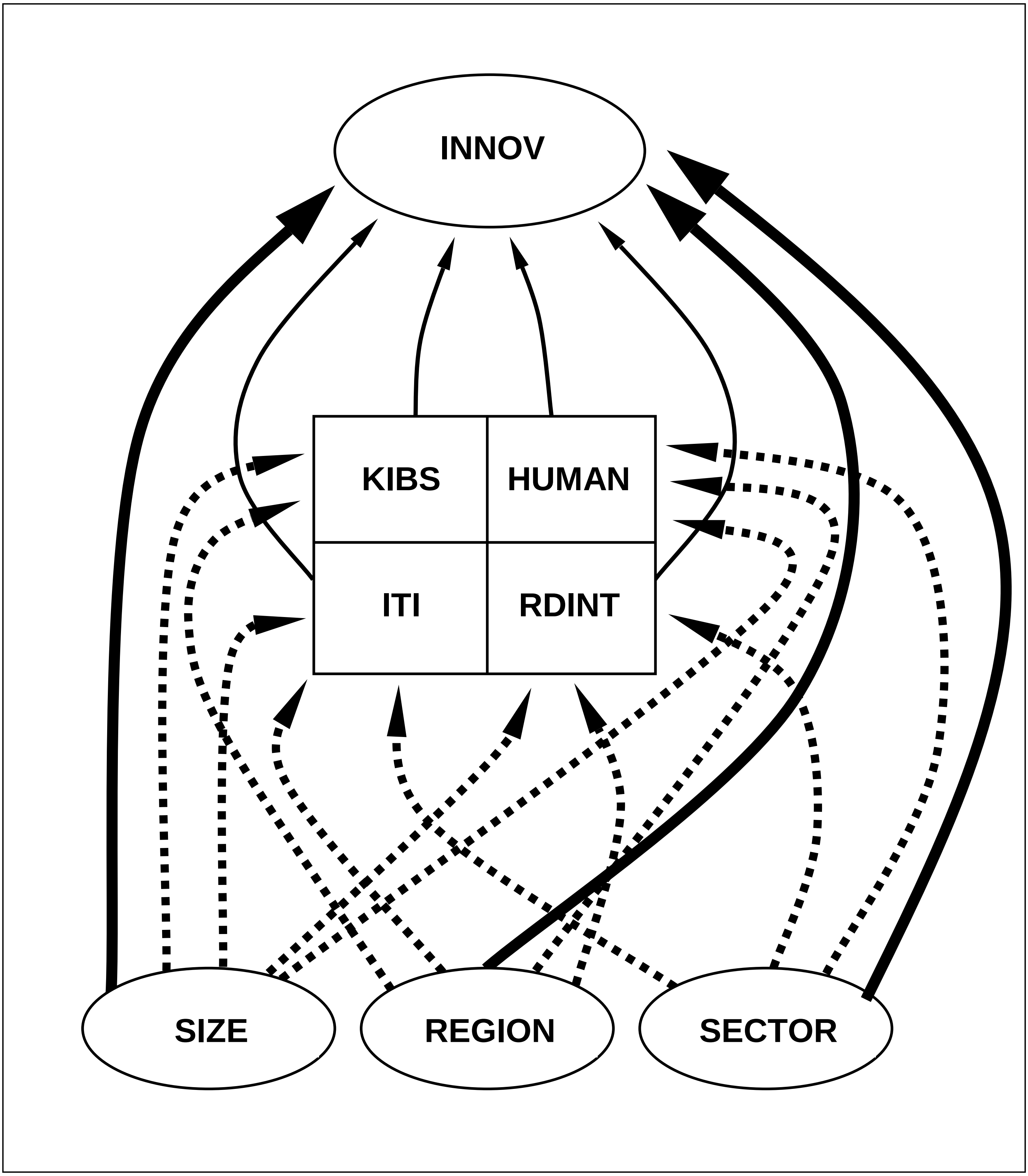
42 Detailed results of PROBIT analysis can be found in the appendix.

Figure 18: **Second path model (INNOV)**



Conclusion

Referring to the three research hypotheses, the empirical analysis indicates the following conclusions: Firms competencies based on different knowledge resources rather determine their success in terms of innovation performance than in terms of growth, at least in a direct way in within a short-term period. Nevertheless, it may be assumed that innovation success leads to economic evolution and firm growth in a medium- or long-term perspective. Only if this assumption proves to be true, then firms' knowledge base has an direct and time-lagged impact on their growth. The second hypothesis referred to firms' "knowledge environment" and drew attention to their (regional) location. Having performed the empirical part of the investigation, it can be argued that the regional setting indeed influences firms' activities and evolution. The PROBIT modelling indicated that the regional setting not only influenced knowledge-related features of SMEs, but also had direct impact on growth and innovation. The third hypothesis assumed that interactions with KIBS and ITI affect SMEs differently. In fact, the first step of the empirical analysis highlighted this difference in showing that more firms co-operated with knowledge-intensive business services than with research institutions. Moreover, the two PROBIT models proved that interactions with KIBS influence innovation performance and growth whereas interactions with ITI have only a significant impact on the introduction of innovations. Thus, it can be argued that KIBS and ITI indeed fulfil different functions for manufacturing firms. The empirical findings lead to the assumption that KIBS' services have a broader character and are requested not exclusively for innovation purposes. On the contrary, co-operations with ITI are performed by a smaller share of firms and contribute significantly to the innovation success. Therefore, it can be concluded that those interactions are more innovation specific and directed to certain problems to be solved.

Summarising, SMEs' innovativeness and evolution in terms of growth seem to be influenced by different factors. Whereas knowledge resources show a high impact on innovation activities, growth rather seems to be influenced by structural characteristics. In this respect, the generation and application of knowledge by SMEs appear as a precondition for successful innovative activities, nevertheless this cannot be assumed to be the unique factor leading these firms to growth.

References

ANCORI, B. (1983): Communication, information et pouvoir. In: LICHNEROWICZ, A./ PERROUX, F./ GADOFFRE, G. (Eds): Information et communication. Maloine, pp. 59-84.

ANSELIN, L./ VARGA, A./ ACS, Z.J. (1997): Entrepreneurship, Geographic Spillovers and University Research: A Spatial Econometric Approach. Paper presented at the International Conference on Innovation and Performance of SMEs, March 17, Cambridge.

ARROW, K. (1962): The Economic Implication of Learning by Doing. *Review of Economic Studies*, **29**, (80), pp. 155-173.

ASHEIM, B./ ISAKSEN, A. (1999): Regional Innovation Systems: The Integration of Local 'Sticky' and Global 'Ubiquitous' Knowledge. Paper presented at the NECSTS-99 Conference on 'Regional Innovation Systems in Europe', San Sebastian, 30 September – 2 October.

AUTÈS, M. (1995): Le sens du territoire. *Recherches et Prévisions,* **39**, pp. 57-71.

AYDALOT, P. (Ed.) (1986): Milieux innovateurs en Europe. GREMI: Paris.

AYDALOT, P./ KEEBLE, D. (1988) (Eds.): High Technology Industry and Innovative Environment: the European Experience. Routledge: London, New York.

BARRÉ, R./ GIBBONS, M./ MADDOX, J./ MARTIN, B./ PAPON, P. (1997) (Eds): Science in Tomorrow's Europe, Economica International, Paris.

BELLET, M./ COLLETIS, G./ LECOQ, B./ LUNG, Y./ PECQUEUR, B./ RALLET, A./ TORRE, A. (1992): Et pourtant ça marche! Quelques réflexions sur l'analyse du concept de proximité. *Revue d'économie industrielle*, **61**, pp. 111-128.

BENKO, G./ LIPIETZ, A. (1992): Le nouveau débat régional: positions. In: BENKO, G./ LIPIETZ, A. (Eds.) (1992): Les régions qui gagnent – Districts et réseaux: les nouveaux paradigmes de la géographie économique. Presses Universitaires de France, Paris, pp. 13-32.

BENKO, G./ LIPIETZ, A. (Eds.) (1992): Les régions qui gagnent – Districts et réseaux: les nouveaux paradigmes de la géographie économique. Presses Universitaires de France, Paris.

CAPALDO, G./ CORTI, E./ GRECO, O. (1997): A Coordinated Network of Different Actors to Offer Innovation Services to Develop Local SMEs Inside Areas with a Delay of Development. Paper presented at the ERSA Conference, August 26-29, Rome.

CLARK, N. (1986): Introduction: Economic Analysis and Technological Change: a Review of Some Recent Developments. In: MACLEOD, R. (Ed.) (1986): Technology and the Human Prospect. Pinter Publishers, London, pp. 1-27.

COBBENHAGEN, J./ DEN HERTOG, F. (1994): Successful Innovating Firms. What Differentiates the Front Runners? Paper presented at the 1994 Spring Meeting of the Six Countries Programme "Innovation – Applying New Ideas for Profit", May 25-26, London.

COFFEY, W. J./ POLESE, M. (1984): La localisation des activités de bureau et des services aux entreprises: un cadre d'analyse. *Revue d'Economie Régionale et Urbaine*, **5**, pp. 717-729.

COHEN, W./ LEVINTHAL, D. (1989): Innovation and Learning, the Two Faces of R&D. *Economic Journal,* **99,** pp. 569-596.

COHENDET, P. (1996): Information, connaissances et théorie de la firme évolutionniste. Présentation au Commissariat Général au Plan, 16 avril 1996. BETA, Université Louis Pasteur, Strasbourg.

COHENDET, P. (1998): Codification of Knowledge: Some Main Issues of the TIPIK Project. Internal Paper, University Louis Pasteur, Strasbourg.

COOKE, P. (1998): Introduction: origins of the concept, BRACZYK, H.-J./COOKE, P./HEIDENREICH, M. (Eds.): *Regional Innovation Systems*. London: UCL Press, pp. 2-25.

CURIEN, N. (Ed.) (1992): Économie et Management des entreprises de réseau. Economica, Paris.

DAVELAAR, E. J. (1991): Regional Economic Analysis of Innovation and Incubation. Avebury, Aldershot.

DAVID, P. A./ FORAY, D. (1995): Accessing and Expanding the Science and Technology Knowledge Base. In: Special Issue on Innovation and Standards, STI (Science Technology Industry) Review No. 16. Organisation for Economic Co-operation and Development (OECD), Paris, pp. 13-68.

DAVIS, G. B. (1974): Management Information System: Conceptual Foundation, Structure and Development. Mac Graw Hill.

DE BANDT, J./ GADREY, J. (Eds.) (1994): Relations de service, marchés de services. CNRS Editions, Paris.

DJELLAL, F. (1993): Les firmes de conseil en technologie de l'information comme agents d'un paradigme socio-technique: analyse de leur organisation fonctionnelle et spatiale. Thèse de Doctorat en Sciences Economiques, Université de Lille.

DOSI, G. (1982): Technological Paradigms and Technological Trajectories: A Suggested Interpretation of the Determinants and Directions of Technical Change. *Research Policy*, **11** (3), pp. 147-162.

DOSI, G./ FREEMAN, C./ NELSON, R./ SILVERBERG, G./ SOÈTE, L. (Eds) (1988): The Technological Change and Economic Theory. Pinter Publishers, London.

ELIASSON, G. (1996): Firm Objectives, Controls and Organization. The Use of Information and the Transfer of Knowledge within the Firm. Kluwer: Dordrecht, Boston, London.

FREEMAN, C. (1982): The Economic of Industrial Innovation. Pinter Publishers, London.

GADREY, J. (1994): Les relations de service dans le secteur marchand. In: DE BANDT, J.; GADREY, J. (Eds.) (1994*): Relations de service, marchés de services*. CNRS Editions: pp. 23-41.

GALLOUJ, F. (1992): Economie de l'innovation dans les services: au-delà des approches industrialistes. Thèse de Doctorat en Sciences Economiques, Université de Lille.

GALLOUJ, F. (1994): Economie de l'innovation dans les services. Editions L'Harmattan, Paris.

GERTLER, M. (1995): Manufacturing Technology and User-Producer Interaction – Regional and National Systems of Regulation. Paper presented at the International Workshop "The Role and Impact of Science and Technology in Innovation and Regional Economic Development. Models, Approaches, Policies and Their Effectiveness", Green College, University of British Columbia, Vancouver B.C., 23-25 August.

GROUPE DE RECHERCHE EUROPEEN SUR LES MILIEUX INNOVATEURS (1989): Milieux innovateurs et réseaux transnationaux: vers une nouvelle théorie du développement spatial. Actes du colloque GREMI-EADA, 28-29 mars, Barcelone.

GROUPE DE RECHERCHE EUROPEEN SUR LES MILIEUX INNOVATEURS (1990): Nouvelles formes d'organisation industrielle: réseaux d'innovation et milieux locaux. Actes du colloque GREMI, 11-12 novembre, Neuchâtel.

HERAUD, J.-A. (1987): Interaction, information et apprentissage: l'auto-organisation en économie. Working Paper BETA, 8709, Strasbourg.

HERAUD, J.-A. (1988): Routine et innovation dans un système économique auto-organisé. *Fundamenta Scientae*, **9**, (2/3), pp. 375-391.

HÉRAUD, J.-A./ MULLER, E. (1998): The Impact of Universities and Research Institutions Labs on the Creation and Diffusion of Innovation-Relevant Knowledge: the Case of the Upper-Rhine Valley. Paper presented at the European Regional Science Association (ERSA), August 31 – September 2, Vienna.

HICKS, D. (1995): Published Papers, Tacit Competencies and Corporate Management of the Public/ Private Character of Knowledge. *Industrial and Corporate Change*, **4,** (2), pp. 401-424.

JAFFE, A. (1989): Real Effects of Academic Research. *American Economic Review,* **79**, pp. 957-970.

JOHNSON, B. (1992): Institutional Learning. In: LUNDVALL, B.-Å. (ed.): National Systems of Innovation. Towards a Theory of Innovation and Interactive Learning. Pinter: London, 23-44.

JULIEN, P.-A. (1996): Information control: a key factor in small business development. Paper presented at the 41st ICSB world conference, June 17-19, Stockholm.

KLINE, S./ ROSENBERG, N. (1986): An Overview of Innovation. In: LANDAU, R./ ROSENBERG, N. (Eds.) (1986): The Positive Sum Strategy: Harnessing Technology for Economic Growth. National Academy Press, Washington D.C., pp. 275-305.

KOSCHATZKY, K. *et al.* (1996): Institutions of Technological Infrastructure. Collective report FhG-ISI/ BETA performed for the European Commission – Eurostat. Karlsruhe/ Strasbourg.

KOSCHATZKY, K./ MULLER, E. (1997): Firm Innovation and Region – Theoretical and Political Conclusions on Regional Innovation Networking. Paper presented at the ERSA Conference, August 26-29, Rome.

LANDAU, R./ ROSENBERG, N. (Eds.) (1986): The Positive Sum Strategy: Harnessing Technology for Economic Growth. National Academy Press, Washington D.C.

LE MOIGNE, J. L. (1986): Vers un système d'information organisationnel. *Revue Française de Gestion,* Novembre – décembre, pp. 20-31.

LUNDVALL, B. A. (1988): Innovation as an Interactive Process: From User-Producer Interaction to the National System of Innovation. In: DOSI, G./ FREEMAN, C./ NELSON, R./ SILVERBERG, G./ SOÈTE, L. (Eds) (1988): The Technological Change and Economic Theory. Pinter Publishers, London, pp. 349-369.

MACLEOD, R. (Ed.) (1986): Technology and the Human Prospect. Pinter Publishers, London.

MAILLAT, D./ PERRIN, J. C. (Eds) (1992): Entreprises innovatrices et développement territorial. EDES, Neuchâtel.

MEYER-KRAHMER, F. (1997): Public research/ industry linkages revisited. In: BARRÉ, R./ GIBBONS, M./ MADDOX, J./ MARTIN, B./ PAPON, P. (1997) (Eds): Science in Tomorrow's Europe, Economica International, Paris. pp. 155-173.

MILES, I./ KASTRINOS, N./ FLANAGAN, K./ BILDEBEEK, R./ DEN HERTOG, P./ HUNTINK, W./ BOUMAN, M. (1994): Knowledge-Intensive Business Services: Their Roles as Users, Carriers and Sources of Innovation. PREST, Manchester.

MORGAN, K./NAUWELAERS, C. (1999): Regional Perspective on Innovation: From Theory to Strategy. In: MORGAN, K./NAUWELAERS, C. (Eds.): Regional Innovation Strategies. The Challenge for Less-Favoured Regions. Regions, Cities and Public Policy Series. London: The Stationary Office/Regional Studies Association, pp. 1-18.

MORIN, J. (1986): Le management des ressources technologiques: un vecteur de l'innovation. *Revue Française de Gestion,* Sept./ Oct., pp. 31-38.

MULLER, E./ ZENKER, A. (1998): Analysis of Innovation-oriented Networking Between R&D Intensive Small Firms and Knowledge Intensive Business Services - Empirical Evidence from France and Germany. In: *Proceedings of the High-Technology Small Firm Conference*, 4 & 5 June 1998, University of Twente (The Netherlands), pp. 175-203.

MUSTAR, P./ CALLON, M. (1992): Réseaux de l'innovation. In: CURIEN, N. (Ed.) (1992): Économie et Management des entreprises de réseau. Economica, Paris. pp. 115-128.

NELSON, R./ WINTER, S. (1974): Neoclassical vs Evolutionary Theories of Economic Growth. Critique and Prospectus. *Economic Journal,* December, pp. 886-905.

NELSON, R./ WINTER, S. (1975): Growth Theory from an Evolutionary Perspective: The Differential Productivity Puzzle. *The American Economic Review,* **65** (2), pp. 338-344.

NELSON, R./ WINTER, S. (1977): In Search of a Useful Theory of Innovation. *Research Policy*, **6**, pp. 36-76.

NONAKA, I. (1994): A Dynamic Theory of Organizational Knowledge Creation. In: *Organization Science*, **5** (1), pp. 14-37.

NONAKA, I./ TAKEUCHI, H. (1995): The Knowledge-Creating Company, Oxford University Press: New York, Oxford.

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT (1993): Les Petites et Moyennes Entreprises: technologie et compétitivité. OCDE: Paris.

PECQUEUR, B. (1989): Le développement local. Syros, Paris.

PERRIN, J.-C. (1990): Organisation industrielle: La composante territoriale. In: *Revue d'Economie Industrielle*, 51, pp. 276-303.

RALLET, A. (1993): Choix de proximité et processus d'innovation technologique. *Revue d'Economie Régionale et Urbaine,* **3,** pp. 365-385.

ROSENBERG, N. (1990): Why do firms do basic research (with their own money)? *Research Policy*, **19**, pp. 165-174.

SAUSSURE, F. (1989): Cours de linguistique générale. Edition critique par R. ENGLER, Tome 1. Wiesbaden: Harrassowitz. Reproduction de l'édition originale (1968).

SAVIOTTI, P. P. (1998): On the dynamics of appropriability, of tacit and of codified knowledge. *Research Policy*, **26**, pp. 843-856.

SCHUMPETER, J. A. (1950): Capitalism, Socialism and Democracy. Harper and Brothers, New-York.

SPENDER, J.-C. (1996): Making Knowledge the Basis of a Dynamic Theory of the Firm. *Strategic Management Journal,* **17**, Special Issue Winter 1996, pp. 45-62.

TEECE, D. J. (1986): Profiting from Technological Innovation: Implications for Integration, Collaboration, Licensing and Public Policy. *Research Policy,* **15,** pp. 285-305.

WEBER, A. (1929): Theory of the Location of Industry. University of Chicago Press, Chicago.

Appendix: PROBIT Algorithms

```
. probit growth kibs human iti rdint size2 size3 region1 region3 region4 region5
region6 region7 region8 region9 region10 sector2 sector3 sector4 sector5 sector6
sector7

Iteration 0:  Log Likelihood =-2206.9462
Iteration 1:  Log Likelihood =-2006.1682
Iteration 2:  Log Likelihood =-2004.3356
Iteration 3:  Log Likelihood =-2004.3336

Probit Estimates                                  Number of obs =   3272
                                                  chi2(21)      = 405.23
                                                  Prob > chi2   = 0.0000
Log Likelihood = -2004.3336                       Pseudo R2     = 0.0918

------------------------------------------------------------------------------
  growth |      Coef.   Std. Err.       z     P>|z|       [95% Conf. Interval]
---------+--------------------------------------------------------------------
    kibs |   .2047764   .0563917      3.631   0.000       .0942506    .3153021
   human |  -.0449839   .0523612     -0.859   0.390        -.14761    .0576421
     iti |   .0433209   .0569892      0.760   0.447      -.0683759    .1550176
   rdint |   .0059198   .0665021      0.089   0.929      -.1244218    .1362615
   size2 |  -.3971257   .0581861     -6.825   0.000      -.5111683    -.283083
   size3 |   -.886012   .0610054    -14.524   0.000       -1.00558   -.7664436
 region1 |   .0389217   .1150251      0.338   0.735      -.1865233    .2643667
 region3 |   .4762278   .0986717      4.826   0.000       .2828348    .6696209
 region4 |   .1613057    .154667      1.043   0.297      -.1418361    .4644474
 region5 |   .0432619   .1024745      0.422   0.673      -.1575843    .2441082
 region6 |   .3434391   .0829516      4.140   0.000       .1808569    .5060212
 region7 |   .2588742   .1244506      2.080   0.038       .0149555    .5027929
 region8 |   .7372279   .1111255      6.634   0.000       .5194259    .9550299
 region9 |   .2982125   .0964825      3.091   0.002       .1091102    .4873147
region10 |  -.3947057   .1386275     -2.847   0.004      -.6664105   -.1230009
 sector2 |  -.0140108   .1366104     -0.103   0.918      -.2817622    .2537406
 sector3 |    .029877   .1054573      0.283   0.777      -.1768155    .2365694
 sector4 |    .090995   .1068488      0.852   0.394      -.1184248    .3004148
 sector5 |   .2305245   .1045066      2.206   0.027       .0256953    .4353538
 sector6 |   .1888627   .1057845      1.785   0.074      -.0184712    .3961965
 sector7 |   .3706132   .1101154      3.366   0.001        .154791    .5864354
   _cons |  -.3325044   .1266549     -2.625   0.009      -.5807435   -.0842652
------------------------------------------------------------------------------
```

```
. probit kibs size2 size3 region1 region3 region4 region5 region6 region7 re-
gion8 region9 region10 sector2 sector3 sector4 sector5 sector6 sector7

Note: region7~=0 predicts failure perfectly
      region7 dropped and 196 obs not used

Iteration 0:  Log Likelihood =-1986.7998
Iteration 1:  Log Likelihood =-1692.3077
Iteration 2:  Log Likelihood = -1689.543
Iteration 3:  Log Likelihood =-1689.5412
Iteration 4:  Log Likelihood =-1689.5412

Probit Estimates                                        Number of obs =   3076
                                                        chi2(16)      = 594.52
                                                        Prob > chi2   = 0.0000
Log Likelihood = -1689.5412                             Pseudo R2     = 0.1496

------------------------------------------------------------------------------
    kibs |      Coef.   Std. Err.       z     P>|z|       [95% Conf. Interval]
---------+--------------------------------------------------------------------
   size2 |  -.1056817   .0632934     -1.670   0.095      -.2297345     .018371
   size3 |   .3066433   .0645389      4.751   0.000       .1801493    .4331373
 region1 |  -.8104413   .1155445     -7.014   0.000      -1.036904   -.5839783
 region3 |  -.7790032   .1027609     -7.581   0.000      -.9804108   -.5775955
 region4 |  -.9858848   .1513736     -6.513   0.000      -1.282572    -.689198
 region5 |   .0019529   .1158502      0.017   0.987      -.2251093    .2290152
 region6 |   .0307611   .0916318      0.336   0.737      -.1488339    .2103562
 region8 |   -1.21915   .1112917    -10.955   0.000      -1.437278   -1.001022
 region9 |  -1.319421   .0988909    -13.342   0.000      -1.513243   -1.125598
region10 |  -1.102508   .1227301     -8.983   0.000      -1.343054   -.8619613
 sector2 |  -.2171386   .1464094     -1.483   0.138      -.5040957    .0698186
 sector3 |   -.113437   .1145619     -0.990   0.322      -.3379741    .1111002
 sector4 |  -.1832892   .1166701     -1.571   0.116      -.4119584    .0453801
 sector5 |  -.1119545   .1145068     -0.978   0.328      -.3363837    .1124747
 sector6 |   -.104495   .1155546     -0.904   0.366      -.3309778    .1219879
 sector7 |  -.2194572   .1178177     -1.863   0.063      -.4503756    .0114612
   _cons |     1.0258   .1299666      7.893   0.000       .7710697    1.280529
------------------------------------------------------------------------------
```

```
. probit human size2 size3 region1 region3 region4 region5 region6 region7 re-
gion8 region9 region10 sector2 sector3 sector4 sector5 sector6 sector7

Iteration 0:  Log Likelihood =-2170.6711
Iteration 1:  Log Likelihood =-1941.3994
Iteration 2:  Log Likelihood =-1939.3985
Iteration 3:  Log Likelihood =-1939.3977

Probit Estimates                                      Number of obs =   3272
                                                      chi2(17)      = 462.55
                                                      Prob > chi2   = 0.0000
Log Likelihood = -1939.3977                           Pseudo R2     = 0.1065

------------------------------------------------------------------------------
   human |      Coef.   Std. Err.       z     P>|z|       [95% Conf. Interval]
---------+--------------------------------------------------------------------
   size2 |  -.2079287   .0595238     -3.493   0.000      -.3245933   -.0912641
   size3 |  -.2192648   .0590637     -3.712   0.000      -.3350275   -.1035021
 region1 |   .4604981   .1161292      3.965   0.000       .2328891    .6881071
 region3 |     .35931   .1015686      3.538   0.000       .1602393    .5583808
 region4 |    .530078   .1552662      3.414   0.001       .2257618    .8343942
 region5 |   .0772997   .1086917      0.711   0.477      -.1357322    .2903315
 region6 |   1.098739    .085698     12.821   0.000        .930774    1.266704
 region7 |   .2790894   .1202561      2.321   0.020       .0433917    .5147871
 region8 |    .829012   .1092752      7.586   0.000       .6148365    1.043188
 region9 |   .2358603   .0977989      2.412   0.016        .044178    .4275426
region10 |  -.0155585   .1343691     -0.116   0.908      -.2789171    .2478001
 sector2 |  -.2832413   .1408274     -2.011   0.044       -.559258   -.0072247
 sector3 |   .0091127   .1073019      0.085   0.932      -.2011953    .2194206
 sector4 |   .3244752   .1070874      3.030   0.002       .1145877    .5343627
 sector5 |   .2403843    .105826      2.272   0.023       .0329693    .4477994
 sector6 |   .5137672   .1057746      4.857   0.000       .3064527    .7210816
 sector7 |   .7585262   .1092256      6.945   0.000        .544448    .9726044
   _cons |  -.9800523   .1220181     -8.032   0.000      -1.219203   -.7409012
------------------------------------------------------------------------------
```

```
. probit iti size2 size3 region1 region3 region4 region5 region6 region7 region8
region9 region10 sector2 sector3 sector4 sector5 sector6 sector7

Iteration 0:  Log Likelihood =-1884.6806
Iteration 1:  Log Likelihood =-1758.1236
Iteration 2:  Log Likelihood =-1757.4567
Iteration 3:  Log Likelihood =-1757.4566

Probit Estimates                                        Number of obs =   3272
                                                        chi2(17)      = 254.45
                                                        Prob > chi2   = 0.0000
Log Likelihood = -1757.4566                             Pseudo R2     = 0.0675

------------------------------------------------------------------------------
     iti |      Coef.   Std. Err.       z     P>|z|       [95% Conf. Interval]
---------+--------------------------------------------------------------------
   size2 |   .0919227   .0656142      1.401   0.161      -.0366788    .2205242
   size3 |   .6852993   .0619795     11.057   0.000       .5638217    .8067769
 region1 |   .0672831   .1182653      0.569   0.569      -.1645126    .2990788
 region3 |  -.2204345    .107103     -2.058   0.040      -.4303525   -.0105164
 region4 |   .2002543   .1602502      1.250   0.211      -.1138302    .5143389
 region5 |  -.1307447   .1069202     -1.223   0.221      -.3403045     .078815
 region6 |   .2633139   .0840455      3.133   0.002       .0985877      .42804
 region7 |   .0866616   .1207926      0.717   0.473      -.1500876    .3234108
 region8 |   .0536683   .1124362      0.477   0.633      -.1667026    .2740391
 region9 |  -.0098492   .0996354     -0.099   0.921       -.205131    .1854326
region10 |  -.3923859   .1347794     -2.911   0.004      -.6565487   -.1282231
 sector2 |    .093996    .136416      0.689   0.491      -.1733745    .3613665
 sector3 |  -.1514421   .1116811     -1.356   0.175      -.3703329    .0674488
 sector4 |   .0355544   .1107089      0.321   0.748       -.181431    .2525399
 sector5 |    .043257   .1092442      0.396   0.692      -.1708577    .2573718
 sector6 |   .2545321   .1079318      2.358   0.018       .0429896    .4660745
 sector7 |   .3345526   .1113875      3.004   0.003       .1162372     .552868
   _cons |  -1.078238   .1246567     -8.650   0.000      -1.322561   -.8339153
------------------------------------------------------------------------------
```

```
. probit rdint size2 size3 region1 region3 region4 region5 region6 region7 re-
gion8 region9 region10 sector2 sector3 sector4 sector5 sector6 sector7

Iteration 0:  Log Likelihood =-1446.0059
Iteration 1:  Log Likelihood =-1344.5068
Iteration 2:  Log Likelihood =-1342.5654
Iteration 3:  Log Likelihood =-1342.5516
Iteration 4:  Log Likelihood =-1342.5516

Probit Estimates                                        Number of obs =   3272
                                                        chi2(17)      = 206.91
                                                        Prob > chi2   = 0.0000
Log Likelihood = -1342.5516                             Pseudo R2     = 0.0715

------------------------------------------------------------------------------
   rdint |      Coef.   Std. Err.       z     P>|z|       [95% Conf. Interval]
---------+--------------------------------------------------------------------
   size2 |  -.1734836   .0703923     -2.465   0.014       -.31145   -.0355173
   size3 |  -.0914196   .0680386     -1.344   0.179     -.2247727    .0419336
 region1 |  -.7208796   .1698231     -4.245   0.000     -1.053727   -.3880323
 region3 |  -.1240559   .1139571     -1.089   0.276     -.3474078    .0992959
 region4 |  -.4638846   .2133195     -2.175   0.030      -.881983   -.0457861
 region5 |   -.094751   .1171819     -0.809   0.419     -.3244233    .1349213
 region6 |   .2919342   .0892678      3.270   0.001      .1169724    .4668959
 region7 |  -.3635629   .1468886     -2.475   0.013     -.6514592   -.0756665
 region8 |  -.2273861   .1278649     -1.778   0.075     -.4779967    .0232244
 region9 |  -.2646147    .111224     -2.379   0.017     -.4826099   -.0466196
region10 |  -.1859202   .1460885     -1.273   0.203     -.4722484    .1004079
 sector2 |   .3856686   .1655135      2.330   0.020       .061268    .7100691
 sector3 |   .1287219   .1423293      0.904   0.366     -.1502385    .4076822
 sector4 |   .2460661   .1415535      1.738   0.082     -.0313736    .5235059
 sector5 |   .2470561   .1400659      1.764   0.078      -.027468    .5215802
 sector6 |   .4326384   .1379745      3.136   0.002      .1622134    .7030633
 sector7 |   .8925665   .1382274      6.457   0.000      .6216457    1.163487
   _cons |  -1.228293   .1507036     -8.150   0.000     -1.523667   -.9329195
------------------------------------------------------------------------------
```

```
. probit innov kibs human iti rdint size2 size3 region1 region3 region4 region5
region6 region7 region8 region9 region10 sector2 sector3 sector4 sector5 sector6
sector7

Iteration 0:  Log Likelihood = -1855.182
Iteration 1:  Log Likelihood =-1519.2376
Iteration 2:  Log Likelihood =-1483.7021
Iteration 3:  Log Likelihood = -1478.987
Iteration 4:  Log Likelihood =-1478.6968
Iteration 5:  Log Likelihood =-1478.6945

Probit Estimates                                      Number of obs =   3272
                                                      chi2(21)      = 752.98
                                                      Prob > chi2   = 0.0000
Log Likelihood = -1478.6945                           Pseudo R2     = 0.2029

------------------------------------------------------------------------------
   innov |      Coef.   Std. Err.       z     P>|z|       [95% Conf. Interval]
---------+--------------------------------------------------------------------
    kibs |   .4686731   .0635795      7.371   0.000       .3440595    .5932866
   human |    .271366   .0616961      4.398   0.000       .1504439    .3922881
     iti |   .5667104   .0753309      7.523   0.000       .4190644    .7143563
   rdint |   1.797665   .1828853      9.829   0.000       1.439216    2.156113
   size2 |   .4136754   .0656684      6.299   0.000       .2849677    .5423832
   size3 |   .7054596   .0704903     10.008   0.000       .5673011    .8436181
 region1 |  -.1178908   .1210164     -0.974   0.330      -.3550787     .119297
 region3 |   .7724521   .1222668      6.318   0.000       .5328137    1.012091
 region4 |   .1343043   .1617458      0.830   0.406      -.1827117    .4513202
 region5 |   .1430025    .113654      1.258   0.208      -.0797553    .3657602
 region6 |   .2523712   .0950725      2.655   0.008       .0660325    .4387098
 region7 |   .7205451   .1398217      5.153   0.000       .4464996    .9945907
 region8 |   .6409897   .1300824      4.928   0.000       .3860328    .8959465
 region9 |   .2086686   .1083068      1.927   0.054      -.0036087     .420946
region10 |   .4501487   .1376945      3.269   0.001       .1802725     .720025
 sector2 |  -.0723644   .1458621     -0.496   0.620       -.358249    .2135201
 sector3 |   .0395658   .1102373      0.359   0.720      -.1764953    .2556269
 sector4 |   -.008098   .1127786     -0.072   0.943      -.2291401     .212944
 sector5 |  -.1194922   .1097893     -1.088   0.276      -.3346753    .0956908
 sector6 |   .2345329   .1149414      2.040   0.041        .009252    .4598139
 sector7 |   .2900065   .1239477      2.340   0.019       .0470735    .5329395
   _cons |  -.6450842   .1374137     -4.694   0.000        -.91441   -.3757583
------------------------------------------------------------------------------
```