7 University-Industry Relationships and Regional Innovation Systems: Analysis of the French Procedure Cifre

Jean-Alain Héraud and Rachel Lévy

BETA, Strasbourg, E-mail: heraud@cournot.u-strasbg.fr
BETA, Strasbourg, E-mail: levy@cournot.u-strasbg.fr

7.1 Introduction

This chapter aims at understanding the role of universities at the level of territory, or "region", that is, as a sub-national entity. A considerable amount of the economic literature and a number of policy-oriented papers have been devoted to university-industry relationships and regional innovation systems. However, little has been done on looking at the links between university and the regional industrial fabric. We address this gap drawing on a database of contractual PhD research projects involving private firms and public laboratories.

Since 1981, there has been a system in operation in France, under the auspices of the French government, which enables doctoral research students to conduct their research partly in a public research laboratory and partly in a firm. This collaborative arrangement, called Cifre (Convention industrielle de formation par la recherche), is a public-private research training agreement. The PhD student's time is split between the laboratory and the firm. The students are recruited by firms, which receive a subsidy from the public agency that oversees the Cifre arrangements, the Association Nationale de la Recherche Technique (ANRT).

Thus, the student becomes involved in both the industry and scientific communities. He/she could be seen as a "cognitive platform" facilitating the creation and transfer of knowledge between science and industry. This role is particularly important in relation to small firms for which working with a Cifre sponsored PhD student is often their first contact with academia. If the experience is a good one there is the possibility that the relationship with the academic world will continue. One of the objectives of this system is to bridge between the scientific and industrial spheres, and to build durable networks involving business and academic institutions. In relation to the students involved the objective is to encourage and facilitate their integration into the labour market. It has been shown that the transition from being at a university to getting a job has been significantly easier for Cifre trainees.

In this chapter we will compare the regional distribution of the laboratories and firms involved in the Cifre scheme to see to what extent this transfer of knowledge between universities and firms is confined to regions or takes place in the broader context of the national system. In other words, we are investigating the notion of a regional system of innovation (RSI).

Certain regions would appear to be self-sufficient in the sense that their firms often collaborate with local academic institutions. However, many regions appear to be "knowledge exporting", because their local scientific specialization is more aligned to industry in other regions, while some regions can be classed as "knowledge importing" because the firms within their region are forced to collaborate on scientific projects with institutions outside their territory, because they lack the relevant competence or it is not available in their immediate area.

Our study will illustrate the variety of regional innovation contexts that are involved. Only a small number of local regions encompass the array of actors and links that are involved in the innovation process: large and smaller enterprises in relationships with universities and public research institutes, "knowledge intensive business services" (KIBS), which capitalize on and diffuse technological knowledge and managerial skills among the other organizations, regional authorities capable of implementing (in coordination with national administrations) the relevant policies, etc. In short, few regions have a RSI, although many of them have important elements of such a system.

In this chapter we focus mainly on one aspect of the innovation system: university-industry collaboration, but our analysis casts light on the regional context in general and leads to a consideration of the specific role of KIBS.

In Section 1 we begin by defining a regional innovation system and describing the role of university-industry collaboration within such a learning environment. In the second section we describe the French doctoral training system – Cifre. Finally we construct regional indicators using statistical data on Cifre in order to analyze the differences between regions in terms of science-industry collaborations.

7.2 Regional Systems of Innovation

In a global economy, science and technology policies are designed and implemented at various geographical levels: national and European, but also sub-national (regional) levels. As a result of this multi-level governance structure, scientific production as well as technological and knowledge transfer must be analyzed using various levels of the innovation system. This requires a specific disciplinary approach, which encompasses the theory of innovation systems in a wider sense, the regional and geographic economy, and knowledge theory.

7.2.1 Different Systems of Innovation

Before addressing the idea of a RSI, we begin by defining in a very general way the concept of a *system of innovation*:

"*A* system of innovation *can be thought of as consisting of a set of actors or entities such as firms, other organisations and institutions that interact in the generation, use and diffusion of new-and economically useful-knowledge in the production process*" (Fischer 2000).

In other words, the different components of the system must interact. But, do they all interact simultaneously? Does their interaction follow a specific pattern? Are all these interactions within the system? The answers to such questions help to define the concept of a system, especially in the sub-national context. We want to stress that in addition to organizing simple "communication", the system must facilitate the creation and exchange of "knowledge". Sharing the same culture, the same languages, and the same routines is a positive factor for the exchange and creation of new knowledge. To take into account these characteristics of knowledge interaction leads to consideration of various notions of national, sectoral or regional innovation systems (Carlsson et al. 2002).

Applying the system approach at the national level, authors such as Nelson (1993), Lundvall and Borras (1997), and Lundvall et al. (2002) underline the fact that nations are typically the political and institutional framework that allows the different actors to produce knowledge based on a common language, culture, and political regulatory environment. Therefore, the national dimension seems to be most appropriate for analysis of the formation and development of an innovation system. Based on this same notion of innovation systems, other authors have developed the concepts of sectoral systems of innovation (Malerba 2002) and technological innovation system (Carlsson et al. 2002).

7.2.2 Systems of Innovation at Regional Level

One of the RSI models in the literature considers that the actors within the regional system share a history, language and culture, which promote relationships based on trust. In this model the actors are in close geographical proximity, enabling face-to-face contact and exchange of tacit knowledge. It is supposed that complex interaction involves a high degree of tacit knowledge exchange, which is typical of innovative networks and learning economies (Foray and Lundvall 1996; Lundvall and Borras 1997). The importance of this notion of RSI has increased in recent years due to the simultaneous processes of globalization and localization (i.e. the relative decrease in national regulation).

The term region in this chapter is not always used to identify a local administration. Techno-economic coherence can often be found at a sub-regional level (in urban areas for instance). In certain cases, trans-border regional systems of innovation exist in which cultural attitudes and sectors of specialization are the same. But, it is also true that political will plays an important role in the design of innovation systems. At the regional level in particular, the early stages of the construction of an innovation system sometimes depend on the specific actions of individuals in initiating such a movement (for example, the "regional developer").

From our point of view, a good definition of a region is: "A meso-level political unit set between the national or federal and local levels of government that might have some cultural or historical homogeneity but which at least has some statutory powers to intervene and support economic development, particularly innovation" (Cooke 2001, p. 953).

Our study will confirm that the existence of innovative structures does not automatically lead to a full-fledged regional system, or, if the concept of a RSI does apply, it will be shown to be a largely open system[1].

There are certain elements whose interaction is valuable for the generation of innovations, possibly leading to the creation of a RSI (Catin et al. 2001; Asheim and Isaksen 2002; Lung et al. 1999):

[1] We have tested the existence of such a regional system in previous works, especially in the case of the French region of Alsace (Héraud and Nanopoulos 1994; Nonn and Héraud 1995). It appears that innovation networks of firms were concentrated only to a limited extent within the region: regional partners accounted for less than 25% of innovative links. Furthermore, this degree of regional concentration varied greatly depending on the type of partner (another firm, public laboratory, technology centre, etc.). Therefore, the existence of a "regional" system of innovation is debatable, at least in the case of French regions.

- The industrial sector (possibly organized within a cluster[2]), composed of small and medium sized enterprises (SMEs) within the region and larger firms – often subsidiaries of national or international groups.
- The science-based sector, with public institutes and university laboratories forming the bulk of the institutions of technological infrastructure (ITI)[3].
- Regional government and other territorial institutions.
- Various institutions whose mission is to promote innovation, for example, technology centres, university technology transfer offices, etc.
- Private actors who act as "go-betweens" and play an important role in advanced regions: KIBS [4].
- The national scientific and institutional system (sometimes with local offices), and the European programmes that increasingly are focusing on regional capabilities.

[2] Industrial clusters are "geographic concentrations of interconnected companies and institutions in a particular field. Clusters encompass an array of linked industries and other entities important to competition. They include, for example, suppliers of specialized inputs such as components, machinery, and services, and providers of specialized infrastructure. Clusters also often extend downstream to channels and customers and laterally to manufacturers of complementary products and to companies in industries related by skills, technologies, or common inputs. Finally, many clusters include governmental and others institutions - such as universities, standards-setting agencies, think tanks, vocational training providers, and trade associations - that provide specialized training, education, information, research and technical support" (Porter 1998, p. 78).

[3] Academic institutions are important elements of the regional technological infrastructure, but other actors within the regional scene can fulfil their function, including certain large firms or high tech SMEs. For a presentation of ITIs and their role in the generation and diffusion of knowledge, see Bureth and Héraud (2001).

[4] This tertiary regional fabric composed of technological, legal, management, or marketing services, tends to build a non-institutional informal knowledge transfer structure in the regions. For understanding their increasing role for active regions in the process of globalization, see Strambach (2001).

7.2.3 The Role of University-Industry Collaboration and the Diversity of RSI

Innovation systems at regional level can involve a large variety of industrial structures and economic dynamics. A number of regions clearly exhibit a type of development based on knowledge and service activities. Braczyk et al. (1998) give the examples of California and Singapore, but they also cite Midi-Pyrénées as a potential innovation system based on knowledge and service industries. Varga (1997) includes regions such as Lombardy, Baden-Wurtemberg, Rhône-Alpes, and Catalonia ("the *Four Motors of Europe*") in a list of the same type, along with Silicon Valley, the Boston area, and Western Canada.

There are also regions that cannot be considered to be complete knowledge-based systems, but that nevertheless host important elements of the innovation system. For instance, the *Third Italy* districts described by Beccatini (1991) were presented in the literature as paradigms of innovative territories although they do not offer significant scientific facilities. Conversely, regional concentrations of S&T institutions are not necessarily linked to the local industrial fabric.

Besides firms, universities and scientific "competence centres" (Institutions of Technology Infrastructure: ITIs), as well as KIBS, play a crucial role in RSI. The functioning of the innovation system implies various transfers of knowledge. In particular, university-industry collaboration plays a major part in regional dynamics, by increasing the stock of knowledge and human capital, triggering technological or methodological spin-offs, and influencing the formation of networks (Gibbons and Johnston 1974; Salter and Martin 2001; Etzkowitz et al. 2000). Private business services are increasingly fulfilling the intermediary function of diffusion, adaptation and capitalization of cognitive assets between firms, particularly SMEs (see Muller 2001).

A number of case studies (Varga 1997; Atkins et al. 1999; Da Rosa Pires and Anselmo de Castro 1997; Fritsch and Schwirten 1999, Jones-Evans and Klofsten 1998; Lee 2000; Rip 2002) have shown the importance of regional cooperation for universities, and stressed the importance of bidirectional contact between them and other regional actors.

Various econometric studies have tried to evaluate the effects of geographic spillovers from academic institutions within a region (Jaffe 1989; Acs *et al.* 1992; Audretsch and Stephan 1996). The majority of these studies use patent citations analysis or large national or European innovation surveys. They focus on spillover effects on the firm side, but not on the bilateral effect of collaboration.

If universities are contributing to the generation of knowledge and are a critical component of the region's knowledge infrastructure (through collaborative and learning relationships with the other actors in the regional system, such as SMEs, big firms, regional administrations, etc.), they are networking to a large extent with actors in the national, sectoral, or technological innovation systems. The research performed by a university (and by a firm) can support the development of a region, but is never restricted only to the region. Public research institutions absorb knowledge from firms and research institutions in other regions and contribute to the innovation processes within their own regions (Fritsch 2001), but they also export the knowledge produced by local research institutions and firms, to other regions.

In this chapter, we conduct an exhaustive study of the French regions to examine the role of bilateral cooperation between academic and business organizations in order to establish whether universities and firms collaborate between or within regions. In so doing we consider two issues:

- the importance of regional collaboration *within* a RSI. The relevance of this issue is linked to the fact that regional excellence does not necessarily result in a closed innovation system. Quoting Landabaso et al. (2001, p. 252): "the regional dimension is important but not exclusive". What is important is to compare the role of intra-regional and inter-regional cooperation, and its impact on the development of the RSI;
- to what extent can the French regions claim to be real and consistent RSI? The importance of this question is stressed in Héraud and Isaksen (2001) and Héraud (2003). Different modes of regional development are possible, since not all regions are deemed to belong to the core group of "poles of excellence" in the new knowledge-based economy.

Statistical evidence from the Cifre doctoral funding system, will show the existence of relationships between universities and firms. We will use these statistics to test whether their interactive learning process operates within a purely regional system or nationally. ANRT[5] gave access to the complete set of Cifre agreements from the time that the system was set up in 1982. By comparing the location of firms and laboratories in the ANRT database we can answer some of the questions raised above.

[5] We wish here to express our gratitude to Philippe Gautier, who allowed us to use the ANRT database and whose expertise in managing it was invaluable.

7.3 The Cifre System

We describe below the Cifre system and evaluate it as an indicator of the science-industry collaboration.

7.3.1 Presentation of the Cifre System

The Cifre doctoral training agreement is a contract between a firm, a university research team (we will call it a "laboratory"), and a PhD student. The object is a research programme of common interest to all parties, leading to: innovative results for the firm[6]; scientific results, i.e. PhD dissertation, and a contribution to the research agenda of the laboratory; and professional training for the student (Quéré 1994). The rationale behind the policy was not only to provide an incentive for innovative work, but also to ease the transition between university and work[7]. The three types of actors and their roles are briefly described below.

- The firm hosts the student for three years, providing facilities for research and an annual salary of at least 20,215 euros. The firm receives a subsidy of 14,635 euros from the ANRT. Both large and small (almost half have less than 500 employees) firms have been involved in the scheme, mainly from industrial sectors such as electrical and electronic products, and chemistry. However, increasingly service sector firms (often consultants and other KIBS) are taking part in this kind of collaboration.
- The PhD student must be under 26, a recent graduate (5 years French university diploma or equivalent), with no previous professional experience. The student is required to work partly in the firm and partly in the laboratory, the proportion varying from case to case. The majority

[6] From the study of the Cifre system over 20 years ANRT (2001), it can be seen that 83% of the firms involved in a Cifre project have benefited from industrial spillovers such as know-how (39%), process (19%), product (17%), patent (14%), and prototype (11%).

[7] From the same study, we can see that 91% of the PhDs were successful (in the case of half of the remaining 9% the thesis could have been finished, but the student gave the preference to immediate employment). At the end of the doctoral project, 67% of the students found a job (40% in the same firm as their Cifre sponsorship), and 10% entered public research. 10% were initially unemployed, but after two years most had found a job. A small proportion (2%) set up their own firms.

students receiving Cifre sponsorship have come from engineering schools.

- The laboratory involved can be in a university (42%) or an engineering school (37%), public research institutes, or sector-specific technology centres. Foreign laboratories are eligible to take part in the scheme. The research fields have, in the past, been mainly confined to computer science, physics, and chemistry, but, more recently, Cifre sponsored students have been studying the human and social sciences, including economics.

The scheme is organized at the national level by ANRT, but applications are made to and scrutinized by the regional offices of the Ministry of Research and Technology (DRRT). This is an example of a national policy that is managed regionally, using the technological and economic expertise of the DRRT for evaluation of the firm in terms of financial capacity and ability to ensure good training conditions. National experts assess the feasibility of the research, and consider whether the scientific background of the student and the quality of the research team are appropriate for the project.

From its creation in 1982 to 2001, more than 10,000 Cifre agreements have been evaluated. Only 9% of applications were rejected. Each year, the number of applications increases and ANRT's target of 820 PhDs annually will soon be achieved.

Of the firms that benefit, 48% of them are independent SMEs or subsidiaries of large firms with less than 500 employees. This large percentage of small organizations involved in science-based projects reflects the promotion of policy to facilitate knowledge transfers to small organizations and underlines the "regional" focus of such policy. Other policies – aiming not only at technology and knowledge transfer to SMEs, but also at transforming attitudes towards and perceptions about innovation – are organized regionally: for example, the Cortechs agreements, involving the training of young technicians (see Héraud and Kern 1997). Experience from the Cortechs agreements, even more than the Cifre scheme, confirms Chabbal's (1995) observations about science policies and innovation policies that the first are mainly national policies, and the second are increasingly regional (focusing on SMEs). The Cifre scheme, however, involves both aspects – scientific impact and innovation networking, and the regional nature of the network has still to be assessed.

7.3.2 The Cifre System: a Good Indicator of Science-Industry Collaboration

We can use the Cifre contract statistics as indicators of the mediation between university and firm (Sander 2000). In the course of their PhD programmes, Cifre sponsored students act as a cognitive platform between the academic and industrial spheres. They stimulate the transfer and creation (by combination) of knowledge between these two worlds.

There are many types of links between universities and industries, and these interactions can be one-way (from science to industry), or two-way (collective learning). The role and the importance of any interaction are dependent on how the exchange is facilitated, i.e. by people, knowledge, technology and/or finance. In Table 7.1 we show the different types of interactions described in the literature (Schaeffer 1998; Schartinger et al. 2001; Scott et al. 2002; OECD 2002; Isabelle et al. 2003) in order to position the Cifre scheme in a more general framework of the various relationships between firms and universities.

Generally, the links represent "one way" transfers from universities to firms and not a real cooperation. But the Cifre system promotes complex relationships, with bilateral exchange based around the PhD student's activities. This young researcher is able to overcome many of the constraints that might hinder communication and allow knowledge and technology to be transferred across the two communities. The Cifre system demonstrates how PhD students can ideally act as a 'two-way bridge' (Meyer-Krahmer and Schmoch 1998) between the academic and industrial spheres. In some previous research, we tested the hypothesis that the students implement a bilateral knowledge exchange between firms and laboratories (Levy 2004).

7.4 Empirical Results

On the basis of the Cifre database, we can characterize the French regions in terms of their university-industry collaboration. The core of our analysis concerns the existence of regional innovation systems: the Cifre statistics are the basis for indicators of regional self-sufficiency in S&T to be constructed. Since a proportion of the firms becoming involved in Cifre agreements are business services, it is also possible to identify the growing role of KIBS in regional innovation networks.

Table 7.1. Different modalities of interaction between universities and firms

	Financial flows	Technological flows	Codified knowledge	Tacit knowledge	Personal flows
Research contract	++	(+)	++	(++)	
Technological co-development	++	++	(+)	(+)	
Co-publications			++	(++)	
Patents	++	++	++		
Prototype or technological artefact		++	++	(+)	
Biological and genetic material		+	+		
Cross-licensing	++	++			
Research project in partnership	++	(+)	++	(++)	(+)
Research consortium and network (including European Framework Programmes)	++	(++)	++	(++)	
Internship of graduate students		(++)	(++)	(++)	++
PhD in firm (typically: Cifre)	+	(+)	(++)	(++)	++
Training of industrial researchers by universities	++		++	(+)	
Recruitment of scientists by industry	+		(++)	(++)	++
Stay of academic researchers in industry			++	(++)	++
Seminars and conferences			++	+	++
Informal contacts				+	++

Sources : Schaeffer 1998; Schartinger et al. 2002; Scott et al. 2001; OECD 2002; Isabelle et al. 2003

+ and ++ indicate the degree of implication and importance of the different modes of interaction in the relationships between universities and firms. Bracketed symbols indicate that transfers are not systematic (the transfer could be made without the participation of people, knowledge, technology, and/or finance).

7.4.1 Towards a Typology of Regions

In an ideal RSI, universities and firms collaborate in a way that leads to relative closeness within the innovation system. This should be reflected in the Cifre database, with local laboratories being often associated with local firms. However, if the NSI does not consist of self-organized regions, but centrally manages the different functions across the whole country, then there will be no systematic geographic correlation between the location of the laboratories and the firms they collaborate with (at least no more than a bias towards proximity for practical reasons). Regions that do not exhibit well-balanced specific innovation systems, but, nevertheless, participate significantly in the NSI, may be strong in academic or industrial competencies. Regions where a large proportion of Cifre agreements are between laboratories in the region and firms from outside are classed as "knowledge-exporting". Firms contribute to knowledge creation; in using this term we focus only on the academic side. If the situation is reversed the region is classed as "knowledge-importing".

This empirical study examines the 10,002 Cifre agreements signed between 1982, when the system was first introduced, and 2001. We calculate two different indicators: one for the absolute balance of knowledge flows, and one for the self-sufficiency of the region. Figures 7.1 and 7.2 depict the number of Cifre contracts involving firms and laboratories in each of the 21 regions of France[8] (Figure 7.2 excludes Ile de France in order that the other regions are more fairly represented).

On average, each region has about 300 Cifre agreements in operation involving local firms and/or laboratories. But there are strong discrepancies between the regions in real terms, reflecting differences in region size, as well as academic and industrial endowments. The overwhelming weight of Ile de France is reflected in the Cifre statistics, as it accounts for about 30% of the laboratories and 40% of the firms. The French NSI is still very centralized, but the other regions also exhibit quite wide discrepancies, since Rhône-Alpes (mainly around Lyon and Grenoble), Midi-Pyrénées (Toulouse), and Provence Alpes Côte d'Azur (PACA), with Aix-Marseille and Nice-Sophia Antipolis account for about 25% of the firms and more than 30% of the laboratories. Not surprisingly, these regions are also among the largest and the richest.

[8] Two regions were excluded, Corse and the Overseas Territories. The reasons were twofold: their small size and the fact that localization indicators are not available. Also, for these two regions we did not have certain specific information (indicators of scientific and technological outcomes) that will be used later in our analyses.

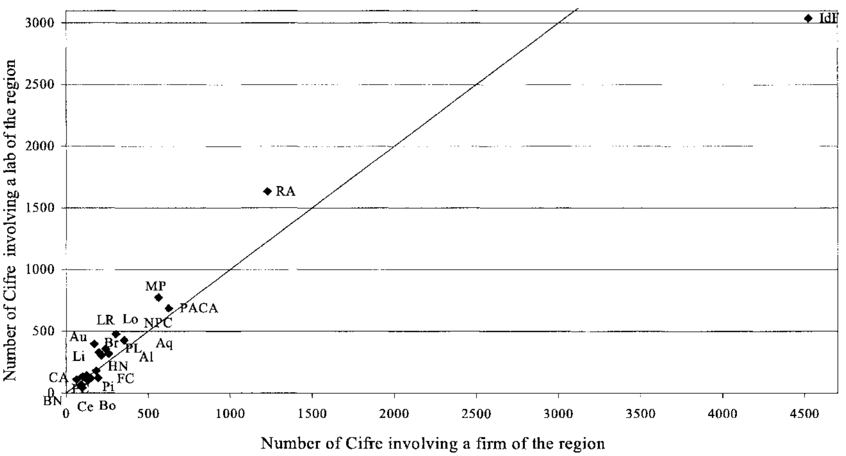


Fig. 7.1. Firms and laboratories collaborating in Cifre contracts in each region

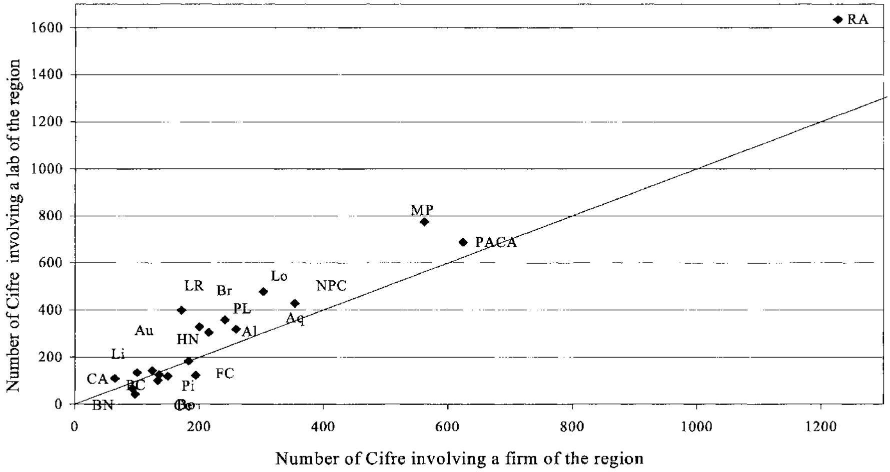
It is also noticeable that some regions are mostly "knowledge exporting" (more regional laboratories are involved than regional firms) while others are "knowledge importing". To measure this differentiation we constructed several indicators, which are presented in Table 7.2 along with other basic information about regions, and plotted in Figure 7.3.

A very simple index (R1) is the number of regional firms involved in Cifre arrangements divided by the number of regional laboratories involved[9]. This index represents the balance of knowledge exchange. Languedoc-Roussillon is the typical knowledge exporter with R1=0,4286 and Champagne-Ardenne the typical knowledge importer with R1=2,2558.

The interpretation of the cases where R1 is close to 1 is ambiguous: are such regions "closed" innovation systems in which all the firms find academic partners locally, or is the number of laboratories and firms importing and exporting external competencies the same? In order to answer these questions, we consider the following ratio (R2): number of Cifre contracts linking partners within the region divided by number of Cifre

[9] $R1 = F / L$; where F is the number of Cifre arrangements involving a firm in the region and L is the number of Cifre arrangements involving a laboratory in the region.

contracts where only one partner is in the region[10]. This gives the self-sufficiency of the region.



Al Alsace *Aq* Aquitaine *Au* Auvergne *BN* Basse-Normandie *Bo* Bourgogne *Br* Bretagne	*Ce* Centre *CA* Champagne-Ardenne *FC* Franche-Comté *HN* Haute Normandie *IdF* Ile de France	*LR* Lanquedoc Roussillon *Li* Limousin *Lo* Lorraine *MP* Midi Pyrénées *NPC* Nord Pas de Calais *PL* Pays de Loire	*PC* Poitou Charentes *Pi* Picardie *PACA* Provence Alpes Côte d'Azur *RA* Rhône-Alpes

Fig. 7.2. Firms and laboratories collaborating in Cifre contracts in each region (excluding Ile de France)

To provide a more accurate test of the characteristic of self-sufficiency, we have considered another indicator (R2'), where the numbers of contracts within the region is weighted by dividing by the corresponding national figures. The values of R2' for the different regions are given in Table 7.2 along with R2. It can be seen that the introduction of this relative indicator does not produce any significant change in the ranking and classification of the regions.

Based on these two (or three) indicators, we can classify the 21 French regions (excluding Corse and Overseas territories) into four types:

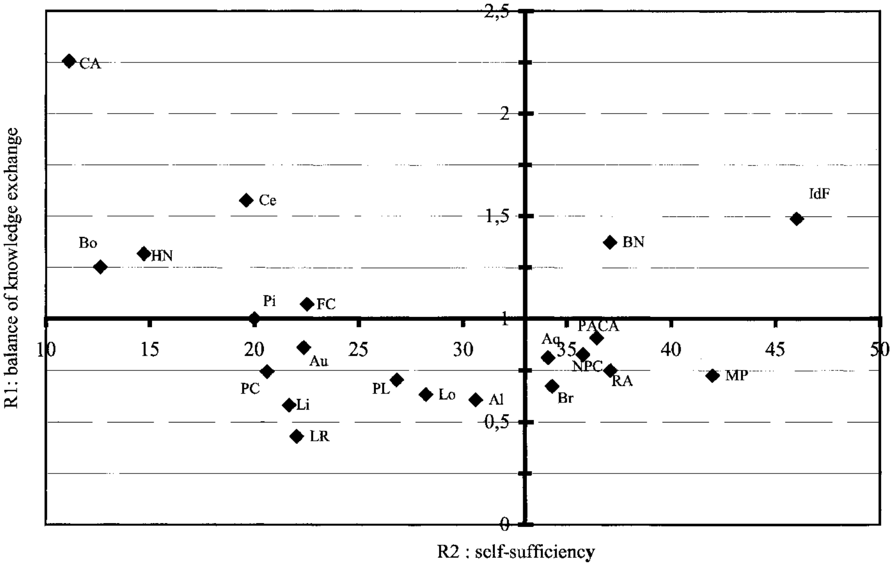
---

10 $R2 = \frac{(F \cap L)}{F + L - (F \cap L)} * 100$; where F∩L is the number of Cifre contracts involving both a firm and a laboratory in the same region

- Type 1 includes self-sufficient (or at least balanced) regions. There are eight regions in this category. Ile de France is a net importer of academic competencies, which is explained by the overwhelming concentration of firm headquarters in the Paris area[11]; the Basse-Normandie region is similar. Other important regional systems, such as Rhône-Alpes and Midi-Pyrénées, are net exporters of academic competencies. These two areas are model regions described in the literature as knowledge- and service-based regions (Braczyk et al. 1998; Varga 1997). They have developed their innovative clusters around the technological competencies of Lyon-Grenoble and Toulouse respectively. Whatever the relative importance of academia and industry, Type 1 regions are regional systems of innovation in the sense that they have apparently developed their internal networks. In this category are four other regions that show balanced flows of knowledge: PACA, Nord Pas de Calais, Aquitaine, and Bretagne. These four regions are not specialized in terms of either firms or laboratories; they tend to build university-industry links within their own territories, but, because of their size, cannot be considered real regional innovation systems.
- Type 2 regions are characterized by open territorial systems ($R2 \leq 20\%$) contributing to the NSI more through industrial demand than academic supply of knowledge ($R1 > 1.25$). Champagne-Ardennes is the best example of this type of region. Champagne-Ardennes has innovative industries, but in terms of academic competencies these are mainly to be found in the neighbouring region of Ile de France. The other regions in this category are also quite close to Paris (Centre, Haute Normandie, Bourgogne) as can be seen from the map in Figure 7.4.
- Type 3 encompasses regions with relatively open systems ($R2 < 33\%$) and net academic exports ($R1 < 0.75$). These regions contribute to the NSI by supplying academic competencies, but do not exploit them to any great extent within their own territories. The best example can be seen in Languedoc-Roussillon, which includes the Montpellier area, which is home to several important technological and scientific institutions grouped together in a large technopole (Voyer 1998), but where the industrial fabric is incomplete. Alsace is an example of a region where there is a highly developed basic science complex (mainly

[11] Indeed, the French national system remains largely centralized around its capital region. In 1998 this region accounted for 49.3% of employment of industrial researchers in France (OST 2002, p. 162) and 48% of total private expenditure on industrial R&D (OST 2002, p. 162). However, it can be seen that the introduction of a relative indicator R2' does not affect our typology.

around Strasbourg) and a significant industrial base composed of middle-tech SMEs and subsidiaries of multinational firms that are specialized in production rather than strategic functions. The other Type 3 regions are Lorraine, Pays de Loire, Poitou-Charentes, and Limousin.



Al Alsace
Aq Aquitaine
Au Auvergne
BN Basse-Normandie
Bo Bourgogne
Br Bretagne
Ce Centre
CA Champagne-Ardenne
FC Franche-Comté
HN Haute Normandie
IdF Ile de France
LR Lanquedoc Roussillon
Li Limousin
Lo Lorraine
MP Midi Pyrénées
NPC Nord Pas de Calais
PL Pays de Loire
PC Poitou Charentes
Pi Picardie
PACA Provence Alpes Côte d'Azur
RA Rhône-Alpes

Fig. 7.3. Relative weights of firms and laboratories and self-sufficiency of regions

- Type 4 regions cover three areas where the knowledge flows are relatively balanced (R1 close to 1), but which are not very self-sufficient (R2 under 25%): Picardie, Franche-Comté, and the Auvergne. These regions do not fit into any standard "regional system" model[12]. This is not to say that these regions have no specific scientific assets or techno-

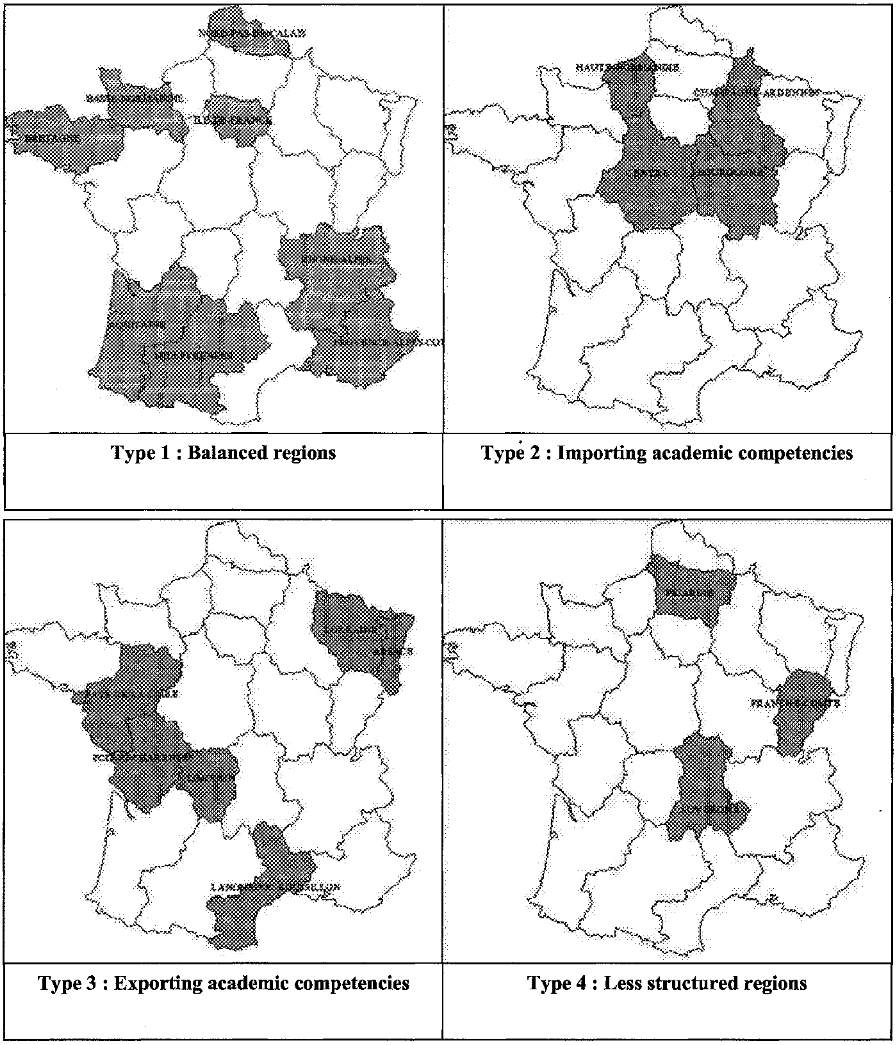
[12] Moreover, Picardie, Franche-Comté, and the Auvergne accounted for 0.5%, 0.5% and 1.1% respectively of the national expenditure by public institutions in France in 1998, and 1.8%, 2.2% and 2.2% respectively of industrial expenditure on research in France in 1998 (OST 2002, pp. 148, 163).

logical identity, but rather that the graph of the links between academia and industry is not restricted to the territory. These regions contribute to the national system in various ways, but without forming a sub-system.

7.4.2 The Role of the KIBS

As indicated in the literature review, a category of firms in the service sector plays an important role in the established systems of innovation: these are the KIBS. In the RSI, they contribute to knowledge flows in interactions between industrial firms and scientific institutions. They have a direct impact on the innovation processes in individual firms by performing their R&D (outsourcing of industrial research) and by improving firms' competencies to innovate (information diffusion, absorptive capacity building, organizational skills, legal advice, etc.). They also work as intelligent intermediaries based on their ability to learn and teach, constituting an indirect network of the actors in the innovation system, by capitalizing on and recycling knowledge (Muller 2001). Their presence and activity are an indicator of a well developed RSI.

Using the information in the Cifre database it is possible to test for the increasing role of KIBS in the past few decades and to characterize the various regions, in particular those supposedly organized as RSI. From such studies as Strambach (2001), we can see that Ile de France and Rhône-Alpes are the two regions of France with a relatively high density of KIBS: the former is comparable to Greater London, and the latter can be compared to the Stockholm or Madrid areas. In the case of Rhône-Alpes region, this confirms that the region is a knowledge- and service-based regional innovation system.



Type 1 : Balanced regions

Type 2 : Importing academic competencies

Type 3 : Exporting academic competencies

Type 4 : Less structured regions

Fig. 7.4. Typology of regions

Table 7.2. Typology of regions

Group of regions	region	Legend	Firm	Lab	F∩L[a]	R1	R2 (%)	R2' (%)	KIBS (%)[b]	Technological density[c]	Scientific density[d]
Type 1: Balanced regions	Ile-de-France	IdF	4523	3040	2384	1,49	46	80	16	217	203
	Midi-Pyrénées	MP	562	774	395	0,73	42	73	13	71	118
	Rhône-Alpes	RA	1227	1634	774	0,75	37	65	14	175	122
	Basse-Normandie	BN	92	67	43	1,37	37	65	12	44	47
	PACA	PACA	624	687	350	0,91	36	64	23	69	95
	Nord-Pas de Calais	NPC	354	428	206	0,83	36	62	10	33	48
	Bretagne	Br	241	358	153	0,67	34	97	14	47	69
	Aquitaine	Aq	259	319	147	0,81	34	60	23	44	77
Type 2: Importing academic competencies	Champagne-Ardenne	CA	97	43	14	2,25	11	19	11	49	32
	Centre	Ce	194	123	52	1,58	20	34	6	85	50
	Haute-Normandie	HN	133	101	30	1,32	15	26	4	79	42
	Bourgogne	Bo	149	119	30	1,25	13	22	5	78	47
Type 3: Exporting academic competencies	Languedoc-Roussillon	LR	171	399	103	0,43	22	39	14	42	124
	Limousin	Li	64	110	31	0,58	22	38	8	34	56
	Alsace	Al	200	329	124	0,61	31	53	11	110	154
	Lorraine	Lo	303	478	172	0,63	28	49	7	62	74
	Pays de Loire	PL	215	305	110	0,70	27	47	15	43	48
	Poitou-Charentes	PC	100	134	40	0,75	21	36	15	43	43
Type 4: Less structured regions	Franche-Comté	FC	135	126	48	1,07	22	39	11	89	49
	Picardie	Pi	183	183	61	1	20	35	9	71	25
	Auvergne	Au	124	144	49	0,86	22	39	8	66	66
Other geographic areas[e]	/	/	52	101	42	/			/		
Total	/	10002	10002	5358	/	/	/	/	13	100	100

[a] Number of Cifre contracts where both the firm and laboratory involved are in the region. [b] Part of KIBS in the total number of Cifre contracts of the region.
[c] Number of patents per capita: index 100 = national average (OST, 2002, p. 167). [d] Number of publications per capita: index 100 = national average (OST, 2002, p. 149).
[e] This entry regroups Corse, overseas territories and the foreign areas (for laboratories only).

We will next examine the links between KIBS and academic institutions reflected in the database. Figure 7.5 shows the increase in the participation of KIBS in the Cifre system[13] since its creation. The trend shows an increase in relative terms, from around 6% of contracts during the first years that the system was in operation, to the present level of close to 20%. Therefore, it can be said that acquiring academic competencies is now a relatively common strategy for certain business services. In one-fifth of cases, industry-university collaboration will be indirectly developed through these links.

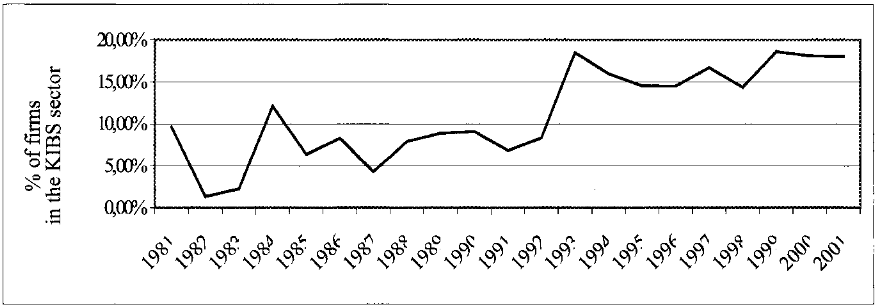


Fig. 7.5. Proportion of KIBS in the set of firms contracting Cifre agreements

Let us now look at where this catalytic role is strongest. The regions generally considered to be fully developed systems of innovation show relatively important proportions of KIBS throughout the period under examination – 16% for Ile de France and 14% for Rhône-Alpes, while Aquitaine and PACA have 24% of KIBS in the firms in their regions[14].

Our interpretation of these results is that while well-formed territorial systems (Type 1 regions) have necessarily developed an efficient fabric of knowledge-based business services, some regions with weaker innovation systems can also have a very high proportion of KIBS, which probably compensates for the lack of industrial partners. In the case of Aquitaine and PACA, which have significant scientific poles, but lack the industrial critical mass of Paris or Lyon-Grenoble, local political will and academic initiatives (science parks, start-up companies, etc.) may have had an influence. At the other extreme, Haute Normandie, with the lowest score of Cifre contracts with KIBS (4%), is a typical industrial region which imports

[13] In the database, we defined a subset of KIBS: R&D subcontractors, ICT services and various consultants.

[14] Cf. Table 7.2.

knowledge from universities outside its region (Type 2). It is probably too close to the Paris area to develop an independent innovation system.

7.4.3 Integrating Classical Indicators into the Analysis

We now compare our results based on the Cifre database, and, in particular, on the four regional types, with the classical indicators of scientific and technological production. For the French regions we use OST (2002) indicators of "scientific density", based on bibliometric data, and "technological density", based on European patent application statistics[15]. Technological density is particularly important as an indicator of success for a RSI; scientific density points to the nature of a regional system.

We start by observing that regional ranking by both scientific and technological density confirms our typology. As shown in the last two columns of Table 7.2 and in Figure 7.6[16], the four Type 2 regions (importing academic competencies) systematically display a scientific density that is lower than their technological density; the six Type 3 regions (exporting academic competencies) have a scientific density that is higher than (or equal to in the case of Poitou-Charente) their technological density. These regions then are clearly specialized either in firms' demand for, or in laboratories' supply of, academic competencies. The industry-university networks they form contribute to the NSI, but are not the basis for a regional system.

The Type 1 set of regions comprises different cases of scientific and technological development. If we compare our results with the two indicators of technological and scientific density, we can see that not all Type 1 regions are well developed RSI even though universities and firms within the region are collaborating.

Ile de France and Rhône-Alpes are the only regions with both scientific and technological indexes generally above 100. They are clear candidates for the title of "RSI"; it is interesting to note that they are also the only regions in this category where technological performance ranks higher than scientific performance.

Midi-Pyrénées has good scientific scores (118) but comparatively poor technological results (71): although the Cifre data indicate a balanced situation between firms and laboratories, the Toulouse area seems to be

---

[15] These regional indicators are normalized: the value100 corresponds to the national density (of the number of publications and the number of patents per capita respectively).

[16] The correspondence is also evident if Figures 7.2 and 7.4 are compared.

more of a sectoral cluster based around aero-space activities within the French NSI than a fully developed RSI.

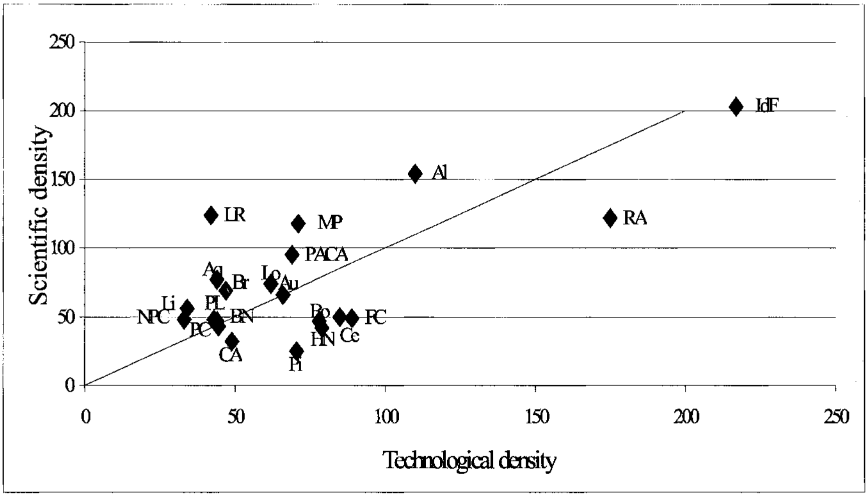


Fig. 7.6. Scientific and technological densities of French regions

Type 1	Type 2	Type 3	Type 4
IdF Ile-de-France	Bo Bourgogne	Al Alsace	Au Auvergne
RA Rhône-Alpes	HN Haute-Normandie	LR Languedoc-Roussillon	FC Franche-Comté
PACA	Ce Centre	Li Limousin	Pi Picardie
Aq Aquitaine	CA Champagne-Ardenne	Lo Lorraine	
NPC Nord-Pas de Calais		PL Pays de Loire	
BN Basse-Normandie		PC Poitou-Charentes	
MP Midi-Pyrénées			
Br Bretagne			

We now turn to the issue of global efficiency. As has been shown, the two regions at the top of the technological ranking are Ile de France (217) and Rhône-Alpes (175). We can definitely consider them to be well-formed and relatively autonomous systems of innovation. One result that is surprising is that Alsace is ranked in third position (110) while being a Type 3 region. The very high scientific score for Alsace (154), just below that of Ile de France, is explained by the academic concentration in the Strasbourg area, which has an international reputation for basic science.

The industry in Alsace is active and efficient (leading to a good technological index, 110), but not very well connected to the local academic supply of knowledge and competencies, since most industry is "medium tech" SMEs and subsidiaries of multinational companies. This explains the Type 3 characteristics of Alsace, i.e. a net exporter of academic competencies. The region is very active in both science and innovation, but not as an integrated system. This territory is mainly the geographical location of a large number of actors of various innovation systems (national, international, trans-border, etc.) as several studies have shown (Nonn and Héraud 1995), and furthermore its industrial fabric and technological system are relatively split between the northern and the southern parts. Alsace has a long tradition of industry, and a large and diversified industrial fabric (often described as a big "production platform" interlinking large and small firms, subcontractors, etc.),

In contrast, although within the same category (Type 3, about the same number of Cifre contracts, high scientific density), Languedoc-Roussillon has a very low technological density (42). The main reason for this difference is the apparent lack of industrial critical mass. The existence of some high-tech firms around Montpellier is not enough to increase this.

Analysis of the empirical results allows us to examine the concept of RSI. Type 1 has been defined as a category of regions characterized by a relatively balanced involvement of local firms and laboratories (R1) and a significant proportion of Cifre contracts linking local firms with local laboratories (R2). However, this is not enough for these regions to qualify as RSI. For instance, Nord-Pas de Calais is in Type 1, but shows weak technological results overall (33, the weakest density of all the regions). Franche-Comté, a Type 4 region, is better technologically (89). In the case of Nord-Pas de Calais the strong participation in the Cifre system in our view is more an indication of a proactive policy than of a RSI; however, in the long run, such a policy could help to construct a RSI.

Most Type 2 regions have weak scientific density, but significant results for technology. The small number of Cifre laboratories is explained by the absence of important academic centres: the firms must find the research partners elsewhere. About one third of the laboratories associated with regional firms are located in the capital region of Ile-de-France. These regions are also characterized by a very small proportion of KIBS. We can conclude that such regions belong to larger systems of innovation: the French NSI or the Ile-de-France RSI. Their relatively high scores in terms of technological results probably reflect the performance of the larger systems, and the adequacy of the region to satisfy the needs and opportunities of the larger systems.

7.5 Conclusion

Our study of university-industry research collaborations, based on the Cifre database, has clearly confirmed some aspects of the French NSI. In this centralized system, there are few genuine subsystems. Outside the capital region Ile-de-France, Rhône-Alpes is the only region with a complete and balanced set of innovation actors. Other regions present interesting characteristics in terms of science and technology, but are generally either specialized in academic knowledge production, or have an efficient industrial network. Both types of regions contribute to the NSI, but without forming real subsystems. Some regions that show good performance in terms of innovation and knowledge creation are far from the model of an autonomous system. Conversely, we cannot support the hypothesis that closed regional systems are good examples of creative territories.

As intermediaries between industry and science, the advanced business services seem to play an important role. Their increasing involvement in the Cifre system is an indicator of this phenomenon and demonstrates a willingness to develop science-based activities. RSI rely strongly on such firms. Regional authorities should take cognisance of this in constructing their innovation policy.

Cifre PhD students are important in bridging academic and industrial communities. They create new knowledge by a recombination of qualitatively different sorts of knowledge and competencies. Whatever the geographic proximity of industrial firms and research laboratories, that sort of mobility of younger researchers between the two communities is a valuable contribution to collective learning. As a policy tool, the Cifre system has proved to be efficient and the French government recently decided to increase the grant to ANRT. Our study shows that geographic proximity is not a necessary condition for science-industry relationships. Therefore, in developing regional policies, science policy and innovation policy should be distinct from one another. There will certainly be links between them, but it would be a mistake to try to force the local science system to exactly match industrial demand.

Overall, we want to underline the importance of the link between academic science and industrial innovation. If this relationship is to be further reinforced within the knowledge-based economy regions should concentrate on a deliberate science policy alongside established innovation policies.

7.6 References

Acs ZJ, Audretsch DB, Feldman MP (1992) Real effects of academic research: comment. American Economic Review 82: 363-367.
ANRT (2001) 1981/2001, 20 ans de Cifre. Conference, ANRT, Paris.
Asheim BT, Isaksen A (2002) Regional innovation systems: the integration of local 'sticky' and global 'ubiquitous' knowledge. Journal of Technology Transfer 27: 77-86.
Atkins A, Dersley J, Tomlin R (1999) The engagement of universities in regional economic regeneration and development: a case study of perspectives. Higher Education Management 11(1): 97-115.
Audretsch DB, Stephan PE (1996) Company-scientist locational links: the case of biotechnology. American Economic Review 86: 641-652.
Becattini G (1991) Italian districts: problems and perspectives. International Studies of Management & Organization 21(1): 83-90.
Braczyk HJ, Cooke P, Heidenreich M (1998) Regional innovation systems. Routledge editions, London.
Bureth A, Héraud J-A (2001) Institutions of technological infrastructure (ITI) and the generation and diffusion of knowledge. In: Koschatzky K, Kulicke M, Zenker A (eds.), Innovation networks. Physica Verlag, Heidelberg, pp. 69-91.
Catin M, Lacour C, Lung, Y (2001) Innovation et développement régional. Introduction to special issue, Revue d'Economie Régionale et Urbaine 1 : 3-10.
Carlsson B, Jacobsson S, Holmen M, Rickne A (2002) Innovation systems: analytical and methodological issues. Research Policy 3: 233-245.
Chabbal R (1995) Characteristics of innovation policies, namely for SMEs. STI Review 16: 103-140.
Cooke P (2001) Regional innovation systems, clusters, and the knowledge economy. Industrial and Corporate Change 10(4): 945-974.
Da Rosa Pires A, Anselmo de Castro A (1997) Can a strategic project for a university be strategic to regional development? Science and Public Policy 24(1): 15-20.
Etzkowitz H, Webster A, Gebhardt C, Cantasino Terra BR (2000) The future of the university and the university of the future: evolution of the ivory tower to entrepreneurial paradigm. Research Policy 29: 313-330.
Fischer MM (2000) Innovation, knowledge creation and systems of innovations. The Annals of Regional Science 35: 199-216.
Foray D, Lundvall B-Å (1996) The knowledge-based economy: from the economics of knowledge to the learning economy. In: Employment and growth in the knowledge-based economy. OECD, Paris, pp. 11-32.
Fritsch M, Schwirten C (1999) Enterprise-university co-operation and the role of the public research institutions in regional innovation systems. Industry and organisation 6(1): 69-83.
Fritsch M (2001) Public research institutions in regional innovation systems: assessment and outline of a research agenda. In: Broecker J, Hermann H (eds.),

Spatial change and interregional flows in the integrating Europe – essays in honour of Karin Peschel. Physica, Heidelberg, pp. 89-100.

Gibbons M, Johnston R (1974) The economic benefits from science. Research Policy, 22: 220-242.

Héraud, JA (2003) Regional innovation systems and European research policy: convergence or misunderstanding? European Planning Studies 11(1): 41-56.

Héraud JA, Nanopoulos K (1994) Les réseaux de l'innovation dans les PMI: illustration sur le cas de l'Alsace. Revue Internationale PME 7(3-4) : 65-86.

Héraud JA, Kern F (1997) Les CORTECHS: innovations, apprentissage en coopération et dynamique organisationnelle. In : Guilhon B, Huard P, Orillard M, Zimmerman JB Économie de la connaissance et organisations. L'Harmattan, Paris: 383-399.

Héraud JA, Isaksen A (2001) Changing nature of knowledge, globalisation and European integration, relevance, effects and opportunities for European less favoured regions. Contribution to the CONVERGE programme, CISEP, Technical University, Lisbon.

Isabelle M, Guichard R, Fleurette V (2003) Analyse économique des modalités de transfert de savoir dans les grands organismes de recherche français. Working Paper de l'IMRI.

Jaffe AB (1989) Real effects of academic research. American Economic Review 79: 957-970.

Jones-Evans D, Klofsten M (1998) Role of the university in the technology transfer process: a European view. Science and Public Policy 25(6): 373-380.

Landabaso M, Oughton C, Morgan K (2001) Innovation networks and regional policy in Europe. In: Koschatzky K, Kulicke M, Zenker A (eds.) Innovation networks - concepts and challenges in the European perspective. Physica, Heidelberg, pp. 243-273.

Lee YS (2000) The sustainability of university-industry research collaboration: an empirical assessment. Journal of Technology Transfer 25: 111-133.

Levy R (2004) Les CIFRE: un outil de médiation entre les laboratoires de recherche universitaire et les entreprises. Document de travail du BETA.

Lundvall B-Å, Johnson B, Andersen ES, Dalum B (2002) National systems of production, innovation and competence building. Research Policy 23: 213-231.

Lundvall, B-Å, Borras S (1997) The globalising learning economy: implications for innovation policy. Final report for the TSER Programme, European Commission, Brussels.

Lung Y, Rallet A, Torre A (1999) Connaissances et proximité géographique dans les processus d'innovation. Géographie, Economie, Société 1 : 281-306.

Malerba F (2002) Sectoral systems of innovation and production. Research Policy 31: 247-264.

Meyer-Krahmer F, Schmoch U (1998) Science-based technologies: university-industry interactions in four fields. Research Policy 27: 835-851.

Muller E (2001) Innovation interactions between Knowledge-Intensive Business Services and Small and Medium-Sized Enterprises. Physica Verlag, Heidelberg.

Nelson R (1993) National innovation systems: a comparative analysis. Oxford University Press, Oxford.

Nonn H, Héraud JA (1995) Les économies industrielles en France de l'Est: Tissus et réseaux en évolution. Presses Universitaires de Strasbourg, Strasbourg.

OECD (2002) Benchmarking industry-science relationships. OECD, Paris.

OST (2002) Rapport de l'observatoire des sciences et technologies (Barré, Esterlé, eds.).Editions Economica, Paris.

Porter ME (1998) Clusters and the new economics of competition. Harvard Business Review November-December: 77-90.

Quéré M 1994, The 'convention CIFRE': a successful French incentive scheme for the management of human resources in research activity. International Journal of Technology Management 9: 430-439.

Rip A (2002) Regional innovation systems and the advent of strategic science. Journal of Technology Transfer, 27: 123-131.

Salter AJ, Martin BR (2001) The economic benefits of publicly funded basic research: a critical review. Research Policy 30: 509-532.

Sander A (2000) Les conventions CIFRE, un indicateur des relations entre acteurs de la création de connaissances dans les régions françaises 37ème colloque de l'association de Science Régionale de Langue française, Lausanne.

Schaeffer V (1998) Les stratégies de valorisation de la recherche universitaire, éléments d'analyse. PhD thesis, University Louis Pasteur, Strasbourg.

Schartinger D, Rammer C, Fischer MM, Frohlich J (2002) Knowledge interactions between universities and industry in Austria: sectoral patterns and determinants. Research Policy 31: 303-328.

Scott A, Steyn G, Geuna A, Brusoni S, Steinmueller WE (2001) The economic returns to basic research and the benefits of university-industry relationships: a literature review and update of findings. Report prepared for the Office of Science and Technology, Department of Trade and Industry. SPRU, University of Sussex, Brighton, UK.

Strambach S (2001) Innovation processes and the role of Knowledge-Intensive Business Services (KIBS). In: Koschatzky K, Kulicke M, Zenker A (eds.), Innovation networks. Physica Verlag, Heidelberg, pp. 53-68.

Varga A (1997) Regional economic effects of university research: a survey. Regional Research Institute Working Paper.

Voyer R (1998) Knowledge-based industrial clustering: international comparisons. In: De La Mothe J, Paquet G Local and regional systems of innovation. University of Ottawa Press, Ontario, Canada.