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Laboratory activity profiles: An exploratory approach

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This article proposes a method for characterizing the "activity profiles" of research laboratories. It is based on the "research compass card model" derived from the sociology of science, and which highlights the five complementary contexts in which research activities develop. A test was conducted in a regional setting on 75 labs. It demonstrates that simple indicators are enough to measure levels of involvement in each activity. Seven "activity profiles" based upon the mix by labs of their marked involvement were identified, crossing both institutional and disciplinary barriers.

Introduction

Numerous analyses made on the management and evaluation of research activities[1-4] have told us that between funds allocated to a research policy (may it be at European or State level, may it concern regional authorities, research councils or institutions, and even within companies) and actual outputs or outcomes, the relation is neither linear nor direct: account must be taken of the conditions under which research activities develop and, centrally, of laboratories. Whatever theoretical stand is taken about the dynamics of science,* such analysis could no longer rely upon the mertonian approach of the individual scientist, if only because of the results of scientometric studies showing the ever increasing discrepancy between the exponential growth of professional researchers and those who gain recognition by publishing in "academic" journals and even more those who are "cited" (i.e., used as an element in the production process of others). It is thus not surprising if Laboratory studies were to become an important element of the so called new sociology of science with the pioneering work of *Latour* and *Woolgar*[6] and its enlightening title: *Laboratory Life*. Surprise came still when grasping that neither administrative sciences nor economics had taken notice of this renewed understanding. For the former, apart from the work by *Crow* and *Bozeman*, laboratories gathered little

* For the presentation of the four models: science as rational knowledge, the competition model, science as a socio-cultural practice and extended translation, see Ref. 5.

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attention in the eighties. Technological paradigms developed by evolutionary economics or the famous chain link model developed by innovation analysts considered science as information and a typical public good. Even the new economics of science, notably developed by *David*, remained in the Mertonian paradigm of the republic of science. While a crude translation of the results of sociology of science into these two fields generated a strong image which we often use in CSI: "the laboratory is to science what the firm is to the economy, the basic unit of production". Paralleling the work of industrial economics, the issue is then to identify, within public research, the main types of productive settings and their conditions of emergence, growth and decay.

This article will be limited to the former aspect, identifying productive patterns. First, it will present the elements which drove to propose the "research compass card model" as support for characterizing the activities of labs. This approach enables to characterize the "activity profiles" of labs. A regional test made will enable to present how simple but robust indicators have been developed and used to follow the degree of involvement of labs in each of the dimensions of the compass card. It will show that, whatever the activity, the analysed set of labs exhibits very contrasted involvement. The third part, using the same test case, will explain methodological choices made for aggregation, which drive us to reject any synchretic indicator, and propose a preliminary taxonomy of "activity profiles". The methodology adopted is based upon the combinations of the limited number of "strong" involvement labs exhibit. The test case will show that limiting the analysis to only two dimensions – academic involvement and market relations – does not account for quite a significant number of situations. In the test case, seven distinct profiles have been identified which cross both institutional and disciplinary borders, a result we take as a further proof of the possibilities of this framework to address the rising issue of organisational dimensions within public research activities.

The research compass card model

When characterizing labs in general, behavioral studies have tended to contrast academic laboratories, conforming to the rules of the scientific institution, to industrial laboratories linked to market pressures.[7] This opposition is not so clear cut, as shown by the pioneering work by *Box* and *Cotgrove*. More recently, studying a large set of US labs, *Crow* and *Bozeman*[8-10] underlined the existence of blurred situations where public labs produce proprietary research or private labs devote themselves to generic public research. They proposed the concept of "publicness" to describe the "environmental context" of labs and, thus, put the emphasis on two contexts and types of regulation: the scientific institution and the "market". *Joly* and *Mangematin,*[11] acknowledging the importance of tacit dimensions and the fact that knowledge cannot be reduced to information, nearly take an opposite stand: an empirical analysis of 20 labs drives them to conclude that the "thematic criterion" plays a large role and that there can be a "compatibility between thematic independence and financial dependence", driving us towards a more complex matrix but still within the above mentioned opposition between scientific and market logic.

The model we propose does not presuppose the precedence of any type of activity over the others. It considers research as a professional activity which is inserted in many different contexts, each having its own regulation mechanisms and ways of producing reputation and/or wealth. It is based upon the numerous studies of scientific activities which add to the above mentioned activities, three complementary ones researchers involve themselves into: education, public policies and public debate of/on research issues. These five contexts are put on a similar footing and define what we call the "research compass card".[12] Each lab is positioned in each of these contexts and the mix of its positions defines its "activity profile". In this section, these five different contexts will be examined and the related indicators of involvement briefly sketched.

The production of certified knowledge

Research activities are primarily supposed to contribute to the production of new scientific knowledge. To acquire this status, results arising from research work have to be examined by "colleagues" and resist all controversies. This cannot be the case for results which are kept locally (or secret). The certifying process which enables claimed results to be tested for their soundness and gain scientific recognition, has now been established for decades. This is through the publication of articles in "refereed" journals which have established codified forms and organized quality control procedures for accepting articles. The existence of such stable rules has been the basis of the development of a new scientific specialty dedicated to the assessment of the production and circulation of articles. Scientometrics is a powerful instrument for characterizing the dedication of researchers (and more widely disciplines, institutional settings and laboratories) to the production of "certified knowledge".*

* We shall not enter here in the debates about the role of scientometrics in assessing researchers' performance. It is however important for the present purpose to note the development of systematic and periodic scientometric assessments e.g. the Dutch practice comparing university departments and centres in given disciplines.

Education, training activities and embodied knowledge

Circulating results is one thing, enabling companies to absorb them is another. Many economists have underlined the heavy human investment needed, some going as far as to propose the concept of "technological communications costs" based on *Williamson*'s transaction cost theory.[13] They thus emphasize the strong relationship which exists between the circulation of results and human mobility. This directly links to a major result of the sociology of science as illustrated by the TEA set studied by *Collins*.[14] Too simply said, knowledge is never fully codified, it remains partly local* and to get access to its tacit dimensions, those interested need to establish direct connections. This can be done through different channels, instruments and technical devices being one, knowledge embodied in persons being another. Their convergence is crucial in so called "emerging" areas: To paraphrase *Latour*, to circulate results, you need to reproduce the laboratory. It is thus no surprise to see that the training dimensions constitute an important activity for many labs and this has long been recognized by research policies: Post-graduate programmes and "formation par la recherche" (to use the French terminology) have been one of their top priorities since the beginning of the 1980s. Here again, indicators translating the involvement of labs in this second dimension are quite simple to build.

Public research and the innovation process

We shall not recall here the numerous works which have been done to renew our understanding about innovation processes. They all tend to replace the linear model – based upon a relay course between specialised entities – research, design, development, methods, and marketing – by a process which is both whirling, taking into account the trail of trials through which innovations take progressively shape (the learning dimension), and heterogeneous, adding to the chain linked model developed by *Kline* and *Rosenberg*,[16] the crucial role of lead users emphasized by *Von Hippel*, and the importance of tacit knowledge explaining, among others, the need for direct links between academic and industrial research.[17] The concept of "Techno-Economic Network" has been proposed by *Callon*[18] to capture the dynamics of innovation processes. This takes into consideration the flexible and reversible arrangements of heterogeneous actors from different institutional backgrounds participating in the innovation process.

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* We shall not enter the debate here about the existence of a tendency towards increased codification as *David* and *Foray* suggest it. Those interested can refer to Ref. 15.

For a research lab, it also clearly identifies another specific type of output: the involvement in the "creation of competitive advantages". This participation can take place at different moments in this process. The most widely recognized is the transformation of an idea into proprietary knowledge, by which economists define invention: such patents have been the subject, as articles, of intense, analytical, scientometric studies. Other well known steps deal with experimental testing and the construction of pilots and prototypes (with the consequence for teams of having large numbers of technicians). Our studies of E.U. research programmes and of the EUREKA initiative have shown the growth of all activities devoted to the acquisition and mastering of "strategic competencies" and, in particular, "basic technological research" more and more often encapsulated into methods and software.[19] All these outputs depend on the networks the laboratory is involved in and of the co-ordination modes that are used: joint output such as co-patenting, contracts (as those studied by *Crow* and *Bozeman* or *Joly* and *Mangematin*), exchanges of materials and persons etc. Tracking these intermediaries which link the collaborating partners is thus a central element for characterising collaborations with industry. We shall see that establishing proxy-indicators relating to the type of activity conducted with firms, provides, in addition to contracts entered into, complementary insights into university-industry relations.

The participation to public or collective goods and finalities

We shall not embark here on an analysis of the long-standing links between research and military activities. They manifest a fourth type of output and involvement: the participation in the achievement of public goals. Defense, passenger security (in transport...), health and, recently, environment are some of the public domains for which research efforts have been mobilized. They may lead to the creation of commercialized products as was the case in France with "large technological programmes" aimed at the development of complex new technical objects such as rockets (see the Ariane project) or nuclear power plants. These activities were in great part initiated by political decisions and their "rationale" deeply rooted in national logic of power, prestige or, since the Second World War, welfare. But they also involve other types of activity, such as norms, food regulations, standards for working conditions, etc. To cope with the research needs directed towards public intervention, governments have often created and developed "mission oriented" research institutions. *Crow* and *Bozeman* clearly show that it would be a mistake to assimilate government intentions with actual activities: Looking at federally-owned labs, they show the need to introduce a "publicness" dimension which relates, not to their initial mission, but to the present financial role of the state (mainly through dedicated contracts). Regulation mechanisms are far more complex to establish in this case since outputs can take many different forms, e.g., issuing norms or standards, certifying products, publishing states of the art ... It is thus difficult to establish, as with science or the market, any clear indicator based on output. Contracts with public authorities may provide a proxy-indicator which, our two tests showed it, presents the same limits as contracts with the industrial sector. And, thanks to open questioning, a set of proxy-indicators based upon linkages and activities, has been since developed.[20]

Research and public debate about science and technology

From cold fusion to the mad cow disease through the memory of water, from neuromuscular diseases and cystic fibrosis to AIDS, from the abortion pill to organ transplantation, research is more and more subject to public debates. Not only do such debates put in question the existence of "a" scientific community which would be able to solve internally these debates and the risks linked to certain developments (an approach often labelled as "technology assessment"), but they also emphasize three complementary aspects. First they remind us that research practices and ethics are a democratic issue which can no longer be solved in the secrecy of scientific committees or bureaucratic decision-making. Second they tell us that public debate is no longer limited to the use of results but also and even more deals with the choice of research topics and themes for the mass of public researchers to focus their activities on. And thirdly they underline a growing role of researchers within the political decision-making process and the necessary related public debates which accompany it. We are again far here from the traditional but still necessary work by researchers to foster a better "public understanding of science" (the French wording is even clearer on this one sided vision of the relations: "vulgarisation"). It is no longer enough to consider the numerous committees in which researchers participate to prepare, implement or evaluate government research priorities and programmes. One also has to consider as an activity per se, the recommendation or advice which is required from them when facing unsolved collective problems such as mad cow disease. Researchers act there as "experts" to help political bodies to shape their opinions or to provide for decisions and policies. All this underlines the growing role of this activity, which has been the object of intense controversy for some years now.* Without a doubt, this fifth dimension is the most difficult to capture. When characterizing French public teams involved in E.U.

* For a further analysis of these stakes and the corresponding three models of involvement of lay people in the production and dissemination of scientific knowledge, see Ref. 21.

programmes, we were struck by the importance given by the larger teams to these activities and by the very diversified involvement it represented. But it is only recently that indicators based upon the identification of "arenas" and the roles played by researchers have been developed and are being tested.[22]

The research compass card and the activity profile of laboratories

The activities of a laboratory can, then, be split up between five dimensions which can be assimilated to the five cardinal points of a research compass card (Fig. 1). The degree of involvement of the lab in each of these dimensions defines a mix which is specific to the lab and is called its activity profile. Such a description includes both traditional definitions as extreme situations (the academic lab that is supposed to produce only certified knowledge or the industrial lab dedicated solely to competitive advantages) while at the same time taking into account those mixed situations most empirical studies have put forward. As such, this model does not take for granted that the conditions of creation of a lab, i.e. its institutional setting and its 'official' objectives, or its effective funding, i.e. its market relations, constitute a relevant criterion to define its activity profile.

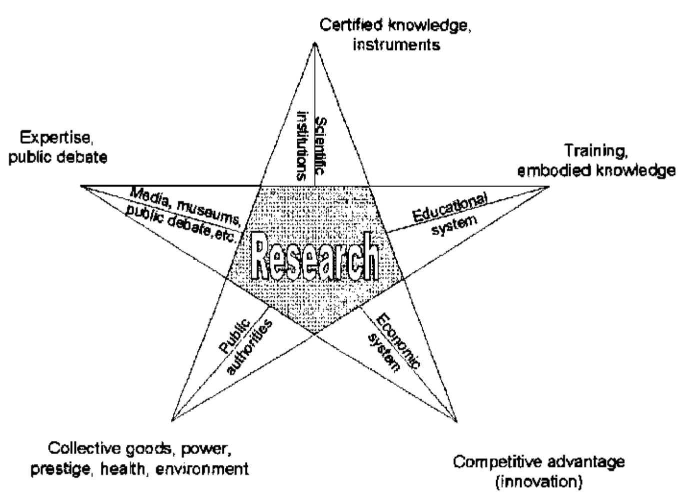

Fig. 1. The research compass card

Validation of these hypotheses and approach required a step by step approach based upon empirical analyses of actual labs. It was organised around three main issues: a) could we, whatever the activity, identify different types of involvement, as, for instance, scientometric studies enable to do for publications. b) If so, could we observe other mixes than those two extremes put forward by the standard economic analyses (the fundamental science linked to information and public good, the applied science driven by secrecy and market conditions)? and c) If so, the challenge was to see whether we faced an infinite variety (as would suggest studies about disciplinary working specificities, about the local dimensions of scientific activity and about the role of path dependency) or whether, without coping yet with reasons for this, we could observe typical configurations which would trespass these "invisible" borders. A programme was started during the nineties to address these issues. The following sections describe first the methodologies developed and their application on a test case.

The characterization of lab activity profiles: methodological issues

Going from principles to effective empirical studies faced the analysts with three main methodological issues: the identification of labs, the definition of indicators of involvement, the aggregation issue. These questions and the choices made (which are far from being the only possible ones) bear a strong effect on the research programme and its present results. They are thus presented hereafter.

The identification of laboratories

Contrary to a firm and most analyses in industrial economics, there is no legal frame to identify actors. Ad hoc decisions are to be made about what are the relevant entities to analyze within larger institutions – may they be research institutions, administrations or universities to name only a few. Box 1 recalls the criteria we used for our first experiment within a large French mission oriented research institution. Basically, three elements were taken into account, largely inspired by managerial work done on firms. The Lab must be recognized within its own institution as a "budgetary" unit; it must be visible as a whole for outsiders from the institution and have a clearly identified representative. Finally, the least visible element but a crucial one, the lab must be capable of autonomous strategies which means that between the goals or missions which justify its existence and the effective definition of projects or research themes it works upon, the lab is active and operates internally the translations required.

Box 1: Definition of a Laboratory proposed in 1992[12]

"Its outputs combine three major elements in different mixes: texts presenting codified knowledge (articles, patents, norms...), embodied competencies (know-how, tacit knowledge...) and technical devices (instruments, prototypes...). They, in turn, are obtained through the mobilization and development of a combination of resources within the lab. All experimental work is based on instruments and researchers are able to make nature speak through the inscriptions they obtain from them.[23] Embodied competencies are found in researchers and technicians who use these instruments, and in a whole series of texts (articles, reports...) which are utilized, transformed, discussed... In this way, the laboratory appears as a place where the social and natural worlds are articulated.[24] The lab must not only question nature but ensure the circulation of its productions.

These results underline two fundamental characteristics of a laboratory.

a) It is capable of autonomous strategies, which means that, thanks to its facility of mobilizing and combining different resources, it can participate in the definition of research themes and/or operations. This demonstrates its ability to influence the definition of priorities or, even, in some instances the setting of political goals. Thus it has to be, as in the empirical definition adopted by *Crow* and *Bozeman*, "a distinct organization with a separate director".*

b) It makes up a codified framework for researchers, technicians, instruments and materials which allows collective learning processes to develop and the production of results, difficult to obtain otherwise. It fosters the accumulation of tacit knowledge, the importance of which has been put forward by *Collins* when studying technological transfers from one lab to another and replication of experiments.

Even within research institutions, this identification is not that evident. Should we for instance consider on the same footing two "unités de recherche" from CNRS classified in the same discipline: one with 6 researchers and the other with over 150 researchers? In the case of the French institution we worked with, the choice was made to retain the smallest recognized budgetary unit, even if those were often split into research teams, mainly because it was at the level of its head of unit that all external

* "A R&D laboratory is defined as a clearly defined research unit of at least 40 personnel involved in physical science, natural science, or engineering research and/or development. Each Unit must have a separate director and be clearly identified as a distinct organization in a corporate, university or government agency setting"..

partnerships were discussed. In our regional test which involved labs from different institutions, we left the institutions decide upon the relevant entities: Some retained the existing institutional arrangements, while others decided that units which were recognized at the national level (e.g., associated to CNRS or INSERM) did not correspond to reality and thus cut them in two for the test.

The definition of indicators for involvement

How to measure the involvement of labs in the five activities, is the second methodological issue. This question should not be confused with the assessment of the performance of the lab in each activity; "evaluation" can only take place when the lab profile is determined and thus the activity put into perspective: How useful is it to evaluate the academic publications of a lab when its activities are focused on its participation to the development of new safety norms!

The answer to this question is however far from evident. The choices we made were different in the two tests. The first test within a research institution aimed mainly at testing the ability of identifying labs profiles. This was done by relying upon central simple existing indicators before making in depth lab analyses to evaluate the relevance and robustness of the method. The second test voluntarily chose to address an inter-institutional setting: This drove first to redefine criteria and indicators to take into account this heterogeneity, and, second to adopt a mailed survey approach in order to maintain costs at a reasonable level and provide for periodic replication.

An important legal point should be noted here. A laboratory is neither a legal entity (for which rules for "secret statistique" apply in France), nor an individual who is then protected by the law "informatique et liberté" and the C.N.I.L. which has all powers about such databases, their access by individuals and treatment and disclosure practices. In the end, CNIL chose to cover also this issue and applied to this computer database similar rules as those for individuals. This sole fact drove to an institutional embedment within an independant public body, The agence d'urbanisme de la region angevine (AURA) specializing in such DBs and to a lasting configuration with the creation of an "observatoire" and the replication of the study every two/three years.

The choices made for each activity will be presented in the next section, while presenting an overview of lab specialisation.

The aggregation issue

In most analyses on firms, the aggregation process consists in transforming every indicator in monetary terms: firms, whatever their field of activity or extension, can then be compared through this equivalent. This does not only deal with output or profit but also for instance to qualify high tech firms depending upon the share of their sales they dedicate to R&D. In other cases, such as the measure of the impact of energy saving policies, physical equivalents have been developed to measure the savings - the so called equivalent ton of petrol, etc. This could be done for scientific activities as long as one considered them only linked to the production of certified knowledge: we all know about institutions and systems which only count academic articles and the citations they receive to judge both the researchers and their labs. Once we accept that research activities can develop in five complementary but very different contexts, we are faced with a difficult aggregation issue: Could we think of an "equivalent citation unit"? We considered that no strong enough normative stand existed to operate this reduction, that involvement in one activity was not commensurable with involvement in another, and that the only acceptable solution was to identify the mixes of involvement which characterize the labs. Each mix "reveals" the strategic choices the lab has made, formally or not, voluntarily or not. This is why we have focused on identifying "typical configurations" of labs activities, which we propose to call the activity profiles of laboratories. It is only then, once these profiles have been identified, that labs can be compared and evaluated: what is the interest of comparing an high tech SME with a large multinational firm? The same applies for laboratories.

Laboratory involvement: an overview

As was said before, we shall focus here on the recent regional test.* The objective of this third section is simultaneously to render the methodology more visible and to confirm the result already observed in the exploratory test made within a research institution: the variety of involvement whatever the dimension analysed. In the Anjou region, we surveyed through a six page mailed questionnaire, 75 laboratories coming from eight different institutions (universities, other higher education institutions, national research institutions as well as regional ones). A first result linked to traditional

* Unless mentioned, all following data come from Ref. 26.

input data, showed that these labs were on average "quite" small:* 16 persons, the teaching and research staff representing half of it while doctoral students represented three fourth of the remaining half. We shall now see that simple indicators have been enough to differentiate strongly lab involvement in each of the first four activities.**

Labs and certified knowledge. To assess involvement in academic life, a set of fours indicators was used (see box 2). The standard indicator of 'academic visibility' (i.e., the number of articles per researcher and per year published in the journals analyzed by the ISI databases) highlighted the strong involvement of 40% of labs. This was complemented by a second indicator based upon the indirect recognition of labs individuals through scientific prices, participation to editorial boards of scientific journals or invited conferences to international conferences. Even though these signs of "individual recognition" mainly concerned the 30 labs which also published numerous academic articles, nevertheless, another quarter of our test population also witnessed a strong "individual recognition", building up a second type of involvement, made of many scientific publications (but not in the so called first class journals) and of other forms of peer recognition, while over a third of the labs under test showed only very marginal signs of involvement. We thus were driven to identify three contrasted attitudes of labs towards "academic" involvement.

Labs, training and embodied knowledge. This second activity tends in many analyses to be left aside as if it built a completely separated world (a situation which can be partly explained in French studies by the nature of the French research system and the major role of institutions dedicated to research). Strikingly, in our test case, it provides a major divide between those strongly and those marginally involved, based upon a simple indicator, the number of PhD students per researcher present in labs: the latter have less than one doctoral student per ten researchers, while the former have around three per four researchers. Box 3 shows that, as for academic involvement, national institutional recognition should not be taken for granted and might bear significant biases when looked upon at the regional level.

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* Especially when compared with those of the preceding study (49 persons on average) or to the average French lab participating to EC programmes (60 persons).[20]

** Both tests have left aside the fifth dimension, participation to public debate, a limitation which, as mentioned above, is being tackled in an on going work.

Box 2: Indicators of academic involvement.

Four dimensions were taken into account with two building the core of the analysis.
(i) Academic visibility (using bibliometric indicators). The basic indicator was the number of articles per researcher and per year published in the journals analyzed by the ISI databases. For social sciences and humanities, the ISI DBs being considered as unfair to French speaking journals, a specific process was devised with the help of CNRS publication service. A journal was considered academic when indexed in at least three international DB (with at most one French one) out of the 50 international DBs in social sciences and humanities taken into account.
The average ratio was 0.4 "academic" article/researcher/year. This is borne by 30 labs with an average of 0.75 article per researcher, while 18 labs witness no article at all, and the remainder an average of 1 article per 14 researchers.
(ii) Indirect forms of recognition gained by individuals. Labs were asked to mention whether some of their staff had won a price (16 cases), had been an invited speaker to an international conference (41) or been organiser of an international conference (33), or was a member of a journal editorial board (32).
Labs mentioned on average 1.4 such activity, 19 mentioning none while 22 mentioned 3 or all of them.
(iii) Indirect forms of recognition gained by labs. This was built upon the presence of post doctoral students (19 labs), the participation to national programmes (18 cases) and to international programs (5 cases).
(iv) the institutional recognition of labs at the national level.
The analysts of the French research system might be puzzled by the fact we did not use, as a major criterion the institutional recognition given either by research institutions (such as CNRS), or, and this played in our test a major role, by the ministry of education (so called "jeunes équipes"). The reason is both paradoxical and simple (see table below): half of the labs (38 out of 75) had such recognition. Out of these 38, there were 20 of the 30 "academically visible" labs, 10 of the 19 labs with only "individual recognition", and also 8 of the 26 non academic labs. If we might consider that the situation is normal for labs of the second type, it remains puzzling to see that 18 labs (10 with academic visibility and 8 with no academic involvement) out of the 56 of these two corresponding groups face paradoxical institutional situations! This is a clear reminder for those who study 'national research systems' that activity can be considered very differently depending upon the level of aggregation (from regional to European level) and thus that criteria relevant at one level could well be not adequate for another.

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Box 2

Labs	Unit	With limited involvement	With only "individual recognition"	With strong involvement
Number		26	19	30
Academic visibility	articles/researcher/year	0.01	0.07	0.75
Individual recognition	number of forms (max=4)	0.5	2.8	1.8
Collective recognition	number of forms (max=3)	0.4	0.4	1.0
Institutional recognition	number of labs	7	10	20

Box 3: Indicators of research training involvement.

Two main indicators were used for qualifying involvement in research training. This is linked to the way French higher education is organised. There are two complementary ways for a lab to get PhD students. (i) Any researcher which has undertaken a specific exam ("habilitation") is authorised to direct PhD students. (ii) This is different from the national labellisation of post graduate training (so called DEA), which is under the direct control of the French ministry of education. A typical DEA is made of a core group of labs ("noyau dur") which have initiated the DEA and generally provide most of the teaching staff. They are surrounded by a set of research labs in which the students will effectively undertake their PhD work: these "laboratoires d'accueil" are an integral part of the labellised DEA. In our regional test, 16 labs (21%) were part of such a core group, while 28 (37%) were laboratoires d'accueil.
The national institutional recognition of the lab for post graduate training (44 labs) provided a first indicator, while the effective presence of PhD students and the ratio to the research staff of labs built the second one. The average ratio is 49%. This density in PhD students is nil or limited (average: 14%) for 29 labs, while it is significant (average 40%) for 12 labs, important (average: 60%) for 19 labs and very important (average 124%) for 15 labs.

This second indicator is the most striking since it clearly opposed two groups of labs as can be seen from the table, while "institutional recognition", being not correlated to effective involvement, built a complementary appraisal of labs insertion in the global research training environment.

	Number	PhD density
Labs involved and recognised	33	70%
Labs involved but not recognised	13	90%
Labs recognised with limited involvement	11	11%
Labs not involved nor recognised	18	5%

Labs and participation to competitive advantages. Resources derived from industrial contracts is a classical indicator of involvement in industry-university relations. They represent on average a third of the budget of Anjou labs (see Box 4 for the construction of this indicator), with clearly opposite situations, a third of labs having none while a fourth finds three fourth of their budget through industrial contracts.

Box 4: indicators of industrial relations.

Two different sets of indicators were used for qualifying labs techno-economic involvement. The first one is related to the role of industrial funding in labs budgets. The second one relates to types of activities undertaken.

• The first indicator, due to the specificity of French public funding of research, is based on the 'marginal' budget of labs, i.e., taking out two main items: salaries of permanent staff and housing costs. It thus considers the origins of funds which are under the control of labs and define its daily working conditions (including the renewal of equipment). On average, 55% of this budget came from the institutions to which the lab belonged or was associated (e.g., a university lab which is associated to CNRS or labellised by the ministry of higher education will receive a long term specific support which will be added to the support he receives from its university), 11% from public national or international programs, and 34% from economic resources (research contracts with industry and services, such as tests). As can now be expected, this was not evenly distributed, 25 labs having no industrial contracts while 18 found 80% of their budget through such contracts, the rest getting between a tenth and a fifth of their budget through such relations.

• The second indicator was based upon activities entered into (and their relative importance for the future of the lab). 9 activities were identified out of which labs on average mentioned 3 (1 being considered important). Three dealt with classical elements of 'industrial development': patenting (mentioned by 8 labs), participation in the design of new products or processes (22 labs), direct commercialisation of products or services (such as new agricultural species or calculation softwares, 9 labs). Three dealt with "expertise" through consulting to companies (43 labs), normative activities on industrial matters (14 labs) or on-going help to ex-researchers having created their own company (11 labs): over two thirds of labs mentioned at least one of these three activities while over a quarter mentioned at least two and a dozen (15% of all labs) considered them as a major element for their lab. Finally a third set of activities dealt with "vulgarisation" (49 labs), continuous training (42 labs) and participation to industrial or economic associations or clubs (47 labs).

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Box 4	Number of labs	Industrial contracts (%)	Number of activities	Out of which important
Labs with weak involvement	19	0%	2	0.4
Labs with limited involvement				
- multiple activities without contracts	6	0%	4	0.8
- contracts and limited types of activities	12	19%	1.5	0.6
Labs with significant involvement	20	16%	5	1.6
Labs with strong involvement	18	79%	4	2

Note: there is a strong correlation between the nature of activities and the degree of involvement: all "development activities" mentioned (35 out of 39) are in the last two groups, while labs with weak involvement focus only on "diffusion" (our last group of activities).

This provided a first insight, but preliminary field work had shown that this did not fully grasp the nature of links with the industrial world. We thus devised a complementary way to characterize the techno-economic involvement of labs by asking them to mention their involvement in a set of nine activities (see Box 4). This helped to further characterize the economic involvement of labs. The 18 labs with heavy industrial funding mentioned on average four activities, considering two as crucial for the lab life. We took this as a proof of the relevance of this complementary approach. It helped in further differentiating within labs with limited industrial resources, a group of labs witnessing numerous activities, a third of them being considered important by labs. Once again, we were faced with very different patterns of participation to the creation of competitive advantages.

Labs, collective goods and public services. Ironically, following lab involvement in innovation for public services has proven a very difficult task. We first used as a potential proxy-indicator, the existence and relative importance of national/international public programmes in lab budgets: half of labs had such contracts, which represented at least a third of their budget in a third of the cases. We also asked an open question for labs to describe the corresponding activities and rate their importance for labs: a third described such activities while judging them central to the lab activities (see Box 5). But there was only partial overlap between both sets, 16 labs exhibiting simultaneously contracts and activities of "general interest" important for the lab. Analysis of the descriptions of the other 9 other labs which considered such activities as important revealed quite a significant number of situations related to clinical research. We thus chose the latter indicator to qualify this involvement, while being conscious that further work is required to define better indicators.

Box 5: Innovation in public services - indicators of involvement.

Two proxy-indicators were used for tracking lab involvement.

• We first took the participation to national or international programmes as a proof of alignment of lab projects to national needs and priorities. This concerned 36 labs.

• We also asked an open question about their participation to such objectives (yes = 40 labs) and its importance for lab activities (judged important for 25 labs). Descriptions made helped identifying three main directions: the national and international management of research activities (through committees, etc.), the support to public decision making (through expertise and public debate) and the participation to new knowledge relevant for, and the improvement of public services.

	Lab number	Out of which participating to national programmes
Not involved in such activities	35	11
With "marginal" or "secondary" involvement	15	9
With important or crucial involvement	25	16

Laboratory involvement: a recapitulation. Each activity has shown us a variety of involvement with 3 to 5 main typical situations for each activity. More than any long explanation, this tells about the variety of potential configurations. Simple additions also show that a laboratory has difficulties to embrace all activities, especially for labs which can be considered as quite small. On average a lab can be considered as heavily involved in less than two activities (1.4 exactly) and significantly involved in near to one complementary activity (0.9 exactly). This is still a high number, which takes us far away from the two stereotypes we started with. The last section will explore the configurations, or activity profiles, that emerged from their combinations. Due to the limited number of labs, it remains exploratory. Still, it might bear some impact upon the way we consider labs.

Typical activity profiles

In this final section, we would like to open the discussion about the existence of typical laboratory configurations, or activity profiles, as we prefer to name them in order to better highlight the importance of the range of activities which labs develop and get involved into. It will first emphasize the methodological choices made for aggregation and the seven profiles identified. It will then try and relate such profiles to institutional and disciplinary dimensions to better position this approach in a wider organisational and disciplinary framework.

Table 1
Involvement of the 75 labs within a regional setting

Involvement into	Number of typical situations	Number of labs with an involvement strong	significant	limited
– Academic activities	4	30	19	26
– Training and postgraduate education	4	33	13	29
– the production of competitive advantages	5	18	20	37
– the production of collective goods/services	3	25	15	35
Number of "relative specialisations"		106	67	
Average number per lab		1.4	0.9	

Seven typical configurations identified

As mentioned earlier, no synchretic indicator was built, the choice was made to focus on the ways labs mix their different involvement. Two choices were derived from previous studies done on labs. The first one was to focus on effective specialisation, i.e., taking into account "strong" and "significant" involvement. Even if this limits the number of potential configurations, there could easily be as many different profiles as labs in the sample analysed. It enables to distinguish a first subset of opposite situations: labs with no strong or significant involvement at all (6 labs) versus labs with all around involvement (9 labs). The second choice was to privilege those labs which are able to simultaneously answer their institutional drive – i.e., be embedded in their teaching and/or research environment – and to be socio-economically involved. The statistical analyses conducted can be translated in a quite simple process. Involvement in research training was central in differentiating two sub-populations of labs (one with less than 1 PhD student per 10 researchers and one with nearly 8), while relations with industry helped in specifying further each subset. These results are common with previous studies, apart from the fact that the relation to professionality is first linked with research training and not academic involvement. This latter indicator plays an important role in differentiating between training labs, while involvement into activities related to public services further specifies a sub-group of training labs (see Table 2). We shall now briefly present the seven profiles, their main characteristics and the debates they have given rise to.

In the first group of 29 laboratories, limited involvement in training goes along with limited production of certified knowledge (no one with "academic visibility", only one in three with "individual recognition"). What makes the difference between these labs lies in their role as service providers. A sub-group of nine labs finds most of its funds through industrial contracts, being heavily involved in the production of competitive advantages; they have been labelled as "*service geared labs*". It is interesting to note that six out of nine belong to universities, pinpointing the difficulty to assimilate effective involvement to institutional background.

Table 2

Main characteristics of the strategic profiles identified in the regional test

	Number of labs	Academic involvement	Research training involvement	Participation to competitive advantages	Participation to innovation in public services
– Isolated labs	6	--/-	--	--	--/-
– Service geared labs	9	--	--	++	-/+
– Intermediate labs	14	--/+	--	+	--
– Research training only labs	10	-	++	-/+	-
– Academic labs	13	++	++	--	-
– Academic labs with a public service focus	14	++	++	+	++
– Academic & economic geared labs	9	+	++	++	-/+

Source : AURA, 1996.

Note: for visualisation purposes, we have ranked involvement from -- (no or very limited involvement) to + (significant involvement) and ++ (strong involvement). For certified knowledge ++ corresponds to "academic visibility" and + to "individual recognition". When situation on an activity is contrasted within the profile we mention the spread, e.g., -/+.

Table 3 shows that the two other subgroups of labs are of far smaller size than all other Anjou labs – respectively 7 and 9 persons as opposed to an average of 16. This includes six labs with no marked involvement (labelled "*isolated labs*") and an important group of 14 labs in an "*intermediate situation*" – i.e., with significant relations with industry, with for half of them an "individual recognition" by peers and also for half an institutional recognition for research training though effectively not involved. Continuous monitoring of these labs[27] has shown that this was a transitory situation corresponding to the "mutating" population identified by *Joly* and *Mangematin*, nearly none being three years later in this situation, half having been disbanded.

Table 3
The workforce composition of the seven profiles

	Number of labs	Total workforce	Researchers	PhD Students	Graduate trainees	Other staff
Average regional lab	75	16	8	4	2	2+
– Isolated labs	6	7	6+	1–	–	–
– Intermediate labs	14	9	6+	–	1	1+
– Service geared labs	9	15	11	1	2	–
– Research training only labs	10	13	6	6	1	–
– Academic labs	13	18	8	6+	2+	1
– Academic labs with public service focus	14	26	10	6+	3+	6
– Academic & economic geared labs	9	13	6	5	1	1

Note: Graduate trainees correspond to master thesis: only those spending over 5 months in the lab are taken into account. Researchers include full time researchers from research institutions as well as "enseignants chercheurs", i.e., teaching staff who officially have half of their time devoted to research activities.

Let us now examine the 46 labs involved in research training. The first striking aspect is that in one fourth of cases (10 labs out of 46), research training does not go along with "academic involvement" (even with "signs of individual recognition"). This group of labs solely devoted to research training was the object of strong debates within the Anjou region. Two conclusions can be drawn from on-going monitoring. This is also a transitory situation: three years later only two of them remained in such position, not because they had disbanded, but because they had merged or climbed the ladder of peer recognition. However, while in the previous situation we no longer monitor a significant number of labs in an intermediate situation, there seems to be a continuous flux of new "research training only" labs, as if, in this regional context, it was an entry point to further establishment.

This situation should however not be overemphasized since all other labs mix both involvement – research training and academic life. These 36 labs split in three groups, depending upon other involvement. A first group of "academic labs" witness no other marked involvement, finding all (and if not the vast majority) of their working funds via their supporting institutions. Opposed to them is the group of nine labs with all around involvement, i.e., being both academic and highly connected to the economic world (which provides on average two thirds of their budget). What was however puzzling, was the limited institutional recognition of these "academic and economically geared" labs, only linked to their participation to national and European programmes. The regional promoters of this work considered the achievement of national institutional recognition a central objective for their potential support. The last group of 14 labs displayed a different mix. Most were well established institutionally, finding through it, a stable and important core budget. Their characteristics was to add to the research training and academic involvement a strong focus on relations with public services, while maintaining, for most of them, significant relations with the industrial world. Table 3 highlights a very interesting phenomenon concerning those "academic labs with a public service focus": they are the largest labs in our sample, no so much because they have more researchers, not because they train more PhD students, but because they are the only ones to have an important supporting staff (mainly technical people), an element, which connected to the simultaneous existence of economic relations, is not without resonance with one of our major findings about the "demonstration" networks promoted by EU research programmes focusing on collective goods, such as energy options or biomedical research.

"Transborder" configurations

Organisational studies have emphasized the role of institutions in shaping productive settings. Similarly science studies have long linked the forms of research collectives to the nature of knowledge produced, i.e., to disciplines (with for instance the well known concept of big science). It was thus central to see whether we could relate given profiles either to institutional or disciplinary grounding. Of course the limited number of labs in the test, the dominating role of two universities do not allow us to draw definite conclusions. Still the mix of lab types does not strongly differ from one institution to the other, the main difference lies less in the profiles themselves than in the relative number of labs in each profile. As *Bozeman* and *Crow* have demonstrated, connections between institutional settings and labs configurations do exist but the they are far from being systematic. Table 4 highlights it further, showing for instance that University A with its 42 labs covers the whole range of profiles. Similarly the disciplinary approach (Table 5) does not highlight either any significant relation with the type of lab. All profiles identified thus cross both institutional and disciplinary borders.

Table 4
Profiles and institutional settings

	Number of labs	University A	University B	Research Institution A	Research Institution B	Other higher education
Number of labs	75	42	15	5	7	6
– Isolated labs	6	4	2	–	–	–
– Service geared labs	9	1	3	2	1	2
– Intermediate labs	14	5	4	–	3	2
– Training only labs	10	7	2	–	1	–
– Academic labs	13	9	3	–	–	1
– Academic & collective goods labs	14	9	–	3	2	–
– Academic & economic geared labs	9	7	1	–	–	–

Note: Institutions have been regrouped under 5 main headings: University A and University B, Research institution A, Research Institution B (which also entails training activities and to which the regional lab working on similar areas has been added for confidentiality reasons), other higher education institutions (4 different ones with only one or two labs each). It should be noted that, as in most French regions, CNRS and INSERM supported labs are university labs (and thus these institutions do not appear as such).

Table 5
Profiles and main scientific areas

Number of labs	Number of labs 71	Social sciences & Humanities 21	Engineering sciences 6	Life & health sciences 36	Materials sciences 8
– Isolated labs	5	3	–	1	1
– Service geared labs	8	3	2	3	–
– Intermediate labs	14	2	1	11	–
– Training only labs	10	6	1	2	1
– Academic labs	11	4	–	2	5
– Academic & collective goods labs	14	1	–	10	3
– Academic & economic geared labs	9	2	2	4	1

Note: labs in earth sciences (2) and in maths (2) have not been classified (they all are part of different types). For confidentiality reasons the whole of human and social sciences have been regrouped in one category (subcategories, such as law, geography or economics, also show wide variety). The same applies for life and health sciences.

Conclusion

If the laboratory is to research activities what the firm is to economic life, then it is important to concentrate more work on this crucial basic unit of production. Based upon the results from the sociology of science, we have developed a model - the research compass card - to point out the different activities in which labs are simultaneously involved: certified knowledge, embodied knowledge, participation to competitive advantages, participation to the development of new public goods or services, participation to public debate. This enables to enlarge our vision of laboratories, too long imprisoned into the two dominating stereotypes of fundamental and applied research.

We have used a regional experiment based upon a set of 75 labs belonging to eight different institutions to develop and test a methodology aiming at measuring, through a set of simple but robust indicators, lab involvement in each of the identified activities, and at characterizing lab "activity profiles" based upon their mixes of marked involvement. The test showed that labs demonstrated very different and contrasted involvement in each activity and that these activities did not mix at random, building a limited set of typical "activity profiles".

We shall not recall them here, but we have derived three major lessons from this test which, we think, pave the way for future analyses.

(i) It is difficult for labs to be "strongly" involved in all activities. Five of the seven profiles are built on one or two such involvement while the other two only add "significant" complementary involvement. Activity profiles thus reveal de facto strategies (may these be formal or not, or depend or not upon a voluntary approach). For institutions in charge of their monitoring and evaluation, this has strong implications: what is the use of evaluating the performance of a lab without taking into account the strategic choices it has made? Activity profiles could be a useful tool to group labs with similar profiles for assessing their relative performance.

(ii) One answer to this problem has often been that labs within a given institution (e.g., a government lab) or a given discipline (e.g., computer sciences) share the same profile. The test, however limited it is, clearly demonstrates that profiles cross institutional and disciplinary barriers. We are thus sent back to the strategies developed by labs, to their logic of action and to the norms, procedures and policies that accompany, foster of inhibit them.

(iii) These results do not however address the second initial question posed, about the dynamics of labs and their conditions of emergence, growth and decay/closure. The periodic monitoring which has been initiated on this test population, has however enabled to identify "transitory situations", i.e., only lasting a few years. This calls for new empirical work on lab trajectories.

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