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# How do Public Laboratories Collaborate with Industry? New Survey Evidence from France

*By*

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## **ABSTRACT**

This paper uses a survey of 130 public laboratories in France to investigate collaborative activities of laboratories with industry. Our statistical analysis shows that knowledge and technology development and transfer occurs most frequently through collaborative and contract research, informal exchanges, conferences, and consortia. The main benefits from the perspective of laboratories are the tangible and intangible inputs received –funds, materials, research suggestions and data. The outputs of collaboration are most often theses and publications along with technological artefacts (new products & processes, software) while patents, licenses and copyrights are less frequent. Collaboration with industry leads laboratories to conduct research in a more timely and reliable way, as well as focused in more applied areas.

**Keywords:** University-Industry Collaborations, Knowledge and Technology Transfer, Public-Private Research Partnerships, Economics of Science, France

**JEL Classification:** L33, O31, O32

## **1. Introduction**

The past 25 years have seen a surge in the number of collaborative arrangements between public research organisations (henceforth PROs) and firms (Cohen et al., 1998; Mansfield and Lee, 1996; OECD, 2002) as well as in the importance of intellectual property issues (Kortum and Lerner, 1998; Hall, 2004; OECD, 2004). The commercialisation of research results has gained increased attention as an activity allowing PROs to leverage additional financial resources and push the rate of innovation in the economy. Indeed, patenting and licensing appears to be an important mechanism for knowledge and technology transfer (Thursby et al., 2001; Thursby and Thursby, 2003) and in PROs specifically, the number of patents applications and the revenues from licensing have increased sharply (Henderson et al., 1998; Nelson, 2001; Thursby and Thursby, 2002).

Yet, we have good reasons to believe that such commercial relations, which conform well to the traditional linear model of research and development, only represent the tip of the iceberg of collaborations between public research laboratories and firms. As a matter of fact, it is now widely acknowledged that the process of technological innovation does not follow an orderly succession of stages from fundamental to applied research and then to development and commercialisation, whereby fully-codified inventions that are autonomously developed in PROs are sold to firms willing to exploit them under complete licensing contracts. Rather, this process is interactive and exhibits feedback loops (Kline and Rosenberg, 1986); it also involves tacit knowledge (Nelson, 1992; Cowan, David and Foray, 2000). Thus, other channels of knowledge and technology transfer are presumably at play between firms and PROs.

These channels can be indirect, as with publications: for example, Narin et al. (1997) showed that U.S. industry patents rely significantly on publications authored at major public research institutions. The relays between firms and PROs in different collaborative settings can be more direct in nature. The latter have been investigated in a recent strand of the economic literature on research and innovation systems that adopts a broader perspective on how PROs contribute to industrial innovativeness (Bozeman, 2000; Cohen et al., 2002; Mowery et al., 2004; Mowery and

Sampat, 2005; Vonortas, 1998; see also references discussed in Sections 6-7). Most of these articles tackle the issue by surveying industrial R&D managers or those responsible for technology transfer offices, or examining specific forms of collaboration – particularly research joint ventures.

Notwithstanding these advances, our understanding of other modalities of collaboration – for example, joint research contracts, consulting, research consortia, and training – continues to be limited. All of these are channels for knowledge and technology transfer that involve two-way interactions and depend on tacit knowledge, existing in tandem with the dissemination of codified knowledge through patents and publications. We also know relatively little of how public research organizations (PROs) benefit from such collaborations and whether they influence research practices or the balance between fundamental and applied research. Although the characteristics, significance, and outcomes of research collaborations of PROs with industry are harder to quantify than patenting and licensing, understanding these activities is crucial for framing science and technology (S&T) policy.

Our paper seeks to shed light on this question of how public laboratories collaborate with industry, and more specifically on the relative relevance of intellectual property-based mechanisms and outputs as compared to other more informal and reciprocal channels, by analysing a survey of 130 public laboratories in France. These labs employ almost 6,800 personnel and count 875 private partners. The survey provides unique data about collaboration between labs and industry in France, including information on the range of positive and negative effects for labs and many details about how labs manage their intellectual property (IP) assets. For this paper, we explore the first half of the survey, which is directly concerned with the modalities of collaboration and their influence on public laboratories – in a forthcoming paper we will explore the questions related to knowledge and IP management (Authors, 2006).

In the next section, we describe how the survey was carried out and the sample characteristics. Section 3 presents the results concerning the modalities of knowledge and technology transfer. Then Section 4 discusses the results surrounding the contributions made by

industry to laboratories and what outputs emerge most frequently. In Section 5 we examine how collaboration impacts research practices and programs. Section 6 compares these results with related studies and Section 7 concludes.

## **2. Sample design and characteristics**

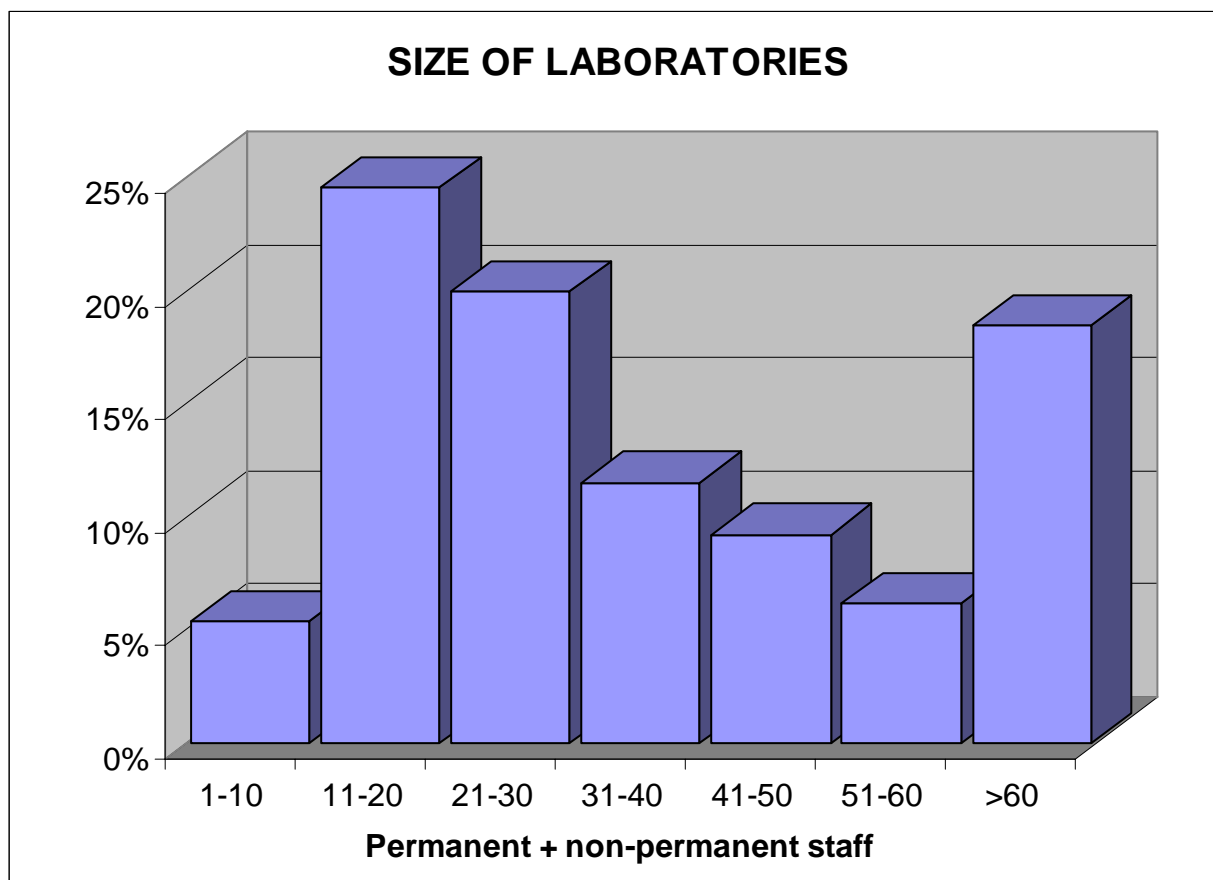
A characteristic of the French public research system stems from its duality, in the sense that universities coexist in approximate parity in terms of human resources with government laboratories (known as “grands organismes”). The former traditionally bear the missions of higher education and basic research while the latter are mostly oriented towards technological research as well as knowledge and technology transfer in specific areas (agriculture, medicine, energy, defence, NICT, etc.) However, this duality should not be interpreted in terms of a sharp division of the French public research system: many agreements exist at the level of organizations and laboratories. One important example is provided by the mixed research teams between universities and government laboratories, known as “Unités Mixtes de Recherche” (UMR).

In 2004, a detailed questionnaire was sent to around 1,800 laboratory directors in the CNRS, CEA, INRA, INRIA, INSERM, Institut Pasteur and the Institut Curie, which constitute all of the labs active in one of the following S&T fields: life sciences, chemistry and ICT. These laboratories were surveyed because of their significant and increasing role in the French innovation landscape. This is evidenced by patenting and licensing statistics<sup>1</sup>, although much less is known about the extent of their broader interactions with firms. The dataset we examine features full responses from 130 collaborating labs, which collectively have 875 industrial partners. In terms of S&T fields, 52% of the labs have a specialization in life sciences, 37% in chemistry and 11% in ICT. These labs account for almost 6800 personnel, including permanent researchers and professors (30%), doctoral and post-doctoral students (24% and 6%), engineers (13%) as well as technicians (23%) and

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<sup>1</sup> In France, they filed close to 600 national patents and 600 European patents in 2000, amounting to roughly 6% and 8% of all French applications for such patents (OST, 2003). They also had more than 3 000 active license agreements at the end of 2001 (including licenses on patents, know-how, software, databases, biological materials, etc.), generating close to €100 M (*ibid.*).

administrative staff (4%). The distribution by size of the labs is indicated in Figure 1, which shows a wide variation. There are notably four outlier “megalabs” with more than 250 members.



**Figure 1**

The distribution of labs among the various PROs is the following: CNRS (48%), CEA (25%), INSERM (18%), INRA (15%), Institut Pasteur (2%), Institut Curie (2%) and INRIA (2%). The sample is not fully representative of the initial labs’ population since labs from the CEA located in the Provence region and working in the field of chemistry are overrepresented.<sup>2</sup>

The PRO’s participations add to 110% because 13 labs are UMRs between several institutions in the sample. Indeed, less than half of the labs in the sample belong only to one institution, since there are many UMRs with universities (63 labs are associations between a government laboratory and one or several universities). So a great number of labs in the sample are

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<sup>2</sup> It is worth noticing that the low response rate was probably a result of the timing of the survey, which coincided with the mass resignation of laboratory directors opposed to budget cuts for research in government plans, and the length of the questionnaire.

themselves collaborative structures funded and supervised by two or more separate PROs. As a benchmark, Table 1 provides information about the relative size of these organizations and their specialization.

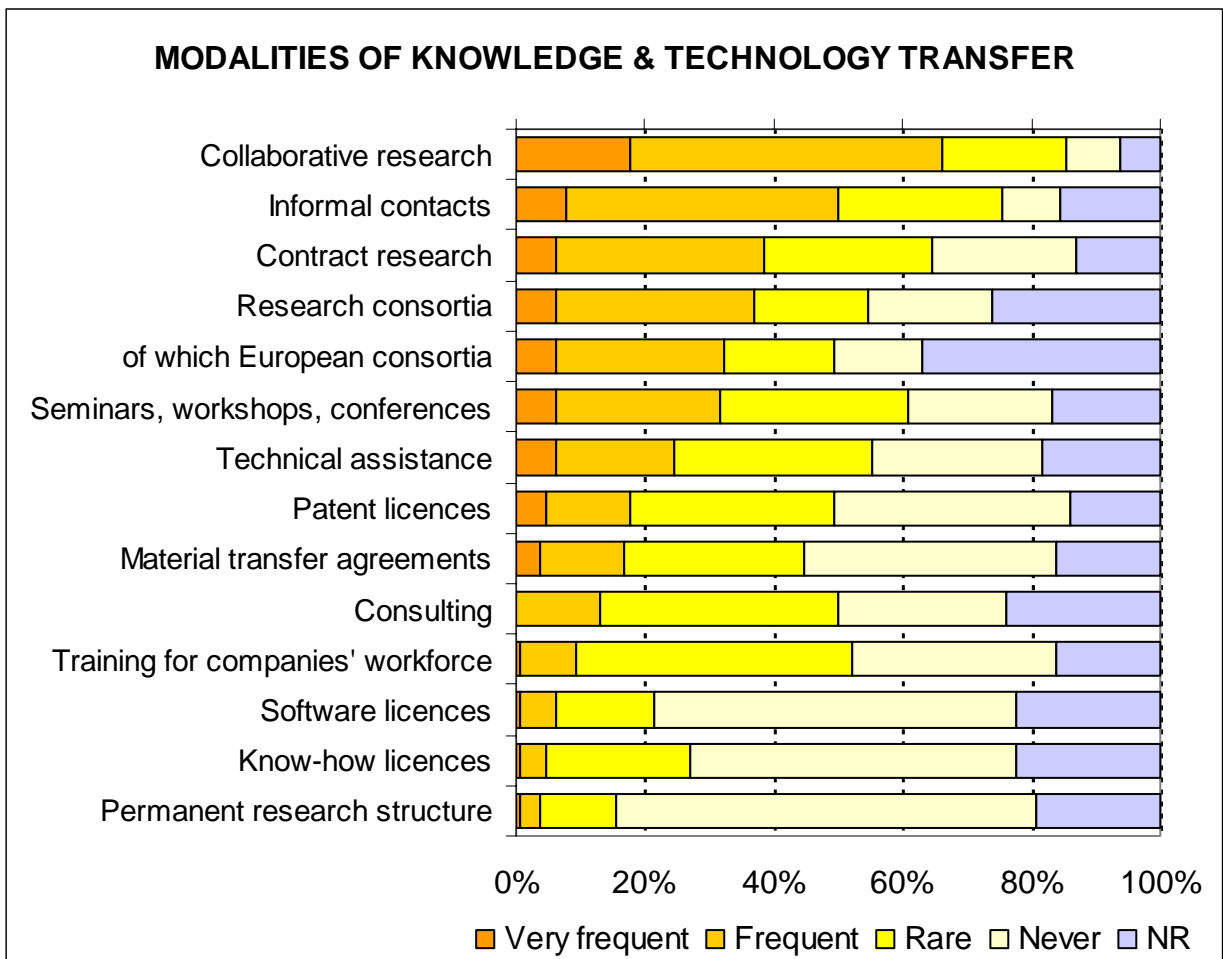
	CNRS	CEA	INRA	INSERM	INRIA	Institut Pasteur	Institut Curie
Employees (2004)	26080	14910	8840	4823	1031	1793	750
Fields of research	Very broad range	Defense Energy ICT Health techn <sup>ies</sup>	Food & nutrition Agriculture Environment	Biology Medical science	Computer science Control	Biology	Cancer

**Table 1**

### 3. Modalities of knowledge and technology transfer

The survey asks laboratory directors to estimate the frequency of “the principal modes of collaboration used between the laboratories and companies” on a 4-point scale. The questionnaire allows for 14 different modalities, which are listed in Figure 2 together with the results.



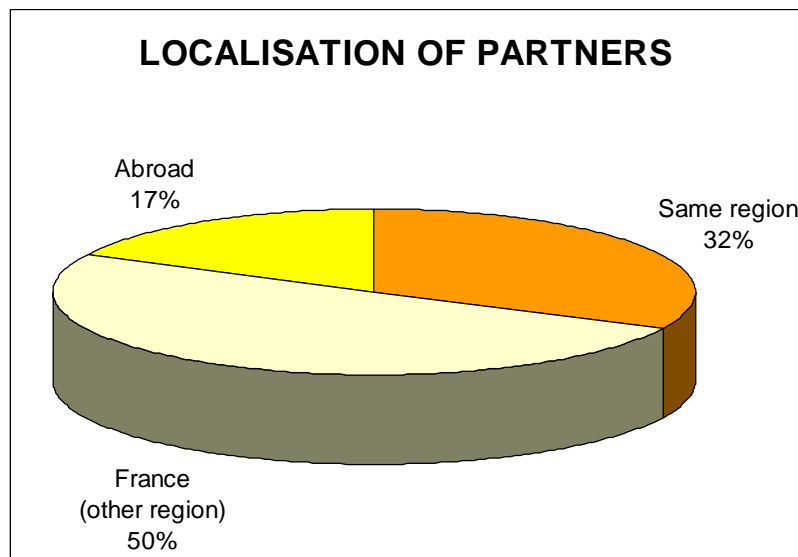


**Figure 2**

The key result, which we anticipated in the introduction, is that IP-related knowledge and technology transfer through patent, software, and know-how license agreements occupies a distant second place compared to (in order of decreasing frequency): collaborative research, informal contacts, contract research, domestic and European research consortia, dissemination events such as seminars and conferences, and technical assistance. Besides licensing, other infrequently used forms of collaboration are: material transfer agreements, consulting contracts, training for companies' workforce, and permanent research structures (e.g., new co-financed laboratories). These modalities of collaboration rarely or never take place for a large majority of labs in the sample.

The survey throws a number of interesting results concerning the location and internationalization of collaborative research with industry. About 90% of respondents report that research is frequently carried out at the lab itself, with slightly fewer than 40% frequently observing

research conducted in both the lab and the firm. Moreover, around a third of the 875 private partners are located in the same region as the lab; of the remainder, 50% are located in a different region in France and 17% in other countries (see Figure 3). Although a minority of the labs' private counterparts are based outside France, it is worth noting that one-half of the labs have one or more foreign partners, and in 42% of cases these were established outside European consortia.



**Figure 3**

Turning to the duration of public-private collaboration (in Figure 4), we find that labs had been collaborating for no more than two years with 1.6 of the 6.9 industry partners reported on average; 2.4 of the 6.9 industry partnerships had lasted two to five years, and longer lasting relationships characterised the remaining 2.9 partners. This result suggests that the exchanges between French PROs and industry are by and large based on long-term relationships (just 29% of the labs do not have any long-term partner), although from the survey we cannot tell whether this is because contracts are periodically renewed or are themselves long-term in nature. Looking more closely at the distribution, it is clear that most labs have few partners, but a long tail indicates the existence of labs collaborating profusely.

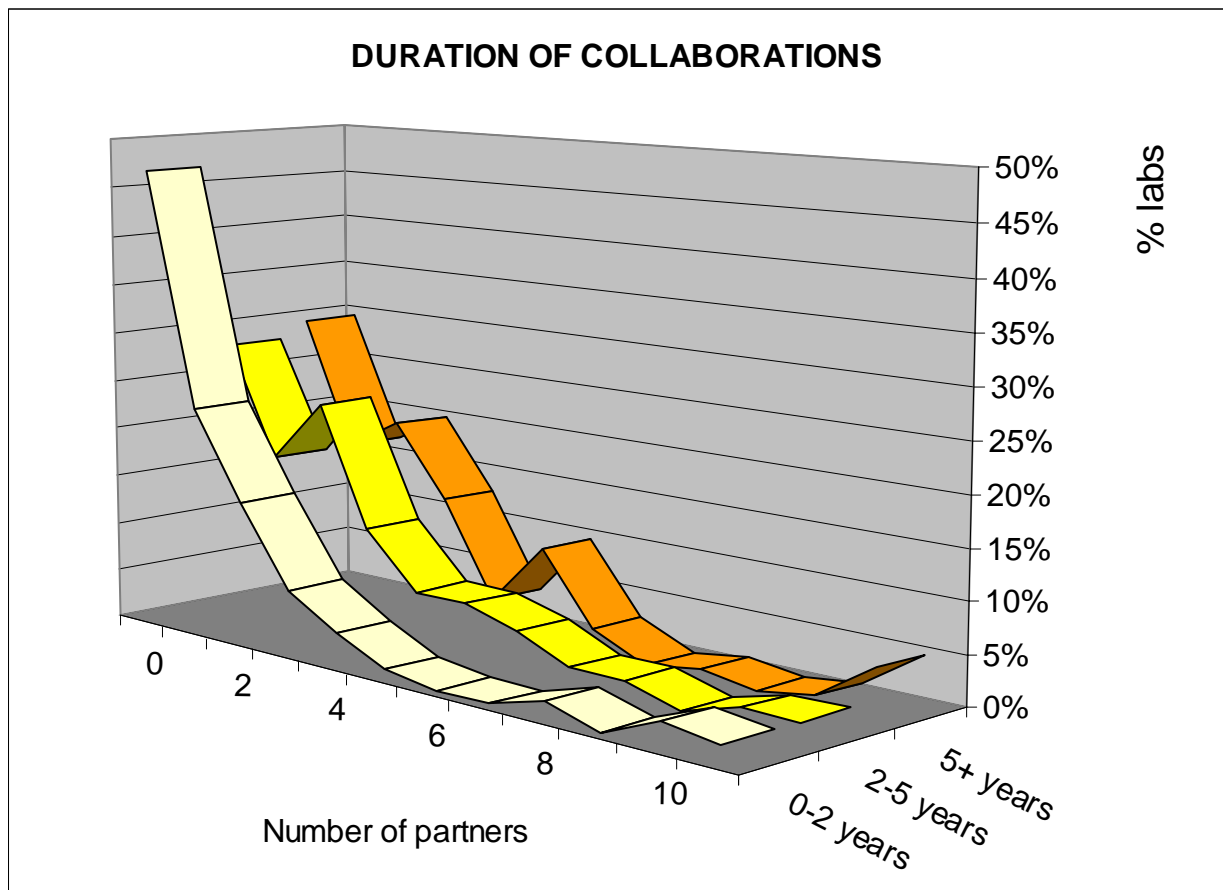


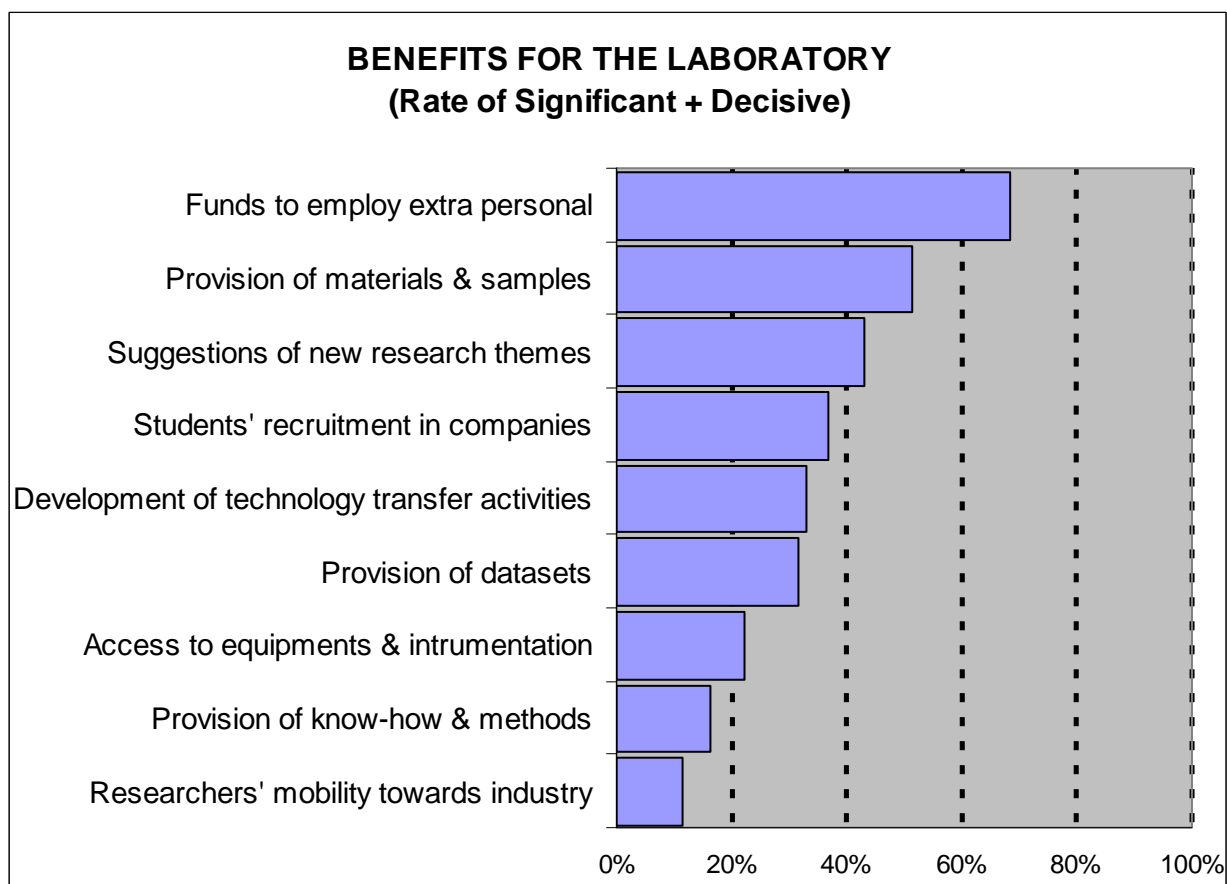
Figure 4

#### 4. Industry contributions to laboratories and results from collaboration

Industry's motivations and rewards for undertaking knowledge and technology development and transfer in conjunction with PROs have been carefully studied (Cockburn and Henderson, 1998; Henderson et al., 1998; Mansfield and Lee, 1996; Zucker et al. 1998). Typically, the reasons turn around short-term considerations of applying technologies, or longer-term ones revolving around increased absorptive and innovative capabilities. In the literature, the former tangible class of outcomes manifests itself and is studied through IP-derived outputs. Much less is known about the perspective of the laboratories.

In the survey, two questions ask lab directors to rate on a 4-point scale the significance of different contributions from industry and the frequency of various outputs from collaborations. In the ranking of contributions from industry in Figure 5, we find that by far the most significant concerns the funds for employing additional research personnel. This is followed in decreasing

order by the provision of materials and samples, the suggestions of new research themes and the recruitment of students by industry, which are thought to be significant or decisive by 37 to 52% of labs. Further down in this list of inputs we encounter the development of technology transfer activities, the provision of datasets, access to equipment and instrumentation, the provision of know-how and methods, and researcher mobility towards the firms. That mobility is considered the least important item is significant and also surprising given its centrality for contemporary science and technology policy.<sup>3</sup>

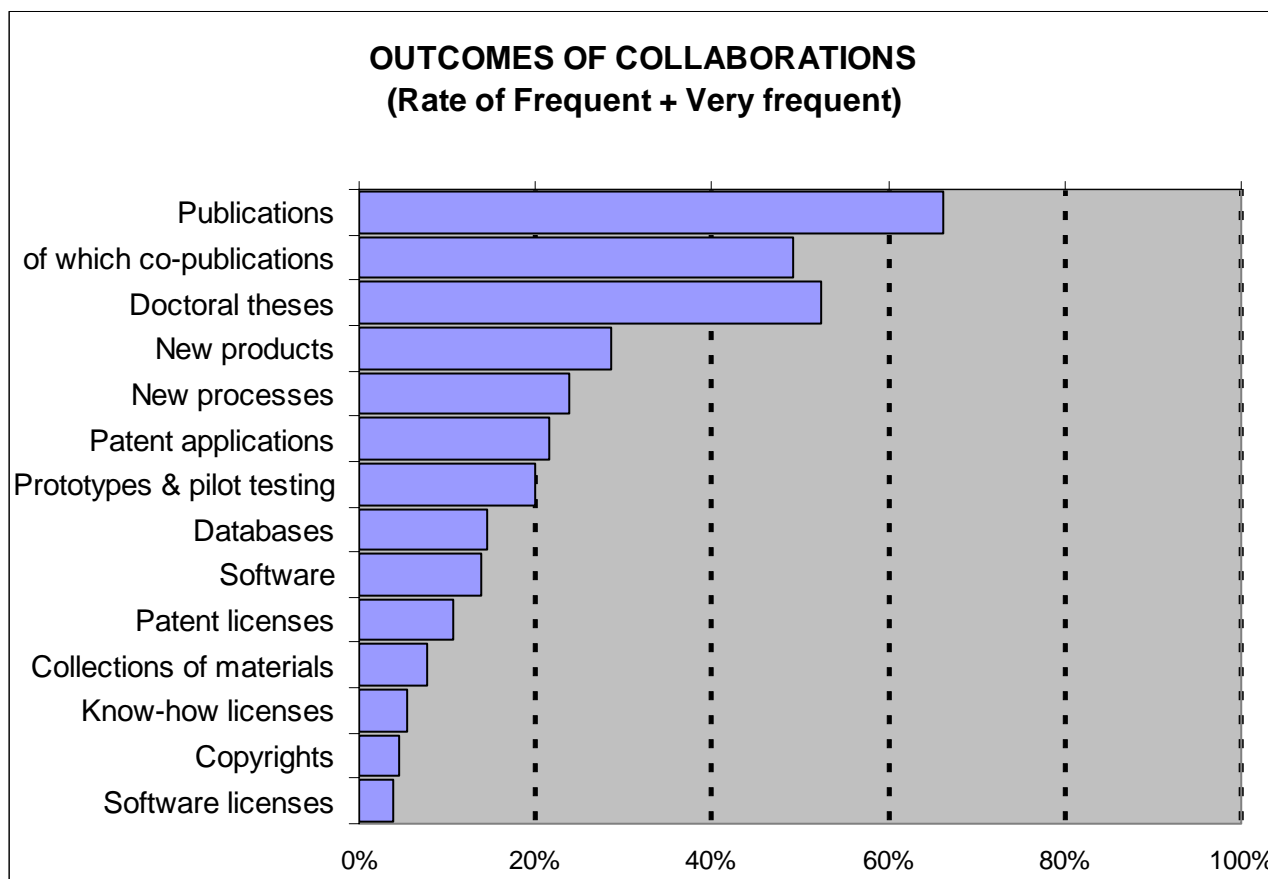


**Figure 5**

Turning in Figure 6 to the tangible outcomes, we find that collaborative activities with industry have a tendency to essentially produce the traditional outputs of research, i.e. publications and doctoral theses. These publications are generally co-authored, which would appear to reflect the

<sup>3</sup> This result is confirmed by responses to questions about exchanges of personnel: around one third of the laboratories have such exchanges in place, but they go predominantly in the direction of the firms to the labs. It is worth noting that while EU policymakers are very enthusiastic with the idea of mobility, the same is not true of all labs, as they must face the negative consequences of researchers leaving: short-termism, recruitment costs, loss of networks, etc.

dominance of collaborative research from the previous section. However, it appears that technological artefacts, encompassing new products, new processes and software, are developed with about the same frequency, while the outputs associated with the appropriation and exploitation of research results, patents, licenses of different kinds, and copyrights, show up only rarely.



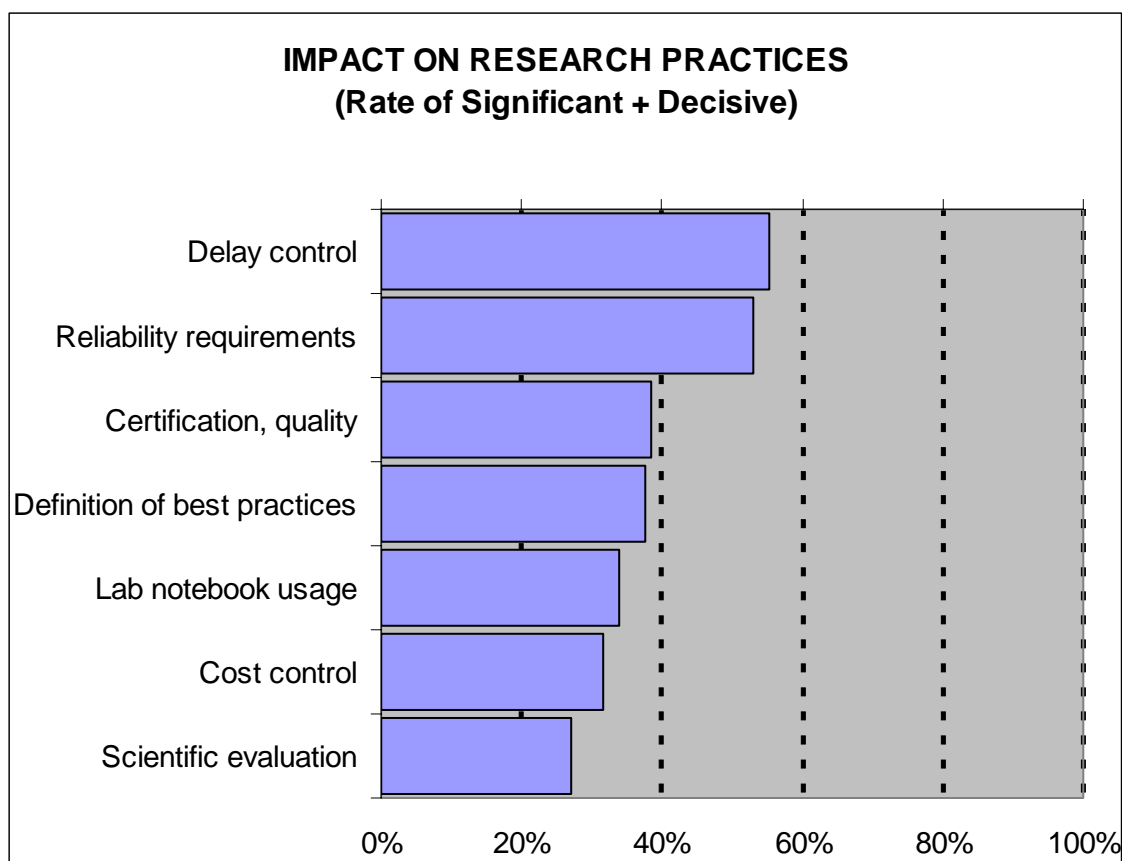
**Figure 6**

## 5. Impact of collaborations on laboratories

In the last section we described specifically the tangible outputs produced from collaborations with industry. There are of course other outcomes and in this section we discuss how these activities influence the general operation and programs of public labs.

Research is a complex process and as such its 'efficiency' can only be evaluated by using multiple indicators corresponding to various dimensions of research practices. The survey asked lab directors to evaluate on a 4-point scale the impact of industrial collaborations on research practices along six dimensions and we report the results in Figure 7. The impact is most significant

concerning the labs' control over delays and requirements about reliability. A weaker influence is observed for the certification and norms regarding quality, the definition of best-practices, the usage of lab notebooks, control over costs and the rules governing scientific evaluation. Overall, these results suggest a positive and relatively significant effect on research practices from collaboration, particularly as regards the timeliness and standards of experimental work.

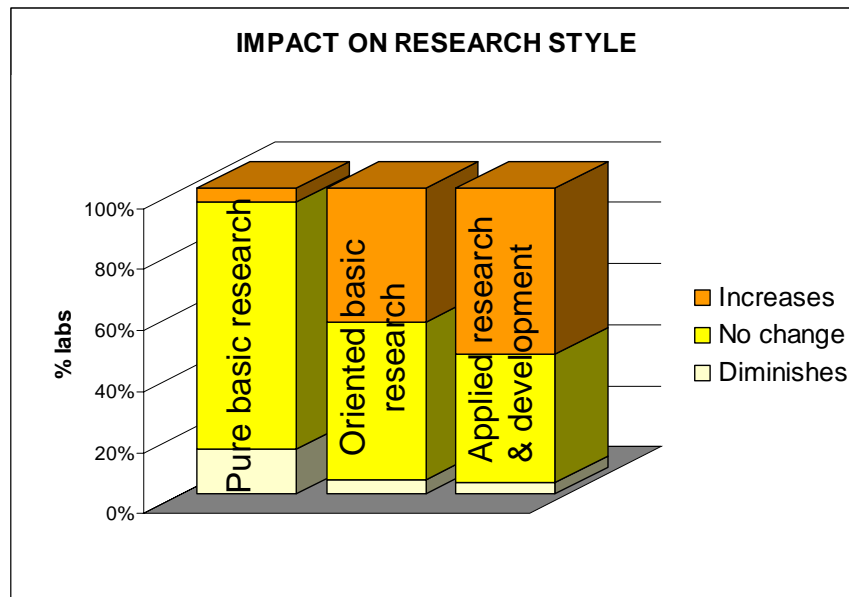


**Figure 7**

Further questions ask labs whether and how working together with industry has changed their research programs. Overall, 58% of the labs in the sample considered this work to have a significant or determinant influence on the themes and programs they engage in. More specifically, we find that collaborating labs tend to step-up their “applied research and experimental development” and, to a lesser extent, their “oriented basic research”.<sup>4</sup> As shown in Figure 8, this shift is accompanied

<sup>4</sup> These three categories follow the classification in the OECD's *Frascati Manual*. More recently, Stokes (1997) has proposed a typology that separates research according to its quest for fundamental understanding and considerations of use, the intersection of which (Pasteur's quadrant) adds interesting insights to a linear perspective.

by a diminution in “pure basic research” in just a small number of labs.<sup>5</sup> This substantial intensification in the applied character of research in many collaborating labs stands out against the marginal importance of patents and licenses.



**Figure 8**

## 6. Discussion

To put the results into context, in this section we compare our findings with earlier survey-based research from the U.S. and Germany that respond to very similar questions.<sup>6</sup>

The survey we’ve presented builds on a questionnaire from a well-known study of over 1000 university-industry research centres (UIRC)s in the U.S. This study was pioneered by a research team at Carnegie Mellon University in 1991. Given the many parallels, we find it useful to compare the findings of Cohen, Florida and Goe (1994) regarding technology transfer mechanisms with our own. Of course, this is not a perfect comparison because the mission, organisation, and funding differ in important respects between American UIRC)s and French public laboratories.<sup>7</sup>

<sup>5</sup> More evidence on this point is presented in Ranga, Debackere and von Tunzelmann (2003), which suggests that such a trade-off is only limited.

<sup>6</sup> Because the articles that exist for France are not based on survey research, and have as their objective to propose typologies of collaboration (Joly and Mangematin, 1996; Carayol, 2003) and IP protection strategies (Cassier, 2002), we do not find it useful to examine this evidence in detail here. This exercise is left for forthcoming work drawing on the results from the complete survey.

<sup>7</sup> Cohen, Florida and Goe (1994, p. 5) define UIRC)s as: “(1) university-affiliated research centers, institutes,

A first result worth contrasting concerns the use and effectiveness of technology transfer mechanisms. Cohen, Florida and Goe (1994) report that UIRCs most often used: research papers and technical reports, telephone conversations, informal meetings with industry personnel, and seminars, workshops, and symposiums. Collaborative R&D was less frequent, and personnel exchanges and delivery of prototypes/designs came in a more distant place. The ranking we discovered is similar in the key role of informal interactions, but different in the greater importance of collaborative research, contract research and consortia for our sample.

In terms of benefits for UIRCs, Cohen, Florida and Goe (1994) list the following (in order of diminishing frequency): R&D funds, opportunity to confer with industry, equipment, information on industry needs, operational funds, access to industrial facilities, practical experience for students, research direction, and industry personnel loaned to academic programs. Our findings echo the cardinal importance of industry sources of R&D funds in the context of French public laboratories but the relative importance of other benefits is different. The influence on UIRCs research agenda was found to be large, as it is in our sample as well. In contrast, just 10% of UIRCs in Cohen, Florida and Goe's study were influenced in their fiscal management and operating procedures, much less than for our survey.

It is worth making a second comparison of our results with a study by Meyer-Krahmer and Schmoch (1998) of university-industry interactions in Germany. Their survey again asks similar questions, but in this case to a sample composed of 433 professors employed in university-affiliated research centres. These German research centres are specialised in the fields of biotech, production technology, microelectronics, software and chemistry.

The university-industry interactions found to be most important for academic researchers in Germany were (in order of diminishing importance): collaborative research, informal contacts, education of personnel, doctoral theses, contract research, conferences, consultancy, seminars for

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laboratories, facilities, stations or other organizations; that (2) conducted research and development in science and engineering fields; (3) had a total 1990 budget of at least \$100,000; with (4) part of the budget consisting of industry-sponsored funds." This definition allows for a great heterogeneity; for example, the UIRCs expenditures range from \$100,000 to \$55 million, with a median of \$1.4 million. Note the respondents were the directors of the UIRCs.



industry, scientist exchange, publications, and finally committees. The ranking that surfaces is close to our own, with the difference that Meyer-Krahmer and Schmoch (1998) is asking about the importance rather than the frequency of the interactions and categories do not exactly coincide.

Concerning advantages of interactions with industry, Meyer-Krahmer and Schmoch (1998) find that the most important from the perspective of academic researchers is additional funding. This is followed closely by knowledge exchange and further behind by the flexibility of industrial funds, additional facilities, and references for public projects. Once again, the ranking that emerges points to the fundamental importance of extra funds for research centres interacting with firms.

## **7. Conclusions**

This paper presented results from a survey of public research laboratories in France having detailed information about knowledge and technology transfer mechanisms with industry. Through this study, we confirmed the importance of collaborative activities involving two-way and informal interactions which are different from intellectual property-based mechanisms such as patents or licenses. This had been remarked by Cohen, Florida and Goe (1994) for a survey of UIRCs in the U.S. and by Meyer-Krahmer and Schmoch (1998) for a survey of academic researchers in German universities.

More specifically, our results corroborate the significance of collaborative and contract research, informal exchanges, research consortia, as well as dissemination and training events. From these wide-ranging activities, the recurrent outputs are publications and doctoral theses, embodied technologies (new products and processes, software) but not intellectual property assets. For public laboratory directors, the added value of industrial collaboration is connected to the funds obtained to employ additional research personnel, materials, suggestions of research themes, and experimental data. It is significant that laboratories that interact with industry observe an internal evolution towards applied research areas and better practices.

The observation that knowledge and technology transmission across the public/private

boundary is occurring to a large extent through channels that do not involve IP should not be interpreted as a failure of laboratories, PROs, or government S&T policies. Like Thursby and Thursby (2003), we take the view that technologies stemming from public labs are usually embryonic and not ready to market, which implies that effective technology transfer will be contingent on complementary knowledge, often tacit in nature. This would explain why collaborative and contract research are the favoured vehicles to structure these interactions.

We see our results as contributing to the literature that tries to “put patents in context” by opening up the analysis to other important mechanisms of knowledge and technology transfer (Agrawal and Henderson 2002). The existing bias in the literature is tied to the methodological difficulties in systematizing and quantifying other kind of transfers, as well as to the greater uncertainty as to their commercial value. Surveys such as we employ, which directly consult those responsible for managing collaboration with industry, are useful in redressing this bias.

The conclusions we’ve drawn from this survey are preliminary and cannot be generalized to other countries, because institutional conditions are so different.<sup>8</sup> Still, their exploratory nature should not put us off from explaining their policy relevance in the context of the ongoing discussions on “the role of the universities in the Europe of knowledge.” Piloted by the European Commission (EC, 2003), this advocates closer co-operation between PROs and industry. This commendable goal is, however, accompanied by an approach that is likely wrong, since it assumes that: “The two main mechanisms through which the knowledge and expertise possessed and developed by universities can flow directly to industry are the licensing of university intellectual property, and spin-off and start-up companies.” Our results contradict this statement and suggest that a broader perspective is needed to frame S&T policy to promote collaborative R&D.

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<sup>8</sup> Whereas patent systems are converging globally, the interactions and exchanges we study are highly context-dependent and subject to varying transaction costs, incentive structures, and cultural attitudes, themselves related to the rules and norms arbitrating public research in different countries.

## **Acknowledgements**

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