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Organizational *vs*. personal social capital in scientists' performance: A multi-level network study of elite French cancer researchers (1996–1998)

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The difference between individual social capital and organizational (or corporate) social capital has been an important topic of research in sociology during the past decade. The existence of this difference between two forms of social capital evokes an old question in a new manner: what matters most in explaining individual actors' performance? Is it personal social or collective resources provided by the organization to which the individuals belong and in which they work? In this paper we provide a preliminary answer to this question based on a multi-level network study of the top 'elites' in French cancer research during 1996–1998. By multi-level we mean that we reconstituted both the inter-organizational networks of exchange between most French laboratories carrying out cancer research in 1999; simultaneously, we reconstituted key social networks of the top individual elites in cancer research in France during that same year. Given our 'linked design' (i.e., knowing to which laboratory each researcher belongs), we were able to disentangle the effects of structural properties of the laboratory from the effects of characteristics of the individual researcher (including structural ones) on the latter's performance. Performance was measured by a score based on the impact factor of the journal in which each researcher published. Our results show that organizational social capital matters more, and more consistently, than individual relational capital in explaining variations in performance by French top cancer researchers.

Introduction

The difference between individual social capital and organizational (or corporate) social capital has been a new topic of research during the past decade in the social sciences (LEENDERS & GABBAY, 1999). In a work environment, individual social capital can be defined as the set of resources that individuals bring to the performance of their tasks through their own personal relations. Organizational social capital can be defined as the set of resources that an organization makes available to its members through its inter-organizational relationships, so as to ensure a capacity for individual

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and collective action. Members have access to such resources of the organization to which they belong, and that helps them in their individual and collective work. Such organizational resources are acquired and capitalized by the collective entity, sometimes over several generations. The existence of this difference between two forms of social capital evokes an old question in a new manner: what matters most in explaining individual actors' performance? Is it personal social or collective resources provided by their laboratory or institution, including by other members of their laboratory, in particular its director?

Network studies can be very useful in analyzing the flows of such individual and collective resources. Many network studies of scientists or of laboratories have been done, beginning with pioneering work by MULLINS et al. (1977).[1] There are many sociological theories insisting on the importance of relational structures on actors' capacity to innovate individually or collectively (CRANE, 1972). However, to our knowledge, there are almost no *multi-level* network studies allowing social scientists to disentangle the effects of organizational social capital from individual relational capital in explaining individual scientific performance.

For example, performance can depend, at the same time, on characteristics of the laboratory[2] (including its position in exchange networks among laboratories), and on the relational characteristics of the individuals (including their position in the networks of exchanges of resources in a milieu of other researchers). Performance thus depends upon the combined structural characteristics of the organization (the laboratory) and the individual (the researcher) because their interdependencies is based on the complementarity of resources provided by each level to solve different types of problems of individual and collective action. The issue thus becomes contingent on the measurement of the relative contribution of each level to actors' achievements. One key aspect of the problem for us is to explore this multi-level dimension and possibly the relative weight of each of these factors for performance at the individual level. We consider researchers to be 'entrepreneurs' who need resources to produce – resources that can be social as well as monetary (BLAU, 1964).

In this paper, we use a 'linked-design' approach (PARCEL et al., 1991) to provide a preliminary answer to this question based on a multi-level network study of the elite of French cancer researchers during 1996-1998.[3] This elite was identified by the number of articles published in scientific journals listed in CANCERLIT, a database of the U.S. National Library of Medicine which specializes in articles related to cancer.

[1] See SHRUM & MULLINS (1988), CALLON (1989), POWELL et al. (1999) and JANSEN (2004) for literature reviews.
[2] For more about individual performance of researchers and collective innovation capacity in similar scientific domains, see CAMBROSIO et al. (2004). See also COLEMAN (1990), BURT (1992) and FLAP et al. (1998) for more general statements about the relationship between social networks and individual performance.
[3] Studying elites is nothing new in the sociology of science (see for example ZUCKERMAN, 1977; HARGENS et al., 1980).

Performance was measured by a score based on the impact factor of the journals in which each researcher published. Our results show that organizational social capital matters more, and more consistently, than individual relational capital in explaining variations in performance by individual members of this elite.

Hypotheses

To explore the multi-level dimension of scientific production, we need hypotheses on the relative weight of each of these factors (laboratory social capital and individual social capital) on performance at the individual level. We argue that researchers, as any other actor, now live in an 'organizational society' (PRESTHUS, 1962; COLEMAN, 1974, 1982; PERROW, 2001); that is, a society in which individual action and performance depend heavily upon an actor's capacity to build and use organizations as tools. Following this premise, we hypothesize that the most important factor is the amount of resources with which the organization provides its members. Applied to the realm of scientific production, this means that we hypothesize that the social capital of laboratories will weigh more heavily on scientific performance than individual relational capital, particularly among elite researchers. In other words, differences in personal social capital should count less for individual performance, at least among elite researchers since reaching that level of performance is already a sign of enormous value. Regardless of individual talent, differences in individual social capital and in individual human capital among elite members are not expected to have a great effect on research performance.

Translated into statistical reasoning, this hypothesis stresses three types of explanatory factors. First, we hypothesize that variables reflecting laboratory social capital play an important causal role in explaining individual performance. Drawing on its social resources, a lab provides researchers with specific resources at each step of their work (LAW, 1989). For example, when a new researcher comes into a lab, he/she usually benefits from established cooperative ties between the laboratory and other laboratories, including his/her boss's reputation and networks. Regular funds, or funds obtained by the lab for specific projects, represent an obvious causal factor for individual performance. For example, if non-profits, private industry, and governmental (national or international) authorities invest in a project, such investments may translate into high quality work and, eventually, presumably, into a higher impact factor for members' publications. The social capital of the laboratory (i.e., access to many resources, and thus to more opportunities to perform effectively) can be measured by its centrality in the network of laboratories.

Second, we hypothesize that variables reflecting social capital of the individual researcher will play a more limited causal role in explaining his/her performance measured in terms of impact factor. We will measure individual social capital by

looking at researchers' access to other elite researchers for multiple kinds[4] of advice; this access can be considered a causal factor in the competition for performance. Centrality measures in the network of the elite of researchers in a specific domain can express that kind of access and be introduced as independent variable in the same model as the variables measuring the social capital of laboratories.

Third, characteristics common to individuals and laboratories can also be introduced as controls in the models. Here, the most obvious common characteristic for both levels is specialty. In any country, researchers may have a tradition of excellence in some specialties and not in others. Such a tradition means that individual performance could benefit from generations of large investments in this area of research.[5] In addition, variations in researchers' human capital (for example, education) are often considered a factor that also makes a difference in explaining individual performance; it should therefore also be taken into consideration.

Methodology

We tested this general hypothesis by carrying out a research project on French cancer research in the late 1990s.[6] In this section we first describe how we selected our population of elite researchers, how we gathered the data, and how we carried out our analyses.

Selection of elite researchers and laboratories in French cancerology (1996–1998)

Fieldwork took place between May and July 1999. In our study, we focused on very active researchers at the time. The selection criterion for membership in that population was the *number* of publications in 1996, 1997 and during the first semester of 1998, as abstracted in CANCERLIT, a database of the U.S. National Library of Medicine which specializes in articles related to cancer. This criterion has two advantages. First, it is

[4] Advice can be considered important in the process of 'constructing doable problems' in that area (FUJIMURA, 1987).

[5] We are aware of the limitations of this assertion. For some cancers, for example, there is no 'angle' for massive and organized research. As long as researchers do not have an 'angle', the milieu multiplies the uncertainties and bets about possible lines of research. Once an 'angle' is discovered – for example through a discovery that retrospectively appears to be a big bang discovery – then research becomes much more routine. In the meantime, manufacturing consensus among scientists consists in converting uncertainty into risky lines of research and finding authorities to justify one's choices.

[6] This research was conducted by the authors, who belong to two laboratories (CLERSE and LASMAS) at the Centre National de la Recherche Scientifique (CNRS). It was funded by CNRS and by a non profit organization devoted to cancer research, the Association pour la Recherche sur le Cancer (ARC). For more about this project, see LAZEGA & MOUNIER (2000), LAZEGA et al. (1999; 2004), and STOFER (2001).

relatively manageable compared to other measurements of performance[7] and it is recognized by the actors themselves. Indeed, status conferred by the number of publications and their recognition is one of the main motivations driving researchers in our population. Second, data collected from CANCERLIT show that French researchers published 9149 articles between 1996 and the first six months of 1998. These articles were produced by 24285 different researchers. Following 'Lotka's law' (LOTKA, 1926; PRICE, 1963), a vast majority of researchers working on a specific problem publish only one paper on the problem and then drop it. A very small and prolific minority of scientists publishes most of the papers in a single domain. In this list we selected precisely those who published the most in France at that time.

This criterion produced a list of 168 researchers who published the most in France. Out of 168, 128 people (76%) accepted to be interviewed. Very few important (i.e. world famous) names are missing in the data. Many of the missing persons are not very central among their French colleagues.[8] CANCERLIT data show that, in the late 1990s, French cancer researchers published every year around 3800 articles on cancer, out of a rough total of 80000 in the world. Our 128 authors did not, by themselves, publish the 3800 articles over that three-year period, but they signed over 3200 of them. Of course, some of these articles were published with several, often many, co-authors. After identifying the French individuals with the largest number of publications in CANCERLIT, we looked at the impact factors of these individuals. The two criteria overlap beyond a certain level, correlation between them being 0.37.[9]

This technique allowed us to identify the 'elite' of most productive authors for the three years considered. Whether or not researchers were consistently present among the 'elite' each year over the three years was not taken into consideration. Our population is

[7] No performance measurement is innocent and all can be politicised (MEYER, 1994). This criterion was the only criterion available to us at the beginning of our study.

[8] This list of scientists includes different types of actors. Those who actually publish a lot, those who co-publish a lot, those who are present in the list of authors because they provide technical help, those who are the directors of research units where the research takes place.Only a few work in the laboratories of the pharmaceutical industry.

[9] These results depend on the hierarchy of reviews and disciplines in the system of evaluation of articles as it is practiced in US institutions. These bibliometrical choices can certainly be criticized (FOX, 1983; LONG, 1978; MULKAY, 1972; RESKIN, 1977), but they apply uniformly to all specialties under examination here and do not prevent us from examining the extent to which researchers' productivity depend, in part, on personal and organizational social capital. We are aware of the fact that this indicator is not a confirmed indicator and that it is not meant to be used for evaluation of individual actors, when possible. Nevertheless, we also know that it is permanently used for that purpose. Not a single researcher interviewed contested that fact. They certainly regret it but do not contest it. It is well known that the journal impact factor is not correlated with "impact of individual publications" in a journal (SEGLEN, 1992; 1997). It is a measure for "journals" and not "individuals". It would be therefore problematic to use impact factors for selecting elites. Recall, however, that, in our case, these elites were not selected based on impact factors, but based on the number of their publications in CANCERLIT. In addition, if there is a bias, in impact factors, against publications in non Anglo-Saxon journals, we made the strong assumption that all French researchers were subject to that bias equally. Thus, this bias would not distort comparisons between French researchers.

thus composed of 'elites' who were particularly productive and 'visible' at some stage between 1996 and 1998. A third of the papers of members of this list are co-publications with foreign (non French) teams.[10] The directors of the largest 82 laboratories were also interviewed. Following our linked design, we made sure that each time a researcher was selected for an interview, his/her director was also selected so as to keep track of the multi-level connection. In 51 cases, the researcher selected was also the director of his/her laboratory. These persons answered both questionnaires.

Research design and data collection

Our 'linked design' consisted in reconstituting two kinds of networks in France in 1999. First, the inter-organizational networks of most laboratories carrying out cancer research. Second, key social networks of the elite of individual cancer researchers among themselves. Knowing to which laboratory each of these individual researchers belongs, we were able to disentangle the effects of certain structural properties of the laboratory from the effects of characteristics of the individual researcher (including structural ones) on the latter's performance. With respect to this design, this study can be considered to be a pilot study linking inter-organizational data with inter-individual data. It allows investigation of inter-organizational linkages and of the effects of this inter-organizational environment on individual members' outcomes, which constitutes our particular theoretical concern.

Since we consider researchers to be 'scientific entrepreneurs' who need resources to produce – resources that can be social as well as monetary (BLAU, 1964) – we measured their access to an important social resource: advice. Seen from the perspective of the individual researcher, scientific research was decomposed analytically into five different steps, starting with the definition of a line of research and ending with the publication of papers. Scientific work was thus reduced to a sequence of tasks, each characterized by a high degree of uncertainty: selecting a line of research, finding institutional support for the project, finding sources of funding, recruiting personnel, and publishing papers. At each step, we assume that researchers draw upon their social capital by seeking advice from other members of the research community. We assume that, in these situations of uncertainty and in a competitive environment, access to advisors constitutes an important social resource for the actor. Performing these tasks is made easier if the researcher can, for each task, seek advice from competent colleagues willing to lend support.

[10] Careers and scientific production of researchers are not uniform (LATOUR & WOOLGAR, 1979; KNORR-CETINA et al., 1980; BARBER, 1990). To account for these variations, we extended the population examined, lowering the threshold of the number of publications –our selection criterion– as much as we could, so as to try to retain, in this list, researchers who were at the beginning of their career and others who were at the end of it.

We thus asked them from whom, among the individuals on the list of the elite of cancer researchers that was presented to them, they would seek advice to deal with these uncertainties when carrying out each specific task: advice with choosing or betting on a line of research; advice for finding institutional support; advice with finding financial resources to carry out the program; advice for recruitment of manpower for one's research; and finally advice and criticism from colleagues who read the papers before they are submitted to journals for review. The picture of the process of scientific research that this provides is, of course, simplified, but qualitative interviews show that these were among the main social resources that researchers seek in their work, at least in the French institutional context. The five advice networks that we reconstituted can be analysed separately and jointly. Based on the methodology of social network analysis (WASSERMAN & FAUST, 1994), we also gathered data on researcher characteristics.

Following our linked design, we also collected data on inter-laboratory networks and on laboratory characteristics. We asked the directors of these laboratories with which, among the laboratories on the list of all the laboratories carrying our cancer research in France, their own laboratory had exchanges of various types. Inter-organizational networks were reconstituted for exchange relationships of several resources. We tracked the recruitment of former post-docs and researchers, mobility of technical and administrative personnel, sharing of technical installations, invitations to conferences or seminars, sharing of experimental materials, joint responses to tender offers, and carrying out of joint research programmes.

In sum, two types of network data were collected through interviews to test our hypothesis: firstly, data on the flow of advice among the 128 top French researchers; and, secondly, data on the flow of resources among the top 82 laboratories doing research on cancer at the time. Network resources representing individual social capital and network resources representing collective social capital were connected by making sure that, for each researcher interviewed, the director of his/her laboratory would also be interviewed.[11] Social capital, individual and collective, respectively, was measured by deriving, from this network data, centrality scores for individual researchers (in the advice networks of the elite in which they belong) and for the laboratories in which they worked (based on the inter-organizational networks reconstituted by interviewing laboratory directors). Thus, the social capital of the laboratory will be measured by its centrality in the network of laboratories. This centrality is equivalent to access to many

[11] 51 persons in our population are both elite scientists and laboratory respondents. Preliminary tests showed that these laboratory directors were perfectly able to differentiate between their own personal networks from those of their laboratory. Further analysis of the data confirms that laboratory directors' personal networks in the elite do not necessarily overlap with the networks of their laboratory. However, a possible bias in this respect remains difficult to estimate with this data.

resources, and thus more opportunities to perform effectively. The social capital of the researchers will be measured by their respective centrality in the advice networks among the elite of researchers.

As mentioned above, our dependent variable is provided by the impact factors associated with articles published by members of our population who were selected based on the number of publications listed in CANCERLIT. Performance is thus expressed as a score based on the impact factor of the journal in which the articles of each selected researcher were published. Technically, we proceeded in the following way: If a researcher published four papers in a journal, we multiplied the impact factor of this journal by four. We then summed the impact factors across publications for each individual. Whether the researcher publishes alone or with a team was not taken into account since each person mentioned as a co-author on a paper receives the same score. We could have divided the impact factor among co-authors, but this would be a questionable procedure since we do not have enough information, for each paper, about who actually did what.

It should be stressed that this research was not designed for standard multi-level analysis (BRYK & RAUDENBUSH, 1992; SNIJDERS & BOSKER, 1999). Our linked design allows only for a first approximation in the study of interaction effects between personal and organisational levels. However, it also allows for analyses that cannot be carried out with standard multi-level techniques, especially providing structural level information about the position of individual members in the overall inter-individual networks of this elite.

Background information on French cancerology as a social milieu

Before reporting our results, it may be useful to provide information that will help the reader in interpreting the result. French cancer research, at that time, was mainly funded by public and non profit institutions. It was strongly concentrated in the Paris region, in terms of resources, in terms of the number of researchers, and in terms of publications.[12] Evaluations of the financial costs of scientific cancer research in France produced approximate figures from $600m to $700m[13] a year: approximately 50% of these amounts were funded by the French government, 20% by the pharmaceutical industry, 20% by nonprofits and 10% by the European Union (LAZEGA et al., 1999). Approximately 3000 tenured researchers worked specifically in that field and around one hundred laboratories of various national research institutions (such as INSERM, CNRS), and of generalist and specialized research hospitals.

[12] More generally, see KATZ (1994) about geography and scientific cooperation.
[13] Around 2000.

Further information about the advice networks within the researcher elite can also help set the stage.[14] They are very sparse, but also very centralized. The social system of French cancer research is very hierarchical. There is an oligarchy of *mandarins* who concentrate many resources in their hands.[15] Overall, at the dyadic level, only a third of the advice ties are reciprocated in these networks. Ties among the very senior and the very junior are very weak, so medium seniority researchers in this system are key.[16] We noticed, for example, an extremely sparse recruitment network (due to the existence of a strong and ritualised formal mechanism for recruitment at the national level called the *collégiale*[17]).

In terms of volumes of exchange of resources, there are very few differences between researchers who declare practising fundamental research as opposed to clinical or mixed research.[18] Clinicians declare relatively more contacts within the list (than outside the list) for discussions of new lines of research (59.5% *vs.* 41%), for advice on a paper before submission (72% *vs.* 55.5%) and for fundraising (34% *vs.* 23%). Working in a laboratory specialized in fundamental research (as opposed to being part of the world of hospitals) seems to reduce exchanges with members of the list with regard to seeking advice on recruitments, on raising funds, and on a manuscript before submission to a journal.[19]

The social world of respondents (HAGSTROM, 1965) is also characterized by the presence of former professors, peers or students. Past exchanges frame new ones in ways difficult to reconstitute. 43% of respondents declare that they recognize, on the

[14] Ninety three percent of the 128 respondents declared that they had discussed the orientation of their work with someone in the list (fundamentalists a little less than clinicians). Slightly less (87%) declare that they were sought out by members of the list for that same purpose. The elite of researchers thus constitutes a milieu in which discussions exist. During the previous twelve months, 56% of the elites had their drafts read by someone on the list before submitting. 84% of the interviewees also have discussions about the orientation of their work with researchers outside this list. Among them, 59% declare that their exchanges are more intense with members of the list than with researchers outside the list, which tends to confirm the quality of our research strategy and results. When focusing on the most instrumental forms of advice concerning researchers' work (recruitment, seeking the 'right' interlocutors to push one's project, seeking funds), responses show weaker reliance on other members of the elite than for the other kinds of resources. Half the respondents (51%) declares having received help from a member of the list to develop or push for a project. Around 35% of our researchers declare that they contacted someone on the list to find an interlocutor in a research organization different from their own. One fourth of the respondents only sought out a member of the list for recruitment purposes.

[15] On the relationship between oligarchy and the emergence of scientific disciplines, see HARGENS et al. (1980).

[16] See ZUCKERMAN & MERTON (1972) and COLE (1979) about the importance of age and seniority differences. Concerning researchers, 40% exchange very little with the members of the list. Dominant factors here are homophily with regard to specialty, geographical proximity, and level of seniority in the profession.

[17] This *collégiale* is an official, national level body that matches candidates with tenured jobs and to which many, in our population, belong.

[18] Out of 128 respondents, 20 declared doing purely fundamental research (15.6%), 47 clinical research (36.7%), and 58 both fundamental and clinical research (45.3%).

[19] For other examples of the 'fundamental versus applied' divide in research, see for example JANSEN (1995).

list, a former professor or research director of theirs (a stronger proportion among clinicians who are more numerous on the list). Around a quarter recognizes a former colleague or someone with whom they were a post-doc. 47% of clinicians (*vs.* 34% of 'non purely clinicians') recognize a former student on the list. A third of respondents (35%) recognizes direct competitors of theirs on the list. This is less the case with purely fundamental researchers who consider that their direct competitors are not very often in France, and therefore not on the list.

At the level of laboratories, we find 'homophily' effects as well: laboratories doing fundamental research exchange more with laboratories of the same specialty, the same institutional affiliation, but not the same geographical location (there are several alliances between the different kinds of *provinces* with different Paris institutions, a fragmentation that can sometimes be misread, at the aggregate level, as a pure 'Province against Paris' effect). The laboratories that are the most active in the inter-organizational exchange networks are also those in which we find the most prominent researchers (i.e., the researchers with the highest impact factors).

French cancerology is thus strongly hierarchical and structured around familiar divides: specialties, clinical *vs.* fundamental, etc. It is not the purpose of this paper to analyse in detail each network separately. We use this background knowledge of the milieu to select appropriate independent variables for modelling performance.

Results

To test our hypotheses, we look at the determinants of performance of individual researchers who were members of the elite of cancer researchers in France at the time. Table 1 provides the basic statistics for the variables used for this test. Table 2 provides the analyses of our data with respect to this linked-design multi-level approach.

Model 1 shows, as predicted, that the social capital of the organizational unit is more important in explaining individual performance of the organization's members than the personal relational capital of these members. In particular, indegree centrality in the networks of inter-laboratory exchanges[20] has a significant effect on productivity whereas indegree centralities of individual researchers in the advice networks of the elite of researchers do not have any significant effect. In our data, the competitive advantage obtained with one's own individual social capital does not exist at all.

[20] There is a need to be careful here. Laboratories working closely with industry may patent their molecules before they publish them, sometimes years later. Controls for patents should be added here to check the robustness of this result; however we did not have access to this data. In addition, out of 93 respondents, 47 had a personal network (among the other elite of researchers) in which there was no overlap whatsoever with the network of their laboratory (i.e. the network of their laboratory as identified by the director of their laboratory). Thus, their laboratory has resources that they may not use directly, although he/she may benefit from these resources indirectly in terms of impact factor.

Results are the same whether one considers outdegree centralities or indegree centralities for individual researchers (model 1 and model 3), or when one considers only indegree centrality in the network of the elite of researchers that seems to be the most important: sources of advice on manuscripts before journal submission. Size of the laboratory is controlled for because it is strongly correlated with "fundamental research", which is included in the model.

Two control variables linked to specialty were also useful. The strong effect of haematology shows that long term institutional investment in a specialty plays an important role in explaining individual performance. Indeed, haematology was (and still is) very developed in France.[21] The same is true with practising fundamental (as opposed to more clinical) research, but this effect should be interpreted more carefully because fundamental research is often said to weigh more in impact factor accounting.

These results are consistent with our ethnographic knowledge of the milieu. For example, the top 40 elite researchers (impact factor above 75) do more fundamental research than the other members of this elite (i.e., in laboratories with less connection to clinical research and hospitals). They work in haematology more than in the other specialties (solid tumours, for example). More than other interviewees, they are members of editorial boards of scientific journals, less so of ethics committees and other scientific councils of non-profits. They have indegree centralities which are on average higher than that of the others in this population. This is especially the case in the discussion network where researchers define their new lines of research. In turn, they seek advice less than others in all the networks examined. They are slightly more cited than others for having been professors, post-docs or colleagues of all interviewees. They tend to work in bigger laboratories that attract more funding from non-profits, from European institutions, less so from private industry.[22]

[21] As already mentioned, French haematology has represented a prestigious tradition for several generations. During the 1980s, this specialty was the first to use, in France as in many other countries, the new techniques of molecular biology and genetic engineering. This enabled it to dominate, at the time of the study, French cancer research. Haematology may have seized these new techniques before other specialties did because it was technically easier than for specialists of other organs (blood cells were more easily available, for example), but also because it was a very structured milieu characterized by a specific social discipline. There is no strong proof of this hypothesis because we lack sufficiently rich data on social discipline in this milieu, but this result tends to confirm other convergent results associating social discipline and performance among haematologists (LAZEGA et al., 2004). The capacity to learn and use collectively, and very quickly, these techniques may in itself be linked to this specific social discipline and the ability it gave to the members of this specialty to both compete and cooperate in a productive way for several generations. This effect is more structural than simply circumstantial and/or typically French. Haematologists and immunologists have often been at the avant-garde of methods. They were therefore in a position to get ahead and publish important paper at the time. For a more general approach to the construction of disciplines, see LEMAINE et al. (1976).

[22] Again, in France, at that time, funding from pharmaceutical companies usually meant lower impact factors, perhaps because results from such studies were patented before they were published.

Table 1. Mean, standard deviation and correlations between variables of Table 2

Variable	Mean	SD	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1	63.53	34.2	0.39	0.06	0.10	0.09	–0.00	–009	0.27	0.12	0.20	0.23	0.00	0.16	–0.12	0.12	0.04	–0.19	–0.07	–0.03	0.04	–0.17	0.33	–0.06	0.00
2	2.49	2.08	1	0.09	0.14	0.01	0.06	0.01	0.30	0.02	0.13	0.19	–0.07	–0.02	0.08	0.15	0.02	–0.22	0.03	–0.06	0.01	–0.03	0.05	–0.07	0.11
3	5.43	5.28		1	0.49	0.33	0.51	0.40	0.50	0.20	0.21	0.32	0.15	0.17	–0.07	–0.08	0.11	0.00	0.16	0.01	–0.09	0.12	0.06	–0.08	–0.13
4	1.10	1.66			1	0.38	0.45	0.35	0.30	0.31	0.06	0.24	0.15	0.04	–0.10	–0.15	0.15	0.06	0.04	–0.07	–0.11	0.11	0.15	–0.08	–0.10
5	0.30	0.64				1	0.39	0.19	0.30	0.20	0.17	0.23	0.05	0.13	–0.10	–0.11	0.05	–0.00	–0.01	–0.00	–0.07	–0.02	0.16	0.03	–0.10
6	1.24	1.84					1	0.42	0.40	0.31	0.10	0.33	0.23	0.00	–0.08	0.07	–0.04	0.09	–0.01	0.03	0.00	–0.12	0.14	–0.18	–0.18
7	0.60	1.04						1	0.03	0.10	0.07	0.00	0.19	0.01	–0.07	–0.06	0.18	0.07	0.02	0.09	–0.11	0.08	–0.07	–0.10	–0.06
8	5.45	3.70							1	0.49	0.54	0.62	0.21	0.18	0.01	0.04	0.06	–0.06	0.16	0.01	–0.01	0.01	0.18	–0.03	–0.06
9	1.08	1.28								1	0.27	0.51	0.47	0.06	–0.05	–0.01	0.01	0.01	0.05	–0.05	–0.08	–0.06	0.07	–0.20	–0.01
10	0.31	0.70									1	0.46	0.08	0.15	–0.09	–0.07	0.12	–0.23	0.24	–0.12	–0.03	0.03	0.15	0.14	–0.10
11	1.22	1.35										1	0.36	0.17	0.01	–0.05	0.11	–0.16	0.24	–0.06	–0.05	0.01	0.12	–0.04	–0.12
12	0.59	0.89											1	0.09	–0.14	0.03	–0.01	0.00	0.12	0.01	0.02	–0.09	–0.05	–0.11	0.02
13	0.69	0.46												1	–0.20	–0.26	0.34	–0.03	0.02	0.27	–0.42	0.03	0.35	0.20	–0.18
14	0.04	0.20													1	–0.08	–0.12	–0.09	–0.00	–0.08	0.12	0.12	–0.13	–0.06	–0.08
15	0.44	0.49														1	–0.14	–0.27	–0.18	0.11	0.30	–0.02	–0.11	–0.19	0.05
16	0.26	0.44															1	–0.13	0.19	0.35	–0.22	0.18	0.10	0.16	–0.05
17	0.47	0.50																1	–0.07	0.48	–0.14	–0.03	–0.06	0.01	0.08
18	0.51	0.50																	1	–0.03	0.03	0.27	–0.11	0.14	0.04
19	2.11	0.97																		1	–0.17	0.06	0.04	0.12	–0.02
20	0.46	0.50																			1	–0.01	–0.43	–0.20	0.09
21	0.45	0.50																				1	–0.46	0.18	0.16
22	0.27	0.45																					1	–0.10	–0.26
23	0.08	0.28																						1	–0.02
24	0.15	0.35																							1

Table 1 (cont.)

Variable number	Variable label
1	Scores based on impact factor
2	Global indegree centrality in inter-laboratory network
Personal network resources	
3	Advice for selecting a line of research (outdegree)
4	Advice on manuscripts before journal submission (outdegree)
5	Advice on recruitment (outdegree)
6	Advice for finding key contacts to develop project (outdegree)
7	Advice on fundraising (outdegree)
8	Advice for selecting a line of research (indegree)
9	Advice on manuscripts before journal submission (indegree)
10	Advice on recruitment (indegree)
11	Advice for finding key contacts to develop project (indegree)
12	Advice on fundraising (indegree)
Human capital and Formal status	
13	MD
14	PhD in Pharmacy
15	PhD in Sciences
16	'Agrégation'
17	Other diploma
18	Laboratory director
19	Number of diplomas
Specialty	
20	Fundamental research
21	Solid tumours
22	Haematology/immunology
23	Surgery
24	Public health

Notes:
a) Variables 3, 4, 5, 6, 7, and 8, 9, 10, 11, 12 are not used in the same models.
b) There is a correlation above 0.5 between variables 3 and 6, 9 and 11, 8 and 11, and 8 and 10. After testing for multicollinearity effects, we chose to keep them jointly in the same models because their presence does not bring interesting changes in the value of the parameter estimates.

Table 2. ***It does matter where you are***
Variables of different levels and their effect on scores based on impact factors of publications by elite French cancer researchers (1996–1998)

Independent variables	Model 1		Model 2		Model 3	
Intercept	27.16	(14.12)	23.03	(13.75)	23.95	(14.05)
Laboratory's network characteristic						
Global indegree centrality in inter-laboratory networks	**5.73**	**(1.67)**	**5.86**	**(1.58)**	**5.27**	**(1.73)**
Researcher's characteristics						
Specialty						
Fundamental research	**17.75**	**(8.42)**	**19.20**	**(8.09)**	**18.41**	**(8.30)**
Solid tumours	0.05	(8.61)	3.12	(7.99)	1.89	(8.32)
Haematology/immunology	**29.04**	**(10.72)**	**30.56**	**(9.89)**	**28.42**	**(10.44)**
Surgery	3.92	(12.88)	9.04	(12.49)	7.59	(13.01)
Public health	5.12	(9.86)	6.06	(9.37)	7.70	(9.64)
Human capital						
MD	10.01	(9.46)	9.50	(9.06)	8.63	(9.41)
PhD Pharmacy	–15.93	(17.85)	–16.64	(17.14)	–17.87	(17.83)
PhD Sciences	5.30	(9.29)	2.72	(8.88)	2.99	(9.21)
Agrégation	–0.54	(9.83)	–0.47	(9.25)	–0.51	(9.43)
Other diploma	–2.14	(10.55)	–3.88	(9.99)	–3.20	(10.43)
Total number of diplomas	–0.51	(5.46)	–0.18	(5.22)	–0.10	(5.32)
Formal status						
Lab-director (*vs.* researcher)	–4.87	(7.13)	–6.03	(6.84)	–7.60	(7.25)
Personal network resources						
Discussion of line of research (outdegree)	0.52	(0.81)				
Advice on manuscripts before journal submission (outdegree)	1.00	(2.62)				
Advice with recruitment (outdegree)	2.44	(5.79)				
Advice for finding key contacts to develop project (outdegree)	–2.86	(2.44)				
Advice about fundraising (outdegree)	–0.74	(3.79)				
Discussion of line of research (indegree)					0.30	(1.33)
Advice on manuscripts before journal submission (indegree)			3.42	(2.55)	1.85	(3.39)
Advice with recruitment (indegree)					0.78	(6.01)
Advice for finding key contacts to develop project (indegree)					2.96	(3.43)
Advice about fundraising (indegree)					–1.72	(4.38)

Unstandardised parameters (standard deviations in parentheses). In Model 1, centralities in inter-personal networks are outdegrees and n=93. In Models 2 and 3, centralities in inter-personal networks are indegrees and n=93. Adjusted r^2 are respectively 0.20, 0.23 and 0.20. Some variables (such as specialty of the lab) were taken out of the model because of strong colinearity with other variables already taken into account (such as specialty of the researcher). In particular, size of the laboratory is controlled for through "fundamental research" with which it is strongly correlated.

In contrast, kinds of human capital do not make a difference here for explaining individual performance. At least among this group of elite cancer researchers, it does not matter whether these individuals are MDs, PhDs or MD-PhDs.[23]

Discussion and conclusion

At the end of the 1990s, cancer research in France was organized as a formal and complex institutional apparatus. Our data and analyses show that within this apparatus, an inter-organizational network of laboratories and an interpersonal network of an elite of researchers established a multi-level and informal exchange system of many kinds of resources (personnel, information, technology, tissues and other 'raw materials', various forms of personal advice, contacts, etc.). This exchange system contributes to organizing scientific activity in the field. Presumably, this highly competitive milieu, in which actors nevertheless depend on each other to some extent, would not be able to reach this level of performance without this informal and multi-level exchange system.

Our goal was to look at the extent to which success in publishing papers in highly visible journals can be explained by the researcher's personal network among the elite of other researchers, or by the characteristics of the laboratory and its position in the exchange system of laboratories. The issue is the measurement of the relative contribution of each level to actors' achievements. Our main results confirm both our hypotheses: the centrality of laboratories in the inter-organizational networks of laboratories matters more than researchers' centrality in the inter-personal network of the elite of cancer research in France between 1996 and 1998. The social capital of the organizational unit to which the individual member of this elite belongs is indeed more important in explaining individual performance of an individual researcher than his/her personal relational capital, controlling for human capital. It does matter where one works, regardless of whether one has personal connections in a stimulating environment that stresses status competition.

We may perhaps speculate beyond our data and suggest that corporate social capital (investments in the organization sometimes over several generations) matters more than the researcher's personal social capital for impact factor performance. It is the main

[23] As mentioned above, our linked design provides an approach to the multi-level character (personal and organisational) of performance that is different from standard multi-level analysis. We nevertheless introduced interaction effects in the models to test for the robustness of the effects obtained. The interaction effect between personal and organizational levels was approximated by the interaction between centrality of the laboratory and overall centrality of individuals across the five advice networks (i.e., a variable composed of the sum of outdegree – then indegree – centrality scores for each individual in all five networks). Results confirm the robustness of the models provided in Table 2. The interaction effect per se is very weak and the parameter estimate does not reach the threshold of twice the value of the standard error in any of the three new models. The main strong effects identified above remain strong and no new strong effect emerges from these controls. Results including interaction effects are available from the authors upon request.

factor carrying individuals – who are, at some point, at the top of their profession – to the top of the top. In our view, this result should encourage multi-level and contextual examination of scientific activity. It suggests the existence of a special level of appropriation, accumulation and stable sharing of multiple resources. In inter-organizational networks, such a level remains difficult to reconstitute in standard multi-level reasoning and measurement.

This main result may be surprising to many specialists of social capital who correlate individual performance with various forms of structural variables without taking into account the collective action dimension of the environment in which these individuals work.[24] But even individual performance depends on collective action, as it often depends on socio-technical characteristics of one's activity (COMET, 2004).

Although this result is robust, it is limited in several ways. Firstly, we lack data that would be needed for deeper understanding of the various kinds of complementarity of individual and organizational resources that help build multi-level social processes that, in turn, lead to performance and visibility. Without longitudinal data, it is difficult to see how the centrality of the laboratory in the inter-organizational network, and that of star researchers, build on one another (or not). Individual and collective action are strongly intertwined, but without dynamic data, our research may miss some of the processes in which individual social capital matters much more for individual performance than it did in this case.

Secondly, we showed that the position of the laboratory in the inter-organizational network counts more heavily (for reaching the higher impact factors), in this case, than the individual researcher's position in the elite of researchers in his/her discipline. However, this result raises immediately the question of how these researchers managed to get into such central laboratories in the first place. This issue can only be examined through data on careers and trajectories through this milieu. Individual and personal networks – following WHITE (1970) and many others since – may matter upstream of collective action (and upstream of socially-constructed individual performance) by simply helping select the individuals who will benefit from that kind of membership. To overcome such shortcomings, much remains to be done.

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[24] See about the relationship between social capital and performance FLAP et al. (1998).

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