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Managing intellectual assets within knowledge-based partnerships:

Insights from a survey of public laboratories collaborating with industry

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Abstract

When public research laboratories and industry meet to produce and exchange knowledge and technologies, they face decisions about how to frame these collaborations to make the best use of each partner's resources, ensure a productive and fair outcome, and defuse any tensions and conflicts. In this paper we examine these questions through a survey of 130 public laboratories in France. This study contributes new insights into the characteristics of contractual and intellectual property agreements within collaborative R&D settings, which reflect both the strategies adopted by laboratories to manage their intellectual assets and the requirements of their private partners.

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

JEL Classification: L24, L30, O31, O32, O34

1. Introduction

Much has been learnt from the empirical literature about how firms protect and appropriate the knowledge-based assets resulting from industrial R&D (Levin et al., 1987; Cohen et al., 2000). As far as public research organisations (henceforth PROs) are concerned, the behaviour towards knowledge production and dissemination was long considered to conform to the model of open science as described by Merton (1973), which leaves no room for formal intellectual property (IP) mechanisms. However, IP issues have gained increased attention by PROs in connection with the new mission they embarked upon since the early 1980s: the commercialisation of knowledge and technology.

In this context, PROs may use IP for the same purpose as firms, namely producing revenues from knowledge-based assets (see Henderson et al., 1998; Nelson, 2001; Thursby and Thursby, 2002). But they may also consider IP as a tool in the advancement and dissemination of knowledge; consider for example the case of the Science Commons where new types of licences are used to allow the wide accessibility of, e.g., research tools, databases (Reichman and Uhlir, 2003). As Brainard (1999) and others have commented, these diverging approaches to IP can lead to tensions and conflicts within collaborative arrangements between PROs and firms.

The focus of this paper is precisely on the management of intellectual assets within knowledge-based partnerships between firms and PROs and how this impacts the circulation of knowledge. Little is known about the appropriation strategies of these two types of organisations when they decide to produce and exchange knowledge and technology in a collaborative way, whether through informal contacts or a more formal partnership. This analysis is based on a survey of 130 French public laboratories that are active in the life sciences, chemistry and ICT, and together employ 6,800 personnel and collaborate with 875 private partners.

Specifically, we will cast more light on the: contractual stipulations regulating scientific publications within collaborative R&D and their impact on research activities, scientific exchanges and outreach communications; provisions for establishing and sharing intellectual property, looking in particular at the mechanisms used by laboratories to safeguard their pre-existing store of knowledge; and the prevalence of ex post conflicts over IP derived from collaborative R&D and how they are resolved.

The paper is organized as follows. Section 2 reviews the recent empirical literature on the management of knowledge and technology transfer (with a special focus on IP mechanisms) and also the literature related to the potential conflicts arising in relation with the norms of open science. In section 3 we describe how the survey was carried out and the sample characteristics. Section 4 presents the general rules that govern the distribution of intellectual property rights for collaborative results as well as the types of legally-protected outputs that belong to firms. Section 5 probes into the contractual provisions that may restrict the dissemination of results to the wider community. It also presents evidence of the conflicts that ensued and how they were resolved. In section 6 we turn to the mechanisms used by labs to protect their knowledge assets. Section 7 concludes.

2. Literature review

There are many motivations for the growing interactions between PROs and firms. From the point of view of a public laboratory, the essential reason is the possibility to leverage additional resources from firms to carry out their research. These can be tangible resources (funds, personnel, materials, equipment) or intangible ones (e.g. the suggestion of new research themes). Several empirical studies confirmed the importance of this central motivation on the side of PROs in various national settings (Cohen et al., 1994, for the

US; Meyer-Krahmer and Schmoch, 1998, for Germany; Goddard and Isabelle, 2006, for France). Other reasons that are also mentioned but for which there is less evidence are the increased mobility of research personnel towards industry, and for the universities specifically a better quality and orientation of training, which would improve the employability of students.

The firms also benefit from a leveraging of resources through an outsourcing of R&D projects which can be either complementary or undertaken at a lower cost in PROs (see Hall, Link and Scott, 2000, for a longer discussion). The evidence suggest that it is the larger firms that have a greater propensity to cooperate with PROs, probably because smaller firms face relatively more important transaction costs. For example, in an econometric study which controls for complementarities between own-firm and cooperative R&D, Veugelers and Cassiman (2005) find that the propensity to cooperate with universities is positively correlated with firm size.

Clearly, firms also gain by absorbing the latest results from public research and can upgrade their internal capabilities by tapping into the more established knowledge base in PROs (Cohen and Levinthal, 1990). This learning by interacting is an essential channel through which public research feeds into industrial innovation (Mansfield, 1991). Governments have fostered closer connections between public research and private firms taking for granted that this will accelerate the transfer of publicly sponsored research results to firms in knowledge-intensive industries and, pushed further by diffusion, increase the rate of innovation for the economy as a whole (Pavitt, 1991; OECD, 2002). In due course, this collaboration would also make public research activities more relevant and responsive to firms' needs.

The preceding comments suggest that collaboration between firms and PROs is a positive sum game, but the fact that it is two highly different social systems that interact

(Dasgupta and David, 1994) has very practical consequences in terms of the management of collaborations. Surveys addressed to the specialized structures that administer technology transfer on behalf of labs and universities – particularly to technology transfer offices (TTOs) – point to a number of difficulties: the scarcity of “gap funding”, cultural differences, and the difficulties of matching inventions with companies. These manifest themselves in different countries (Decter, Bennett and Leseure, 2006). A study by Siegel et al. (2004) also cites weak incentives for academic researchers to invent, to disclose their inventions and to transfer them to firms as another obstacle.

Intellectual property issues constitute another barrier preventing firms from partnering with universities at the research stage, as discussed by Hall et al (2001). Using data about a set of 38 private-sector projects that were funded by the US Advanced Technology Program, they find that the probability that a firm encounters insurmountable IP barriers that refrain it from working with a university (i) increases with the project’s share of public funding (through the ATP) and (ii) decreases with the project’s duration. The authors’ interpretation is that IP raises stiff management difficulties when the project has clearly identifiable results ex ante and/or when these results can not easily be appropriated.

Hertzfeld et al. (2006) also tackle the issue of difficulties arising from the management of IP in research joint ventures. In line with Hall et al, they find that resolving issues of IP protection is especially difficult when one of the participants is a university. According to their sample of large US diversified firms, TTOs’ personnel is inexperienced and tend to overestimate the value of invention, leading them to adopt overly tough bargaining positions. They find the firms’ experience in research joint ventures is a significant determinant of the probability of patents being the most frequently used IP protection mechanism in a research joint venture involving a university. Yet, strategic partnerships with selected universities help forming a flexible and predictable basis for collaboration, implying the existence of both contractual and relational solutions for the management of knowledge-based assets in collaborative settings.

Given that there are wide variations in the licensing rates and revenues between PROs that are comparable in terms of their S&T productivity (Chapple, Lockett, Siegel and Wright 2005), it would appear that the foregoing difficulties have been unevenly resolved. One reason is that specialised agencies such as TTOs only gradually gain the experience for managing the intellectual assets of PROs. Owen-Smith's (2005) case study of a technology licensing office (TLO) founded by an elite university in the U.S. indicates that this process is evolutionary and history-dependent. Collective learning requires interactive feedback between TLO staff to distil and then apply the lessons from past experiences. And, as the process of licensing is itself dynamic and highly relational, tapping into the revenue streams of a technology will usually require working around past licenses and contract research agreements by bargaining with strategic private partners.

Another important reason why TTOs sometimes find it hard to generate licensing revenues has to do with the mix of conflicting objectives they are called upon to advance. Unlike firms, where profit considerations are paramount, TTOs continually need to balance the search for revenue against the social objectives of PROs –such as the dissemination of knowledge through teaching and outreach activities– and the specific needs and goals of academic inventors among the faculty. These constraints have been analyzed recently by Jensen and Thursby (2001) and Jensen, Thursby and Thursby (2003), by focusing on faculty's incentives to disclose inventions and the terms of licensing agreements. Based on empirical evidence from TTOs at 62 U.S. universities, these papers suggest that the strategy followed by these structures is a function of the preferences of their stakeholders and academic partners.

The foregoing argument about conflicting incentives for TTOs paves the way for the debate on the erosion of open science institutions as defined by Merton (1973). This is because within collaboration with industry, restrictions may be imposed on the diffusion and circulation of information, either to preserve the option of patenting specific results or more generally to build fences around knowledge-based assets that spill over so easily. Moreover, firms tend to value applied projects, so collaborative public labs may have to shift to more applied research possibly at the expense of less basic research. Recent empirical studies investigate the extent to which these features challenge the norms of open science, which is argued to create a trade-off between the short-run and long-run benefits for R&D performing firms (Nelson, 2004).

Restrictions concerning the diffusion and circulation of scientific information have been empirically attested by several contributions. Focusing on publication delays, Blumenthal et al. (1997) surveyed a large sample of scientists in the field of life science and found that participation in collaborations with private firms and commitment to the commercialization of research results were often associated with such delays, to allow for the firm to file a patent application, or to protect the competitive advantage gained by the firm from specific research results. In their survey of 511 joint university-industry research centres in the US, Cohen et al. (1994) found that for half of them, the industrial partner could force a delay on the publication of research results while for one third, it could have some information deleted from papers prior to publication. Notice that, in many cases, restrictions on the timing for disseminating results are intertwined with those that affect the freedom to make specific results public.

Empirical evidence is contrasted regarding the "skewing problem" (Florida & Cohen, 1999), by which public laboratories would do more short term and applied research and less basic research in response to the requirements of industrial partners. A recent study by Van Looy et al. (2004) using publications counts compares scientists who engage in contract research with firms to those who don't at the Katholieke Universiteit Leuven in Belgium. They conclude that the former group publishes more than the latter in applied fields but no less in basic fields. Hicks & Hamilton (1999) studied a very large sample of university publications and university-industry co-publications from 1981-1994 and found that the proportion of basic research papers did not decrease over time although that of co-authored papers between academia and researchers in firms did increase.

In a paper presenting other results from the present survey (Goddard & Isabelle, 2006) we found that, because of collaboration, labs tend to step-up their "applied research and experimental development" and, to a lesser extent, their "oriented basic research" while this shift is only marginally accompanied by a diminution in "pure basic research". Still, further research is needed to ascertain whether system dynamics that are promoting short-run interests of firms and PROs are on balance welfare-enhancing in the longer-term.

3. 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[1], although 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 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 administrative staff (4%). The distribution by size of the labs is indicated in Figure 1, which shows a wide variation and, notably, four outlier "megalabs" with 250+ members.

[1] 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*.).

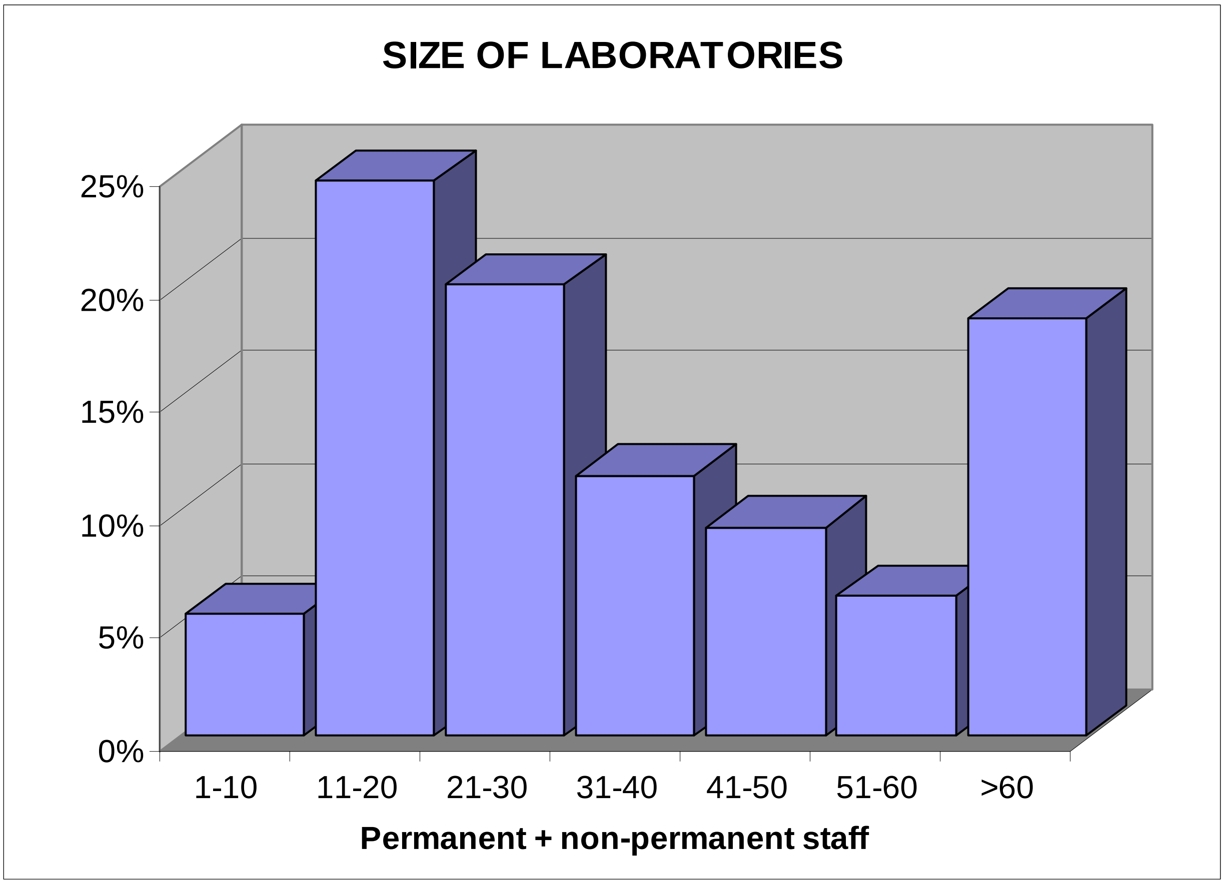

Figure 1

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.[2]

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

[2] 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.

labs in the sample are themselves public 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[ies]	Food & nutrition Agriculture Environment	Biology Medical science	Computer science Control	Biology	Cancer

Table 1

In Goddard and Isabelle (2006) we presented results corresponding to the first half of the survey, concerning the significance of various forms of collaboration between public laboratories and industry and the outcomes of collaboration. From this analysis it turns out that licensing is a less common channel for knowledge and technology transfer than joint research contracts, informal exchanges, conferences, or research consortia (see figure 2 below). This account from public laboratories in France therefore agrees with Cohen et al. (1994), who find a very similar ranking of knowledge and technology transfer channels for University-Industry Research Centres in the U.S. In particular, both underline the importance of publications, public meetings and conferences, and informal exchanges.

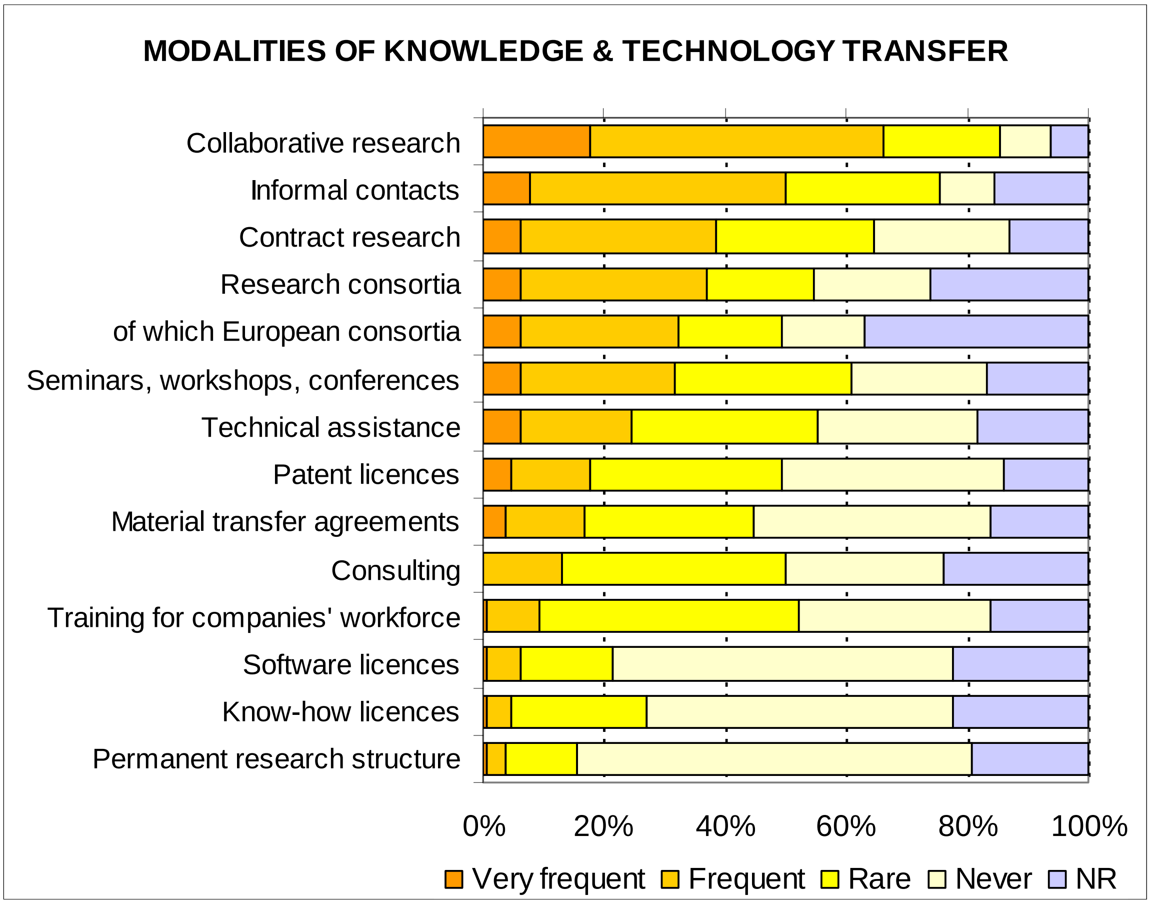

Figure 2

4. The collaborative production and allocation of intellectual property

This section reports on the results for a battery of questions about the allocation of IP stemming from projects undertaken with or for a private partner. In response to a general question about the typical allocation of results, we find that the most common arrangement is joint ownership (71% of the 130 labs agreed to this form of ownership frequently or very frequently). The results in Figure 3 indicate that separate ownership according to the provenance of results (i.e., each partner owns what it develops) is frequent or very frequent in 39% of labs. For 32% of the responding labs, the outputs are exclusively assigned to just one of the collaborating partners, and more often this is to firms (exclusive ownership by firms is frequent in 18% of labs vs. 14% reporting exclusive ownership by the PRO).

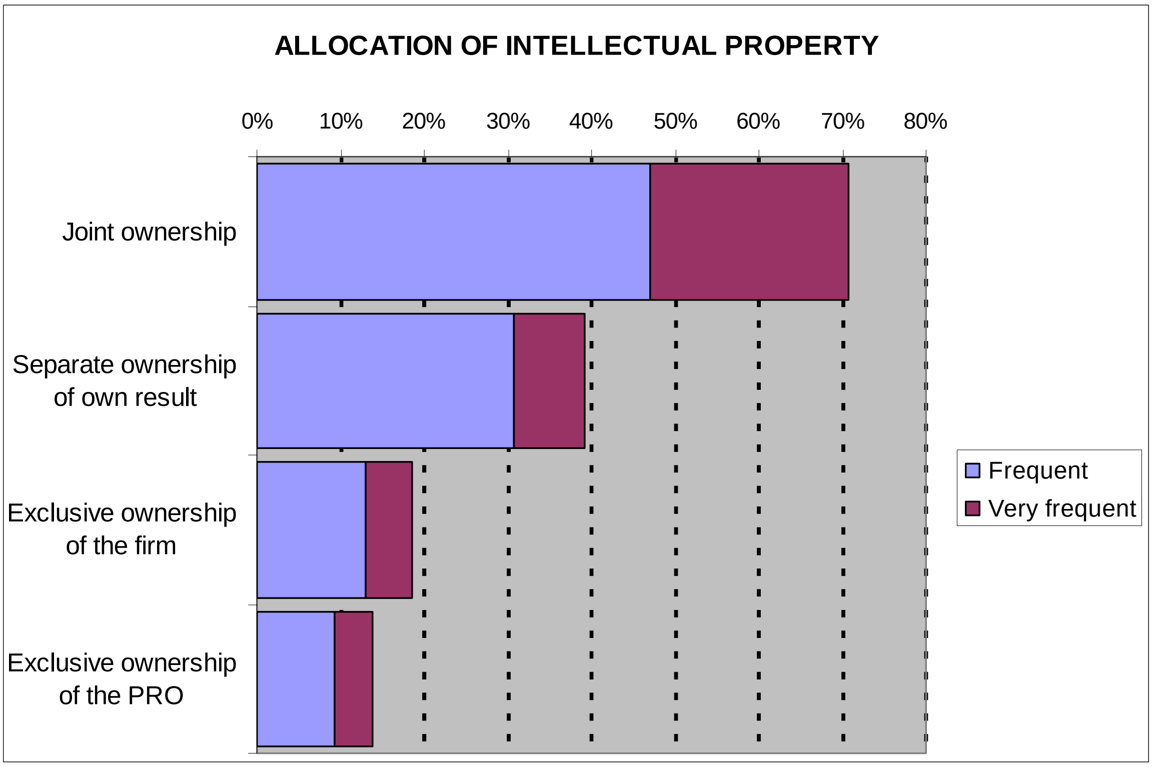

Figure 3

There are two ways of interpreting these results. One is that there is a near even balance of two different ownership patterns: one with labs and firms arranging to jointly own results; and another assigning exclusive ownership using a pre-agreed rule (exclusive ownership) or the actual R&D history (separate ownership). The other is to group joint and separate ownership, as both divide the potential stream of returns, whereas exclusive ownership gives the returns to just one partner. From this perspective, the results suggest a predominance of agreements specifying an ex post split in returns (71%+39% vs. 32%).

Another phenomenon that requires an explanation is why so many labs interact with their private partners under several ownership rules: 40% of labs frequently or very frequently use 2 or more ownership arrangements (see table 2) whereas 69% do so at least occasionally. It is also interesting that 31% labs assign exclusive ownership to themselves for some collaborations and to firms in others. This shows that labs enjoy a degree of flexibility when it comes to their formal IP arrangements and that they do exercise this – it is not possible for us to tell whether this is because they are dealing with different private counterparts, or a function of the collaboration modality, or another factor, but we believe this is an interesting question for future research.

Proportion of labs frequently or very frequently interacting under different ownership rules

	NR or zero	1	2	3	4
% labs	5%	55%	32%	8%	0%

Table 2

A closer inspection of the labs that assign exclusive ownership yields additional results. For the 24 labs reporting that property over results was frequently or very frequently for the private partner, there is a greater than average presence of contract research, technical assistance and consulting. Instead, for the 18 labs in which property was frequently or very frequently allocated to the lab, the bias is in favour of contract research and patent licensing. Granted that this sample is small and therefore we cannot confirm whether these relationships hold more generally.

Turning from the ownership of intellectual assets in general to the specific sorts of intellectual property produced for private partners through collaboration, we find that co-owned patents and confidentiality contracts stand out frequently or very frequently for about 40% of labs. In a distant second tier, we find patents owned by firms (13% of labs), co-owned copyrights (19%), exclusive licenses with limits to the applications (19%), and non-exclusive licenses (17%). The last group, which is observed frequently or very frequently by less than 10% of labs, includes copyrights owned by the firm, and exclusive licenses without limit in the applications. These results appear below, in Figure 4.

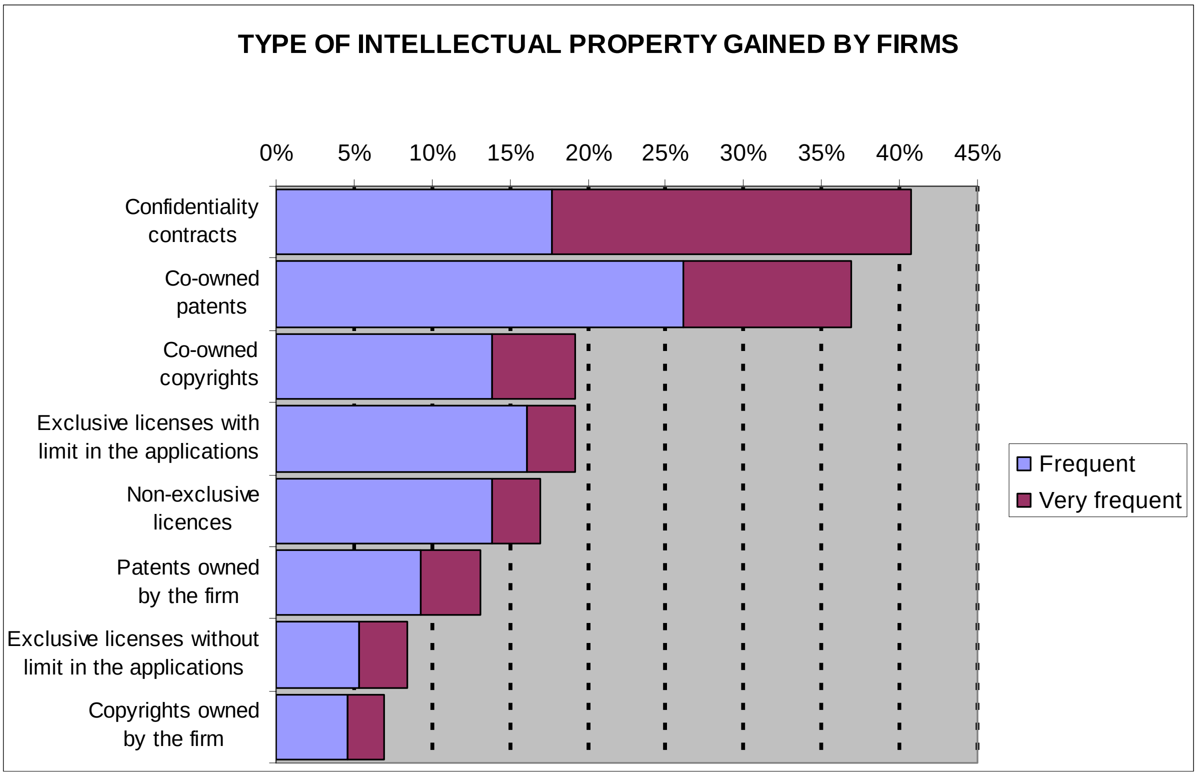

Figure 4

This set of results unpacks the ownership of intellectual assets, providing much more detail than usual about the prevalence of co-owned and firm-owned IPR in collaborative public-private R&D. Specifically, the results appear to support the traditional hypothesis that firms appropriate knowledge, inventions and technologies with two alternative strategies: by keeping them secret using mechanisms such as “confidentiality contracts”; or with patents that provide legal ownership rights. This insight merits a more careful investigation of the data. We believe that the former constitutes an ex ante condition for collaboration whereas the latter should be treated as an ex post result where projects succeeded. In other words, these strategies could be complementary from the point of view of firms. This interpretation is consistent with the findings of Hertzfeld et al. (2006) from their study of IPR management by US firms involved in research joint ventures.

A simple method of studying the implications of these appropriation strategies is to investigate the salient characteristics of the labs in question. Interestingly, all 15 labs responding that confidentiality was frequently a result but patents were not fall under two headings: there are life science labs and labs affiliated to CEA in nuclear research. Compared with the sample as a whole, these labs are more deeply associated with (notably European) consortia, for which we know that managing intellectual property issues is particularly difficult. In the 10 labs for which non-exclusive or exclusive licenses very frequently result, there is a greater propensity to set up permanent research structures. Our interpretation is that, since these structures call for a strong commitment through large investments, their founding members presumably agree beforehand on extensive licensing terms allowing for the appropriation and exploitation of any commercial results that may come out.

In the survey, the labs were also asked for precise numerical estimates of the stock of IP they own and the most recent annual flow. Unfortunately, the responses to these questions were incomplete and the resulting data does not allow us to make any reliable conclusions.[3] If anything, the data suggests that the labs may be collaborating profusely with industry but up to now this has not necessarily translated into tangible legal rights over the knowledge, inventions, and innovations that are being created. As such, the "objective" numerical measure of IP accumulation tends to confirm the respondents' estimation of the modest importance of IP as an output of research partnerships and joint activities or as a mechanism of knowledge protection.

3 Methodologically, this highlights the potential difficulties in knowing the exact numbers of IPRs when they are disaggregated more finely, particularly in labs that are larger in size or have significant turnovers of research personnel and management. Confidentiality issues may be important as well, and we can't discount the possibility of a bias as labs with poor filing and awards records may prefer to not respond.

5. Collaborative R&D contracts and scientific communication

In the survey, lab directors were asked about the delays imposed on publishing activities during collaborative R&D. Of the 130 labs, 55% frequently or very frequently agreed on contracts providing for a delay before the publication of the results. Labs which agreed to contracts that postpone publications were asked to indicate the average duration of such delays. The answers reveal that 45 out of 96 labs envisioned delays of less than 6 months; the remaining 53% were asked to wait for periods longer than 6 months before they could report their research results.

To assess the effects of holding-up publications, the survey asks labs whether they consider the delays to be prejudicial for their scientific activities. 22% of the 102 respondents to this question considered delays to be either an important or fundamental handicap, whereas the remainder saw them as having no impact or a marginal one. To detect differences across disciplines (life sciences, chemistry) we calculated the conditional probabilities of the delays being considered highly prejudicial.[4] This calculation shows that the conditional probability is higher for labs working in the life sciences (26%) than for those in chemistry (16%).

There is a positive correlation between the extent of the delay and its perceived harm: every lab director for whom delays are strongly detrimental faces 6+ month delays. This could worry TTOs that have a policy of agreeing to long contractual delays. Of course, further research is needed into how contractual publication delays affect scientific activities, as this is a question that cannot be answered with the evidence available in this survey or in the literature. In this regard, notice that economic studies generally view

4 As the survey figures few ICT labs, these calculations are not meaningful for that group and are not reported.

publication delays as endogenous, i.e. a decision of researchers with a vested interest in filing patents and directly exploiting scientific results, not an external legal constraint.[5]

The survey also asks about informational restrictions within collaborative R&D. We find that industrial partners frequently or very frequently negotiate the contractual right to suppress specific items of information in publications for 52% of the 130 labs in the survey. This means that the fraction of labs with information-based contractual provisions is similar to those with time-related provisions, and in both cases is over 50%. Additionally, labs whose collaborative results are bound by one restriction will normally also be bound by the other (42 out of the 130 labs).

It is possible to go deeper into this issue because the survey also probes how often and how tightly restrictions 'bite' ex post. To the question of whether firms effectively restricted information for publications, we find that 26% of labs experienced this problem frequently or very frequently; the remainder never or rarely did so. The conditional probability of having effective restrictions given that the lab is working in chemistry is twice that of labs in life sciences (40% vs. 19%). A striking result is that 25% of labs frequently or very frequently were confronted with situations in which the industry partner required secrecy over all of the results emerging from a research project.[6]

We believe that, taken together, this set of results signals potential pitfalls for different participants in collaborative R&D projects. For public laboratories, it suggests that these projects are often contingent on endorsing a bundle of contractual provisions that could limit researchers' freedom to publish results in a timely and inclusive manner. In

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[5] See, e.g., Breschi et al. (2005), who in an interesting study about publication and patenting activities of academic inventors in Italy find weak evidence for a small "publication delay effect" – by which they mean that inventors put off publishing while file a patent. The issue of endogeneity and whether contractual provisions are finally binding or not is just one of the problems in determining the maximum delay that should be tolerated for collaborative R&D. Equally important is the fact that the scientific publishing process is itself subject to a series of normal delays due to refereeing and authorial revisions, and the question is how to balance the cycles of IP application, exploitation and scientific publication.

[6] A rapid examination reveals that an important part of the labs tied down by total secrecy are working in the life sciences – which leads us to suspect that they are working on behalf of large private pharmaceuticals with more pressing demands for secrecy and IP-protection.

many cases the limitations will become binding ex post, and on occasions dissemination will be impeded altogether. Moreover, it is worth point out that the sample features labs that don't report ex ante contractual restrictions but for which there were effective limits ex post on the information that could be published, and even some that confronted a demand for total secrecy.

For PROs with supervisory and funding roles, there could be a need to regulate contracts across-the-board to avoid situations in which the interests and bargaining power of firms forces an outcome that is detrimental to open science practices. This has been the trend in American research universities. For example, the rules set out in Stanford University's *Openness in Research* policy handbook allow publication delays of up to 90 days for collaborative R&D "for patenting purposes or for sponsor review and comment on manuscripts, providing that no basis exists at the beginning of the project to expect that the sponsor would attempt to either suppress publication or to impose substantive changes in the manuscript". [7]

Besides the foregoing restrictions; lab directors were asked whether collaborations resulted in limitations concerning scientific communication with colleagues in the same lab, with other researchers, with companies other than the partner(s) itself, or with the larger public. The results are shown in Figure 5.

7 To have arrangements that go beyond the 90 days, university authorities have to be satisfied as to the rationale for this delay and receive assurances as to the timing and control over publication decisions. These arrangements cannot be imposed on student members if they would "present a barrier to the timely submission of the student's thesis or dissertation". This handbook was first issued in 1969 and the current version has been in force since 1996.

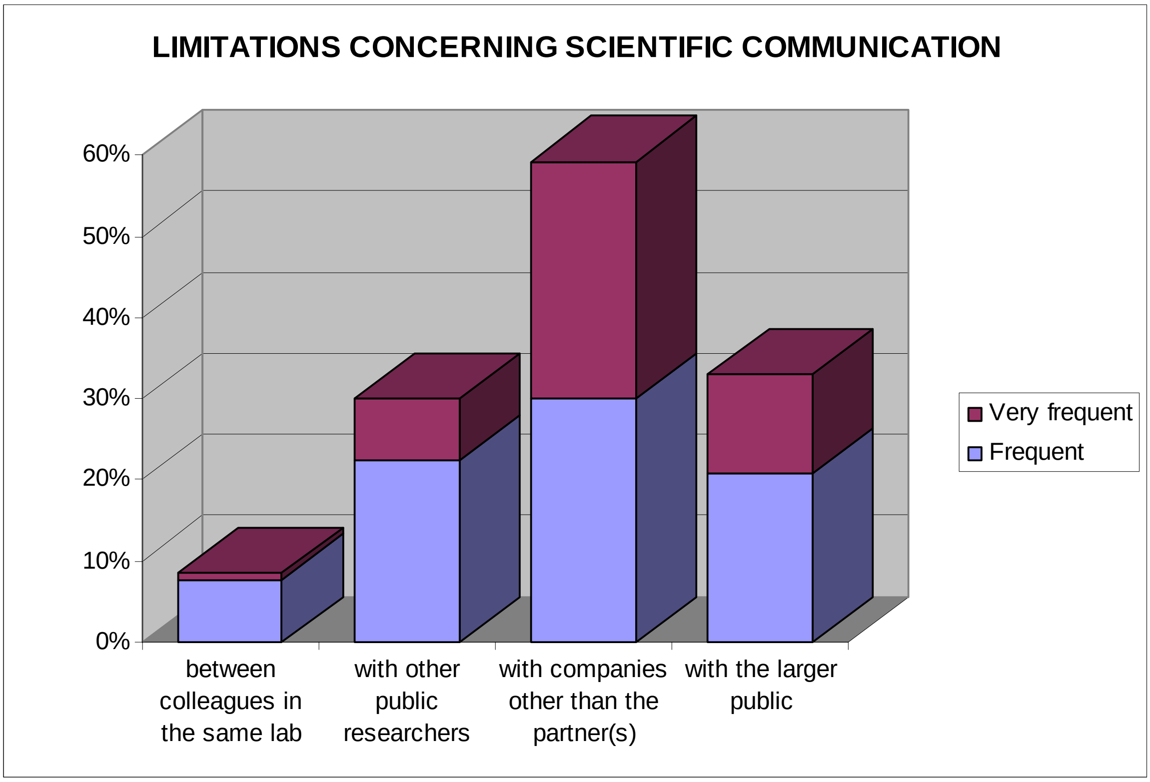

Figure 5

Not surprisingly, scientific communication appears to be frequently or very frequently limited with companies other than the partner(s) for a large majority of labs (59%). Indeed, such communication would considerably lower the value of the collaboration for the firm in a competitive setting. What is striking is that these restrictions also apply to researchers at other PROs (30% of labs). It is true that the latter may themselves be collaborating with some other possibly competitor firm. But nonetheless these results corroborate the idea that firms safeguard their competitive advantage by building tight fences around the knowledge produced within collaborations, in view of the spillovers that tend to be associated with the production of knowledge and the low cost its reproduction and transmission.

The same picture holds for restrictions towards the larger public (33% of labs), although it is not very clear what “scientific communication” means in this setting.

Generally speaking, the drawback of inhibiting communications to the wider scientific community is that it hampers the cumulative process upon which the growth of knowledge production depends. Although occurring only to a small extent (8% of labs), restricted communications *within* the lab could have consequences that are even more burdensome, given that in this case the true locus of scientific and technological knowledge production is torn apart.

As a last result about how contracts frame R&D collaborations, note that these sometimes were not able to prevent conflicts about intellectual property issues. 15% of the 130 labs that collaborate with firms experienced such a conflict or a discord with a partner during just one year (in 2003), which seems a high rate. As compared to the whole sample, these are mainly bigger labs (median = 60 employees vs. 28 for the entire sample) that also have more partners (6 vs. 4). So the "probabilistic effect", by which having more partnerships could be associated with a higher risk of facing an IP conflict, seems to prevail over a "capacity effect," by which bigger labs can more successfully manage their partnerships because of a better division of labour, greater experience, etc.

Only 5 of these labs had not solved the conflict or discord by 2004 – that is, at the time of the survey. The resolution of the dispute for the other labs was through mutual agreement but never taken to the courts. Some substantive reasons for this could be that the conflicts under consideration involve partners rather than competitors, and also that litigations are very costly. Also, it seems unlikely that a dispute would be taken to the courts within the one year period that is addressed here, in particular before the partners exhausted every possibility of a friendly settlement. Similarly, it is very improbable that a court could settle any dispute over IP within a year.

6. The protection of intellectual assets by public laboratories

In this section, we address the question of the strategies adopted by public laboratories to protect their endowment of knowledge assets, inventions, and technological innovations. This is a fundamental question, because it helps to put IPR and contracts in their proper place, as two possible instruments of protection and appropriation in a broader knowledge management strategy. This question has been widely discussed for firms interacting in e.g. RJVs (see Hertzfeld et al., 2006), but not for interactions between public laboratories and firms.

The survey asked lab directors for the frequency of specific “defensive” strategies. The results in Figure 6 show that the strategy selected frequently by most labs (70%) is to retain the property of results obtained prior to the contract (normally by specifying this explicitly within the contract). About half the labs protect their acquired knowledge base by asserting a comprehensive “knowledge inventory” that they recorded unilaterally (56%) or by imposing a right to re-use the results of projects in their own research (45%). Secrecy and patents, the favoured instruments of firms for defending intellectual assets, are less popular among public laboratories, yet still relevant: 44% frequently keep part of the lab’s knowledge secret whereas 30% use their stock of patents. Last of all, we find that 30% of labs frequently give the firm limited usage rights for specific applications and retain others.

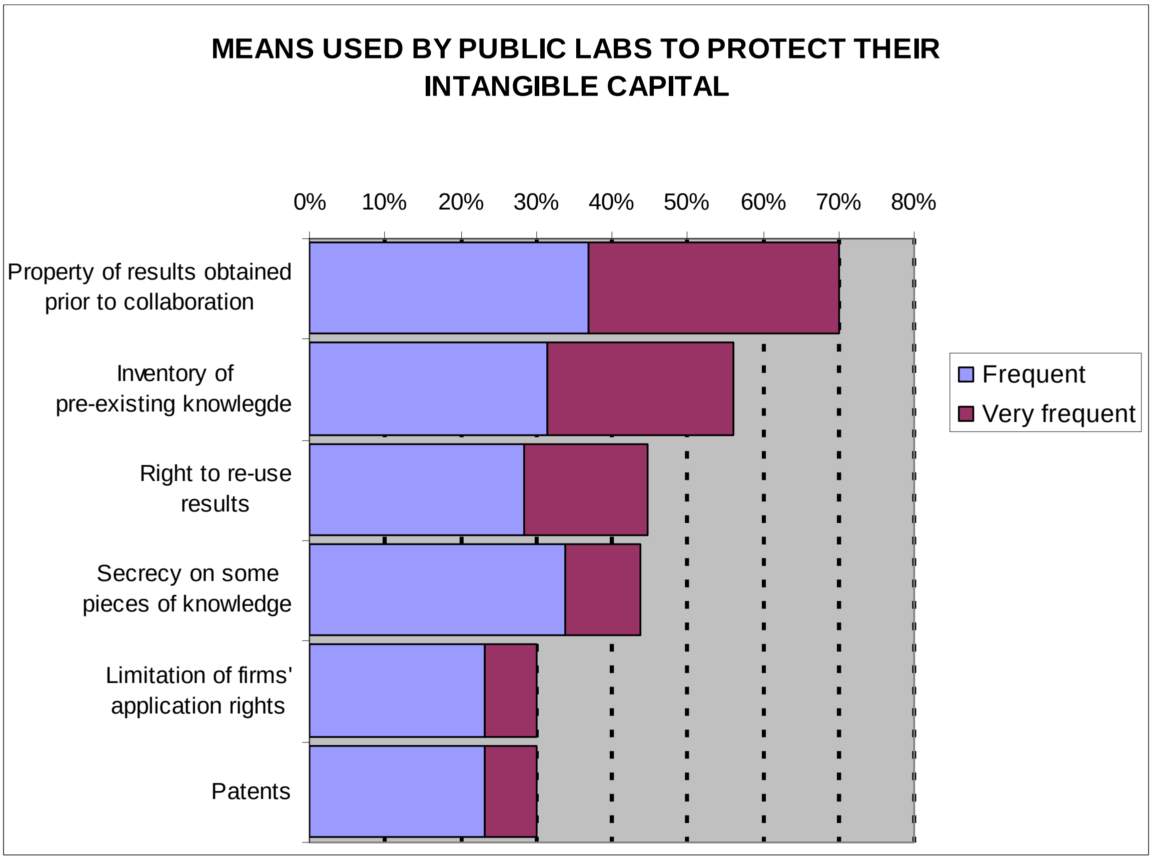

Figure 6

These results shed light on the variety of defensive strategies used by public laboratories (at least in France) to protect an essential asset, their unique stock of scientific and technical knowledge.[8] The fact that labs are less prone to use secrecy and patents than other protection strategies is interesting, and reiterates the as yet secondary importance of IP instruments for collaborative labs. Nevertheless, we didn't expect as many of the labs to resort to these instruments.

Contractual provisions are more prevalent. It is worth noticing that these provisions specify ownership of intellectual assets prior to collaboration rather than over results produced in the course of collaborations (see Section 4). The distinction between

[8] Another important asset is the research personnel. In a previous paper drawing on the same survey, we find that knowledge embodied in research personnel is "sticky", since few researchers in labs involved in collaborative R&D migrate towards the private sector; Goddard and Isabelle (2006).

the flow and stock of intellectual assets is important because the results which emerge may have an important monetary value, but be marginal from the scientific point of view compared with the mass of results the labs already possess. Thus, an effective appropriation strategy needs to combine instruments that can exploit the former and protect the latter.

Because of the difficulties of signing and enforcing formal agreements specifying the individual ownership of results ex ante, labs resort to complementary protection strategies (71% of labs use more than one protection mechanism). One is to insert clauses allowing the lab to re-use any results of the collaboration in its future research activities – of course, this would not necessarily allow the entire academic community to use them. Another is to assemble an inventory of its knowledge resources, which could result from a formal and comprehensive policy at the PRO level, or from a more fragmentary and informal recording activity by lab members for instance through experimental records and notebooks.[9]

From our results, it turns out that a much less common means for protecting results from collaboration is to include limited application rights. There are several possible reasons for this. Of course, clauses limiting applications are irrelevant in situations where results are exclusively owned by the firm. More interestingly, the fundamental uncertainty surrounding potential outcomes leads to a situation of incomplete contracting where it would not be possible to sign such an agreement. Such clauses therefore seem to be useful in specific types of projects, probably those in which the development is on technologies that are more mature. Although negotiated on a project-by-project basis, from the dynamic

[9] We know from a specific question in the survey that 30% of labs rely on laboratory notebooks to prove the state of their existing knowledge assets and 19% of labs draw on these documents to defend their interest in conflicts. At the same time, this defensive function of notebooks is considered to be less relevant than their scientific uses (for writing publications, supervising doctoral students, etc.).

perspective of public labs they establish the boundaries within which nascent technologies can be developed further, enabling generational spillovers.

7. Conclusions

How to simultaneously appropriate and exploit the results from knowledge-based partnerships, foster open communications among private and public partners, and yet protect the unique intellectual assets of public research organizations? That is the research question we tackled in this paper.

The survey results we presented indicate that even when one considers a specific organizational form (laboratories affiliated to large PROs) and a single country (France), there is a great diversity in how intellectual assets are managed. From this heterogeneity, some regularities emerge. One is the pervasiveness of joint ownership of results, which marks a new trend, because until the 1980s intellectual property used to be retained by the firms that sponsored the research. The ownership of results is usually implemented through patents, which by-and-large are co-owned, and also through confidentiality contracts, which we assume create an option to file patent applications ex post as well as to maintain secrecy. On top of confidentiality contracts, clauses contemplating publication delays and reporting restrictions are commonly included ex ante and can prove limiting ex post.

From the foregoing, we can conclude that public-private research collaboration is predominantly framed by the simultaneous co-ownership of results and a specific set of contractual mechanisms. Hagedoorn (2003) provides an explanation for why joint ownership goes hand-in-hand with contracts in the case of RJVs between firms. In effect, co-ownership should only be considered as a last resort solution given its legal complexity. But private partners use it extensively because it is even more costly (not to say impossible) to partition collaborative results since R&D projects are surrounded by great uncertainty about outcomes that, moreover, mainly consist in new knowledge which is characterised by e.g. indivisibility and tacitness.

What we find particularly interesting in the results from the survey is that they show us what arrangements are necessary for partnerships between PROs and firms, where different norms and incentive structures drive appropriation, exploitation, communication, and protection of results. When firms interact, they can agree to joint ownership because this is complemented with contractual safeguards that prevent hold-up and maximise profits. For partnerships with PROs, there is instead a need for safeguards that curb the propensity to openly disclose and disseminate results to the scientific community, which would evidently hinder commercial exploitation through IP. The other side of the coin is that PROs seek to include clauses to re-use and publish possibly IP-protected results. The problem, then, is to implement a contractual solution for all the foreseeable uses of the diverse partners holding a stake in the venture.

Another interesting finding we presented is that, in an environment permeated with IP, public labs actively protect their knowledge base through multidimensional defensive strategies. The strategies clearly differ from those of firms, which favour patents and secrecy as instruments. Instead, public labs tend to focus on systematically identifying, recording and safeguarding their specific knowledge assets. This can be done at the time of negotiating an agreement by specifying that labs retain sole ownership of prior results; or in a more continuous manner, by registering a knowledge inventory. This approach has the purpose of codifying otherwise opaque and intangible assets. It thereby allows a better valuation of the potential contribution of the research teams, and could be useful as a "bargaining chip" vis-à-vis private partners – in the same way as strategic patents are useful to firms for negotiating RJVs.

Contrasting with this heterogeneity in how public labs manage their intellectual assets within knowledge-based partnerships with firms, there is a natural tendency for PROs and R&D funding agencies to define default rules for IP ownership, licensing, and contracts in collaborative settings. This is meant to prevent moral hazard and improve the bargaining position of collaborating researchers. But based on our results we would argue that a one-size-fits-all policy is unlikely to be well-aligned to the wide variety of partners and collaboration modalities. This misalignment could even create insurmountable obstacles for collaboration. Still, our results are not conclusive on whether a more sophisticated rule or greater flexibility would make things better. There is an enduring need for results in this area to inform the managers of labs and firms about the hazards of collaborative activities and how they are best prepared for and resolved.

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