Network Lift from Dual Alters: Extended Opportunity Structures from a Multilevel and Structural Perspective

Emmanuel Lazega, Marie-Thérèse Jourda, Lise Mounier

Network Lift from Dual Alters:
Extended Opportunity Structures from a Multilevel and Structural Perspective

Emmanuel Lazega, corresponding author
Institut d'Etudes Politiques de Paris, CSO-CNRS
emmanuel.lazega@sciences-po.fr

Marie-Thérèse Jourda
CEPEL-CNRS, Montpellier
marie.jourda@univ-montp1.fr

Lise Mounier
CMH-CNRS, Paris
lise.mounier@ens.fr

Abstract:

This paper uses multilevel network analysis to identify an extended and latent opportunity structure for actors dually positioned in both intra-organizational and inter-organizational networks. This extended opportunity structure combines actors' direct ties with indirect ties that they can add to their own network by 'borrowing' some of their boss's two-path contacts. We call 'dual alters' contacts that can be reached through this multilevel path with help (or absence of obstruction) from such 'embedded brokers'. We test the specific effect of this extension on actors' performance using a dataset derived from a multilevel study of the elite of French cancer researchers (1996-2005). We find a significant effect of this extension on members' performance when dual alters provide complementary resources, thus providing proof of a 'network lift from dual alters' presence in the focal actor's network. Network lift allows sociologists to measure the extent to which performance measured at the individual level depends in a complex way on the multilevel and combined characteristics of the intra- and inter-organizational context in which individuals belong. We believe that this measurement of latent and extended opportunity structures will help meso-level sociologists in their approach to social processes and inequalities in the organizational society.

Keywords: Multilevel network analysis, fish/pond design, embedded broker, dual 3-paths, tacit learning networks, performance.

Emmanuel Lazega is professor of sociology at the Institut d'Etudes Politiques de Paris and a membre of CSO/ORIO-CNRS. He uses network analyses combined with other methodologies to explore meso-social processes characterizing collective action.

Marie-Thérèse Jourda is a research engineer at CEPEL-CNRS, Montpellier, specialized in quantitative methodology applied in the social sciences. Her research projects focus on social network analyses, public policies and cultural policies.

Lise Mounier is a senior research engineer, a membre of the CMH–CNRS, Paris, working in the field of social networks and organizations.

Network Lift from Dual Alters:
Extended Opportunity Structures from a Multilevel and Structural Perspective

Introduction

The fundamental question of the influence of social structure on behavior and performance of actors has been examined with renewed interest in recent decades thanks to the development of structural sociology and the analysis of social and organizational networks, particularly from a multi-level perspective (Snijders and Bosker, 1999; Kozlowski and Klein, 2000). Network data help model opportunity structures in new ways (White et al., 1976; Burt, 2005). In particular, new approaches to "duality" in social life, i.e. co-constitution of individuals and groups initially measured by bipartite or two-mode networks (Breiger, 1974), have enriched this multilevel perspective. These approaches complement rather than compete with more established hierarchical linear modeling (Bryk and Raudenbush, 1992), especially by taking into account new elements in the definition of opportunity structures. They usually observe two or more systems of superposed and partially interlocked interdependencies, at the same time inter-individual and inter-organizational, and provide several formalisms (Wilson's, 1982; Fararo and Doreian, 1984; Snijders and Baerveldt, 2003; Lubbers, 2003; Robins et al., 2005; Van Duijn, 2006; Wang et al., 2012) that craft a formal theory of interpenetration of distinct entities such as individuals and groups. Various modes of articulation for the different levels have thus opened new avenues for research in that area, exploring, for example, meso-level networks (Hedström et al. (2000) or "linked design" networks (Lazega et al., 2008).

In this paper we further explore the possibilities offered by multilevel network analysis. We argue that it can develop sociologists' understanding of opportunity structures. As each level of agency constitutes a system of exchange between different resources that has

its own logic and processes (Lazega, 2012), it is important to examine both levels separately and jointly. Joint study allows us to identify opportunity structures and the actors that benefit from relatively easy access to the resources that circulate at each level, and also to measure their relative performance; but also situations in which the interplay between the levels has less positive effects for the actors. We suggest that the knowledge of multi-level interdependencies, and additionally of the manner in which actors manage theses interdependencies at each level, adds an original dimension to multi-level reasoning and to meso-level exploration in sociology.

We use the "linked design" approach because we think that dual-positioning individual actors (in the network of their inter-individual relationships and in the network of relationships between the organizations to which they belong, i.e. in which they are affiliated) facilitates identification and measurement of 'extended' opportunity structures. This in turn leads to specific hypotheses concerning the relationship between position in these complex multilevel structures, strategy, and performance (measured at the individual level). The term "strategy" refers here to the fact that actors manage their interdependencies at different levels by appropriating, accumulating, exchanging and sharing resources, both with peers and with hierarchical superiors or subordinates.

Determinants of performance are widely examined in the social network literature (see Flap et al., 1998, or Quintane et al., 2012, for example). Our way of presenting the problem of contextualizing action and actors' performances echoes the preoccupations of organizational sociologists who reason in terms of individual and collective social capital (Leenders and Gabbay, 1999; Hsung et al., 2009). Our purpose is equivalent to addressing the difficult question of the integration of different levels of analysis in which they situate social capital. For this, we extend Burt's (1992, 2005) work on 'borrowing' social capital in a new way. With respect to the link between individual social capital and performance, Burt's theory is

that, in social settings in which individuals compete, performance increases when actors have dense ties within their workgroup and high brokerage scores beyond the group. In particular, his work shows that members benefit from brokerage and structural holes unless they are in a highly dependent and dominated situation, in which case they can try to borrow someone else's (a champion's, a mentor's) relationships to reach the same levels of performance as their average competitors. Borrowing social capital can be an efficient strategy for members who suffer from a lack of legitimacy (for example women in a male-dominated organization): it consists of benefiting from a colleague's or a superior's support through a use of the latter's network, a kind of support that leads to an increase in work performance.

Based on this perspective, we propose to observe extended opportunity structures, as defined above, by focusing on actors' multilevel relational strategies of borrowing contacts from their boss's network. We identify a specific kind of borrowing effect on performance, an effect originating in the multilevel dimension of the structure, and we call it 'network lift'. This borrowing can be considered an outcome of a specific mechanism of 'embedded brokerage' in the sense that it is provided by hierarchical superiors who act as bridges embedded in the inter-organizational networks. For embedded brokers, embeddedness in a relatively closed inter-organizational network lowers the risks of building bridges between subordinates compared to the risks taken by brokers, for example, in open markets. We measure the role of specific kinds of actors' indirect and potential contacts provided by such embedded brokers. We call these contacts 'dual alters' and argue that they have an important and specific role in shaping this lift effect, i.e. in creating a focal actor's latent, multilevel and extended opportunity structure.

We carry out this approach using a dataset, collected by Lazega et al. (2008), in the sociology of sciences that measures the networks of an 'elite' of French cancer researchers in 1999-2000, examined at both the inter-individual and the inter-organizational levels. In itself,

the study of "elites" is not new in the sociology of science or in network analysis (see for example Zuckerman, 1977 or Hargens et al., 1980). In particular, several studies about complete networks of scientists or laboratories have been presented before, beginning with the pioneering work of Mullins et al. (1977). Jansen (2004) provides a literature review. But this dataset is particularly suitable for the purpose of analyzing performance in relationship with extended opportunity structures.

The article is organized as follows: we first discuss the notion of extended opportunity structure and the role of hierarchical superiors and dual alters in shaping it. We then hypothesize that the richer members' dual alters are in complementary resources, the higher these members' performance. The dataset used in the analyses is then presented: it is focused on tacit learning networks among scientists and the complex determinants of their performance. A model is fitted to measure the effect of access to such dual alters on actors' performance. New descriptive analyses are provided to illustrate and interpret these results. Finally we explore the limitations of our approach and suggest further developments.

Borrowing social capital from hierarchical superiors as embedded brokers

Extending Burt's idea of borrowing social capital, we focus specifically on the actor's own hierarchical superior as the strategic partner who can sponsor, in our case indirectly, the actor's access to resources. Here actors and ties are nested within organizational units but the ties can also be among actors of different organizational units. From this perspective, borrowing relational capital is seen as a complex social process that provides performance with a collective dimension even when it is measured at the individual level. Actors have a complex inter-individual network at the personal level combined with an equally complex inter-organizational network at the collective level; the latter is based on affiliation ties or

personal ties with managers (hierarchical superiors) who themselves have ties in other organizations across the boundaries of their organization. We aggregate the two networks and treat the 'extended' network as a latent, meso-level structure adding actual and indirect relational capital for the focal individual members. The linked-design allows analysts to look at the extent to which extended relational context adds an extra effect on performance by providing this indirect potential social capital for these individual members. This extended context can either increase, i.e. lift, or maintain, or decrease members' individual performance. The expression 'lift' is meant to signify that an increase is partly traceable to the multilevel dimension of the system.

We call dual 3-path (or tetradic) the chain of ties that create, at the aggregate level, this extended context. Figure 1 visualizes this chain.

-Figure 1 about here-

We call i actors (i.e. respondents in the empirical research), their observed direct contacts j, and dual alter k their indirect potential contacts accessible through the embedded brokerage by their managers. Dual alters are the induced, indirect contacts that are part of a focal actor i's relational capital via such substructures. This organizationally extended network is constructed by adding to the observed network of actors i all the indirect ties k that i can access through their manager and through the manager's ties to other managers at the inter-organizational level. We assume that this potential can be more easily realized than creation of ties from scratch by individual actors, provided that members and managers get along reasonably well within the context of cooperation in their organization; and provided also that managers see the value for their organization of helping their members in accessing new resources through their inter-organizational ties. Realizing this potential is equivalent to

closing a complex and multilevel 3-path, thus reaching potential collaborators leading to complementary resources. Closing this dual 3-paths means adding dual alters that one can reach through one's boss's network. Dual alters are thus equivalent to Burt's borrowed contacts generated by Breiger's duality.

Borrowing relational capital, however, is a complex social process that provides performance with a collective dimension even when it is measured at the individual level. In that sense, this complex process adds a new effect to the effects already taken into account in the literature on social capital based on measurement of the relationship between networks and performance. Firstly, variations in kinds of contacts are important. Thus it may be relevant to identify indirect contacts k that vary in terms of wealth: some have many resources to share, as distinguished from others who are poorer contacts with less resources to share.

Secondly, variations in kinds of resources exchanged also matter for identifying such effects. The value of the observed and potential relational capital depends on the nature of the task to be performed. This presupposes that the expanded network must be specified resource by resource. In an environment in which actors behave strategically, the issue of the relative utility of their contacts' resources is also an appropriate one. The expanded network may or may not provide each member with access to complementary sources of resources. The network lift effect is relative to the utility of the resources of the indirect contact. These complementary sources may be useful or not useful with respect to providing resources that ego does not already have. In the case of social capital that is managed in a tightly organized environment, it may thus be relevant to distinguish resources of rich contacts k that are complementary to that of i from resources of rich contacts k that are redundant with resources already available to i. Network lift can thus be thought to be provided by complementary resources borrowed from rich dual alters. Given this link between relative utility and network lift, a network of indirect ties that provides non-complementary resources, i.e. 'more of the

same' in terms of resources, should be an inter-organizational network that does not provide lift in the sense that it does not carry the individual and increase his/her performance.

Hypothesis

Based on this discussion of social capital focusing on dual alters as indirect and potential sources of performance in the extended network accessible through the inter-organizational level of agency, we expect the following in terms of shaping a latent extended opportunity structure: *Controlling for the effect of direct contacts, the richer members' dual alters are in complementary resources, the higher these members' performance*. Assuming that members get along with their hierarchical superiors who will broker their access to indirect contacts, and assuming that these indirect contacts are willing to share their complementary resources, these contacts' help should be identified as a specific source of members' performance increase over time, i.e. network lift.

The hypothesis that actors may benefit from such a network lift by access to dual alters is not a surprise in itself for social scientists who have long argued that position in the structure has an effect on behaviour and performance. But our approach adds a new multilevel dimension to opportunity structure, as well as methodology and data for their measurement. We can thus measure, for example, the specific effect of indirect social capital potentially provided by hierarchical superiors embedded in inter-organizational networks.

A case of tacit learning networks among scientists across laboratories

We explore the value of this extended network for individual performance under these conditions in a study of an 'elite' of cancer researchers in France (1999-2000). A detailed

presentation of this dataset can be found in Lazega et al. (2008) who measure the critical importance of resources directly provided by the organizations to their members in explaining the latter's performance. Evidence for the existence of a 'network lift from dual alters' effect is based on measurement of the multilevel networks and performance levels of these scientists over ten years (1996-2005). This dataset is well suited for measurement of the extended opportunity structure because it includes and combines inter-laboratory networks, inter-individual networks within a specific subpopulation of scientists in that field, and performance variations. Performance is measured by impact factor scores (IF) –a measure of a scientific journal's impact, based on citations to its articles. Each researcher's performance was measured at the individual level by assigning to each of his/her publications the IF score of the journal in which it was published, and then by summing across all publications.

Respondents belonged to five broad specialties: first, diagnostic, screening, prevention and epidemiology (a set of disciplines which will be pooled below under the label 'epidemiology'); second, clinical research without fundamental research; third, clinical and fundamental research in haematology-immunology; fourth, fundamental research focused on pharmacology; and fifth fundamental research in molecular/cellular biology or genetics. At the time of the study, haematology-immunology was the dominant specialty in cancer research in France, following generations of investments in the study of leukemia by French researchers who were among the first to learn and apply collectively the methodologies of molecular biology, with a visible effect in their performance measurements. However, if the latter specialty had the highest IF scores, (at the time, its scores were no longer increasing. At the same time, another specialty was making new progress: diagnostic, screening, prevention and epidemiology had increasing IF scores, a sufficiently strong collective development for a visible effect in their performance measurements.

The networks of interdependencies among laboratories and among scientists in France at the time were reconstituted during face to face interviews. First, the inter-organizational networks between the majority of laboratories engaged in cancer research; second, the advice networks, i.e. networks of access to tacit knowledge, constructed by members of the "elite". This was done in the following manner. At the individual level, each researcher is considered a "scientific entrepreneur" who needs resources that may be social or monetary. From the individual researcher's point of view, scientific research may be analytically broken down into a sequence of five steps, each characterized by a strong degree of uncertainty: selecting a line of research, finding institutional support, finding sources of financing, recruiting personnel, and publishing articles. At each step, one must suppose that the researchers depend upon their relational capital and that they seek advice from other members of the research community in order to handle these uncertainties. In this competitive and uncertain environment, access to advisors is an important resource because carrying out these tasks is facilitated by access to advice offered by competent colleagues who agree to help. Five advice networks were thus reconstituted, one for each of these five steps.

At the inter-organizational level, systematic data about inter-laboratory networks and about laboratories characteristics was also collected. The laboratory directors indicated with which other laboratories, among those in France practicing cancer research, their laboratory exchanged different types of resources. The list of reconstituted transfers and exchanges includes the recruitment of post-docs and researchers, the development of programs of joint research, joint responses to tender offers, sharing of technical equipment, sharing of experimental material, mobility of administrative personnel, and invitations to conferences and seminars. The complete inter-organizational network examined here is the aggregated and dichotomized network of all these flows; dichotomization created a tie between two actors if there was at least one tie between them in one of the aggregated matrices.

At the inter-individual level, the five advice networks are aggregated and dichotomized to reconstitute a complete network of 126 researchers and of density 0.06 with average degree 8.8. Likewise, the inter-organizational network of 82 laboratories reaches a density of 0.04 with average degree of 6. The number of cases in which the director of the laboratory and the researcher i answered the organization-level questionnaire and the individual-level questionnaire respectively, is 93. We use the characteristics of i, j, and k over two periods of time: four years before the measurement of the networks (1999-2000) and five years after these measurements. The effect we are mostly interested in is the effect of characteristics of indirect ties k on i's performance. Specifically, we create two kinds of articulation between the individual's network and the organizational network.

First we measured the status of the actor and the importance of their organization using his/her centrality in the advice network of this population. Centralities used here are indegrees (incoming ties) and outdegrees (outgoing ties). This provides a uniform basis for the interpretation of our results. The status of the organization is measured by three criteria: its indegree centrality in inter-organizational networks, the indirect resources to which its members declare having access (its outdegree), and its size. This produces an endogenous partition of the population into four classes that are baptized metaphorically for a more intuitive understanding of this dual positioning. Class 1 actors cluster the Big Fish in the Big Pond (BFBP), class 2 the Big Fish in the Small Pond, class 3 the Little Fish in the Big Pond, and class 4 the Little Fish in the Small Pond. The construction of the four classes positioning actors at the meso level used the following median values thresholds: in order to be considered a Big Fish in a Big Pond, the researcher's indegree centrality must be higher than 5.2, that of the laboratory higher than 2.75; the laboratory's outdegree must be higher than 2 and its size higher than 26 researchers. The same thresholds are used for the three other categories (Big Fish in a Small Pond, etc.). Given the high number of internationally visible

12

publications used to select this population, even the researchers that we call "little fish in little ponds" are researchers at an exceptional level. Consistent with Lazega et al. (2008), performances are not considered as simply floating on the extended networks of individuals, but as supported also by the status of their organizations.

We then create a second combination of the individual network and the organizational network by identifying for each individual actor: 1) His/her contacts j who are both his own personal direct contacts and persons who belong to the organizations with which his/her own organization has inter-organizational ties; and 2) His/her dual alters k who are reachable through the managers of their organizations who could provide access to new and complementary resources.

The dependent variables used here to test our hypothesis are IF scores in period 2. Independent variables include, for each actor i, j, and k their specialty as identified above and class derived from centralities (BFBP, etc) and size. In this case, k's centralities are measurements of k's wealth with respect to various resources: k is rich if his/her centrality is above the mean of outdegrees of j, which is very selective.

Results

To test our hypotheses we look at the effect of rich k contacts[1]. All members do not benefit in the same way from indirect ties and managers' ties do not represent all the relational possibilities offered by the organization; peers can also broker ties to new contacts. However, sharing relational capital is part of a manager's job and observing this potential represents a good start for specifying network lift as a specific organizational effect on members' performance. For the purpose of this paper, we will remain at the level of the

---

[1] An online document –a companion to this paper on the site of the Journal– provides a visualization of this effect.

structure and average across all members to look at the pattern of the new extended network and its effect on members' performance.

Table 1 presents the results of the final regression models computed for this purpose. The dependent variable is the researcher's performance in time T2. Researchers' characteristics are measured in time T1 and may have an effect on performances in time T2. In these models we only look at researchers i who have dual alters in Model 1 (n=93) and at researchers who have rich dual alters in Model 2 (n=58). Effects are sorted based on characteristics of i, j, and k. Recall that, based on our hypotheses, all researchers with dual alters do not necessarily have a high performance. Here epidemiology includes diagnostic, screening, prevention and epidemiology proper; Clinical research is separated from fundamental research; Clinical and fundamental research are mainly combined within haematology-immunology (at the time of the study); and Fundamental research can be either focused on pharmacology or use molecular/cellular biology or genetics.

- Table 1 about here -

Results show that rich indirect contacts k matter in our population's performance levels. After selection of the richest dual alters k, i.e. taking out of the analysis all dual alters that are below the threshold level (i.e. above the mean of j's outdgrees), the usefulness of these k contacts for researchers' performance level comes to light –at least for the actors/researchers who can take advantage of the existence of these indirect contacts. In this Model, the more actors have LFBP in their direct contacts, the less they have BFLP in their direct contacts, the more they have rich indirect contacts in epidemiology, the higher their performance in period 2. LFBP have low performance levels during the first period, but these levels increase during period 2 thanks in part to these dual alters whose performance is high

and can be shared in co-publications. This confirms that for actors' performances to improve, they need to count on rich potential resources (dual alters) that are complementary to their own and to that of their direct contacts.

Performances of j during the second period, as independent variables, are never significant perhaps because they were already used in the previous period. The performance of these resources is perhaps no longer the same at time t2. In contrast, dual alters' performances do lift members' performances controlling for variables that routinely explain variations in returns on investment in social capital. As will be shown by Figure 2 below, researchers i with access to high performing dual k are not necessarily those whose performances are the highest. Interpreting this result seems to require a closer look at the evolution of the performances of these researchers so as to provide interpretations that are different for different sub-populations. In the next section we identify six groups of researchers for whom these lifting effects of dual alters, whenever present, can have different explanations.

Reintroducing the content of the network to explain the relative contribution of each network is thus highly illuminating because it helps with differentiating extended networks and dual alters that provide new and complementary resources from networks that provide redundant "more of the same" resources.

Interpretation and illustration

One important aspect of the specific effect of the mechanism of embedded brokerage on performance highlighted by this analysis is the complementarity of researchers' specialties. Here we measure complementarity as the result of two requirements: firstly, focal actor's resources in a group that are below the mean; and secondly alters' resources for this group

must be above the mean ; if they are not, resources are considered redundant and unhelpful in terms of providing network lift. In other words, as measured here, complementarity is not a purely individual variable but a measure of redundancy or non redundancy of resources at the level of performance groups. For example, in this case and at that time, performance levels increased when focal actors were clinical researchers contributing to fundamental research in haematology, directly in contact with fundamental researchers specialized in molecular biology, as well as indirectly in contact with researchers in epidemiology (including diagnostics, screenings, and prevention -the hot specialties at the time of the study, i.e. making real progress in terms of impact factor scores at the end of the 1990's).

The importance of complementarity of resources can be teased out of the data by identifying different performance groups in the population and y looking at the relative utility of resources provided by j and k in such groups. Analyzing the evolution of performances at the individual level for all researchers in our population, we are able to cluster these researchers into six groups of performance, i.e. six categories of evolution of such performances over ten years. In effect, in order to better understand the effects identified in the models above we calculated for each researcher his/her "career" of IF score between 1996 and 2005 and his/her position compared to the annual average of all IF scores. We also calculated the evolution of this score as compared with the evolution of this mean in the first and the second periods. Figure 2 presents these evolutions for the six groups of performance identified by this analysis.

-Figure 2 about here-

Group 1, the 'top of the top' in terms of performance, are always above average and progressing towards the top over time. Group 2 are also above average during the two periods

but they do not make much progress. Group 4's performances decrease: they start above the mean in period 1 and are below in period 2. Group 3 start below the mean in period 1 but are in the amazing position to try to catch up with Group 1 in the second period. Group 5, although they remain below the mean in both periods, make progress during the second period. Group 6 performances are below the mean in period 1 and decrease even further during period 2.

In the following Figures 3.1 to 3.3 we compare outdegree centralities, resource by resource, of the members of each performance group with that of their direct contacts and that of their dual alters. We focus on three contrasted groups –Groups 1, 3 and 4– in order to illustrate the effects of the latent and expanded network that is accessible through dual alters that are rich indirect k contacts, i.e. dual alters with high indegrees and high outdegrees (i.e. at least as high as the average j contact).

-Figure 3.1 to 3.3 about here-

Selecting among dual alters only those with indegrees and outdegrees equal or superior to that of the mean values for direct j contacts shows, for example, that Groups 1 (the top performers) had dual alters that are not complementary in the resources they provide. Group 1 members are quite atypical. Resources of their indirect contacts k are redundant, almost always below the mean. However, there is strong complementarity between their resources and that of their direct contacts, suggesting that they have already transformed their dual alters k into direct alters. Members of this group are not always very central overall but strongly supported and compensated by their direct ties. They select and use their direct contacts 'perfectly'. They seem to have 'filled up' already in terms of the contacts they need to carry out their work. Here, those who make progress are not the most central but those who have access to complementary social resources.

In contrast, Group 3 members, the "catchers up", who are not central, do have a few rich indirect contacts that are more resourceful and prestigious than they themselves and their direct contacts are. Weak centralities of i can be compensated by their j and k in two networks out of five. These indirect contacts can provide them with complementary resources with respect to Project, Funding, Recruitment and Manuscript reading. Group 3 members, mostly LFBP, are thus particularly helped by the centrality of their laboratory. Access to these dual alters is thus likely to have been helpful with respect to their performance increase. These are 'mixed' results: when they need it, these actors may count on a certain level of complementarity in the resources of their direct and indirect contacts. This tends to show that those who make most progress start low and have access to complementary resources to compensate for the lack of their own.

For Group 4, however, who have decreasing IF scores and among the lowest performance levels in the second period, lack of access to rich dual alters (with respect to Discussion, Project support, Recruitment and Manuscript reading) may have slowed down their progress. When Group 4 needed complementary resources, neither its actual contacts nor its dual alters could provide them. This Group counts on itself exclusively and thus do not benefit from network lift. Their extended network will not give them access to BFBPs who share, but perhaps access to BFBP who exploit. The case of Group 4 and 6 shows that our multilevel approach does not focus necessarily on situations in which the interplay between inter-organizational and inter-individual networks have a joint positive effect. It is complementarity between resources of the focal actors and resources provided by their dual alters that creates the joint positive effect for which we have found evidence.

In sum, the contribution of the extended network of dual alters is thus relative to the nature of resources that the actor already has in order to perform his/her tasks. In order to provide lift, the multilevel network must provide both dual alters and complementarity of the

resources that they make available. Examining centralities in each detailed kind of advice network at the inter-individual level helps in specifying the relative utility or contribution of the extended network. Figures 3.1 to 3.3 illustrate how an extended network including dual alters and providing complementary resources provides network lift and increases its members' performance levels. In contrast, an extended network providing non complementary resources, *more of the same* resources, does not provide network lift. We do not have enough observations in each performance group (12, 10 and 22 respectively) to replicate the above regression models (Table 1) for each one of them. With the abovementioned qualifications in mind, however, especially those related to relative utility and complementarity of resources, these descriptions are sufficient to identify and specify the network lift effect in the learning process among colleagues. The implication is that the network lift effect is unevenly distributed because actors have access, thanks to their hierarchical superior, to different kinds of dual alters providing either complementary or non complementary resources.

Conclusion

In this article, we have outlined a new, multilevel network approach to social capital that identifies an extended intra- and inter-organizational opportunity structure. This extended opportunity structure is created by a mechanism of embedded brokerage. We shows that it produces a 'network lift' effect on the performance of members of organizations in an inter-organizational system. Actors have a complex inter-individual network at the personal level combined with an equally complex inter-organizational network at the collective level; the latter is based on affiliation ties or personal ties with managers (hierarchical superiors) who themselves have ties in other organizations across the boundaries of their organization. We

aggregate the two networks and treat the extended network as a latent structure adding actual and indirect relational capital. Our analyses found empirical evidence confirming our hypothesis about the role of members' dual alters.

This is not a latent and extended opportunity structure that individual actors can always take advantage of on their own, without help from their hierarchy. Our multilevel approach thus confirms the existence of a relationship between 'borrowing' relational capital by any individual members, sharing relational capital by hierarchical superiors, and performance. Further analyses of this network lift effect also shows that it is unevenly distributed. It works under specific conditions of levels of resources of dual alters and complementarity of their resources in terms of relative utility for the focal actor. Even if individual performance is thus even less individual than previously thought, borrowing seems more complicated for some groups than for others, and the same kind of borrowing does not always have the same lift effects. For some, dual alters make a difference (suggesting the existence of a 'rich get richer through embedded borrowing' effect); for others, they do not.The advantage of the proposed approach is that it specifies and measures an organizational dimension of what has become a rather complex network determinant of performance.

Several limitations of our study of network lift can be reported at this point. First, the conditions under which, and the extent to which, individuals can rely on such a lift effect is still a matter of debate. As already called for by Snijders and Baerveldt (2003), the simple presence of a sufficient number of multilevel sub-structures in such complex dual opportunity structures will be tested only when adapted instruments are made available by statistical research (Wang et al., 2012) and when more knowledge is gathered about the intra-organizational relationships between members and managers of the organizations –i.e. unpacking the affiliation tie. Our purpose is not to put a positive twist on the old story about

French science as a system of '*mandarins*' in which powerful directors of laboratories control the access of their members to other researchers and to the environment, especially prevent their subordinate from going directly to someone working with or under another *mandarin*. Indeed further work should test the extent to which researchers go directly to colleagues (who happened to be dual alters) in whom they are interested, or whether managers introduce dual alters to their members, or whether the latter would have to go up to their own *mandarin* and s/he could (or not) put them in contact with the dual alter. Consistent with considering each level as a full-fledged level of collective action, our next hypothesis would be that, even when this system does not keep each researcher dependent upon his/her *mandarin* (which is usually thought to stifle progress and innovative thinking), the inter-organizational network of the laboratory opens up opportunities that many individual members would not perceive, access or seize on their own (Lazega et al., 2008). Second, empirical analyses and interpretations of the relationship between extended networks and performance need to be further refined. For example, the richness of direct contacts in complementary resources might also be a factor that should be controlled for in further research explaining the differences observed. Third, indirect ties and access to rich dual alters has an effect that is measurable over time only. This raises the question of the actual dynamics of such multilevel opportunity structures and its specific impact on network lift effects.

This kind of analysis could prove particularly well adapted to certain types of questions that sociologists explore in complex meso-level processes. Further use of this approach could test the generality of this method of extension of opportunity structures in other areas of interest to sociologists. It will hopefully prove to be useful in measuring the dynamics of multilevel opportunity structures in contemporary organizational societies

(Perrow, 1991) and in revisiting old substantive and theoretical questions addressing social

inequalities.

References

Breiger, R.L., 1974. The duality of persons and groups. Social Forces 53, 181–190.

Bryk, A.S., Raudenbush, S.W., 1992. Hierarchical linear models, Newbury Park, CA, Sage.

Burt, R.S., 1992. Structural Holes: The Social Structure of Competition, Cambridge, Harvard University Press.

Burt, R.S., 2005. Brokerage and Closure. An Introduction to Social Capital. Oxford University Press.

Fararo, T.J., Doreian, P., 1980. Tripartite structural analysis: generalizing the Breiger-Wilson formalism; Social Networks 6, 141-175.

Flap, H., Bulder, B., Völker, B., 1998. Intra-organizational Networks and Performance: A Review; Computational & Mathematical Organization Theory 4, 1-39.

Hargens, L., Mullins, N., Hecht, P.K., 1980. Research areas and stratification process in science. Social Studies of Science 10, 55-75.

Hedström, P., Sandell R., Stern, Ch., 2000. Mesolevel Networks and the Diffusion of Social Movements: The Case of the Swedish Social Democratic Party. American Journal of Sociology 106, 145–172

Hsung, R.-M., Lin, N. and Breiger, R.L. (eds.) (2009), *Contexts of Social Capital: Social Networks in Markets, Communities, and Families*, New York and London: Routledge.

Jansen, D., 2004. Networks, social capital, and knowledge production, Forschung für Oeffentliche Verwaltung, Universität Speyer, Discussion paper series 8.

Kozlowski, S.W.J., & Klein, K.J. (2000). A multilevel approach to theory and research in organizations: Contextual, temporal and emergent processes. In K. Klein & S. Kozlowski (Eds), *Multi-level theory, research and methods in organizations.* (pp 3-90). Jossey-Bass.

Lazega, E. (2012). Sociologie néo-structurale, in R.Keucheyan and G.Bronner (Eds), *Introduction à la théorie sociale contemporaine*, Paris, Presses Universitaires de France.

Lazega, E., Jourda, M., Mounier, L., Stofer, R. 2008. "Catching up with big fish in the big pond ? Multi-level network analysis through linked design", *Social Networks*, 30:157-176.

Leenders, R., Gabbay, S. (Eds.)(1999). Corporate Social Capital and Liability. Boston, Kluwer.

Lubbers, M. J. (2003). Group composition and network structure in school classes: A multilevel application of the p* model. *Social Networks, 25*(4), 309-332.

Mullins, N., Hargens, L., Hecht, P., Kick, K. (1977). The Group structure of co-citation clusters. A Comparative study, American Sociological Review 42. 552-562.

Perrow, Ch. (1991). A society of organizations. *Theory and Society*, 20, 725-62.

Quintane, E., Carnabuci, G., Robins, G.L. & Pattison, P.E. (2012). An investigation of the temporality of structural holes. Academy of Management Best Papers Proceedings. OMT division.

Robins, G.L., Woolcock, J., Pattison, P. (2005). Small and other worlds: Global network structures from local processes. American Journal of Sociology 110, 894-936.

Snijders, T.A.B., Bosker, R., 1999. Multi-level Analysis, London, Sage.

Snijders, T. A. B, Baerveldt, Ch., 2003. A multilevel network study of the effects of delinquent behaviour on friendship evolution. Journal of Mathematical Sociology 27,123-151.

Van Duijn, M.A.J. (2006). "The Multilevel p^2 Model: A Random Effects Model for the Analysis of Multiple Social Networks", *Methodology: European Journal of Research Methods for the Behavioral and Social Sciences*, 2:42-47

Wang, P., Robins, G., Pattison, Ph., and Lazega, E. (2012), "Exponential random graph models for multilevel networks", submitted manuscript

White, H.C., Boorman, S., Breiger, R.L., (1976) Social Structure From Multiple Networks I. Blockmodels of Roles and Positions. American Journal of Sociology 81,730-80.

Wilson, T.P., 1982. Relational networks: an extension of sociometric concepts. Social Networks 4, 105-16.

Zuckerman, H., 1977. Scientific Elite. Nobel Laureates in the US. NY, The Free Press.

Table 1: Effect of dual alters on focal researchers' Period 2 performance levels

| Independent variables	Unstandardized coefficients			
	Model 1		**Model 2**	
	β	S.E.	β	S.E.
Intercept	19.8*	(8.02)	17.97	(14.98)
Focal actor i characteristics				
Specialty				
Epidemiology (diagnostics, prevention, etc.)	13.3	(10.3)	16.7	(13.07)
Clinical (without fundamental research)	-		-	
Clinical (with fundamental research in haematology)	35.02*	(13.2)	39.14*	(17.86)
Fundamental with pharmacology	-		-	
Fundamental in molecular biology	15.02	(10.63)	-	
Fish-Pond category membership				
BFBP	15.65	(8.9)	-	
BFSP	-		-33.11*	(11.26)
LFBP	-		-	
LFSP	-		-	
Direct contact j characteristics				
Average performance at Period 2	-		-0.17	(0.24)
Specialty				
Epidemiology (diagnostics, prevention, etc.)	-		-	
Clinical research (without fundamental research)	-		-2.74	(4.53)
Clinical (with fundamental research in haematology)	-		-	
Fundamental with pharmacology	7.95	(4.66)	12.22	(6.27)
Fundamental in molecular biology	10.6**	(3.40)	20.15***	(4.97)
Fish-Pond category membership				
BFBP	-		-14.14*	(5.68)
BFSP	-9.88**	(3.30)	-	
LFBP	-		12.33	(6.35)
LFSP	-		-	
Dual alter k characteristics				
Average performance at Period 2	-		0.3	(0.19)
Specialty				
Epidemiology (diagnostics, prevention, etc.)	**-**		**21.64***	**(10.93)**
Clinical (without fundamental research)	-		-	
Clinical (with fundamental research in haematology)	-		-	
Fundamental with pharmacology	-		-	
Fundamental in molecular biology	-		15.93	(11.25)
Fish-Pond category membership				
BFBP	2.55	(1.77)	-	
BFSP	-		-	
LFBP	-		-	
LFSP	-		-	

Outcome of stepwise ANOVA models explaining Period 2 performance levels of researchers i based on explanatory variables including the characteristics of i's indirect contacts k (dual alters), controlling for i's characteristics and for the characteristics of i's direct contacts j. All dual alters of actor i are retained in Model 1; only 'rich' dual alters (as defined in the text) are retained in Model 2. Variables for which there are no parameter estimates were removed from the model during the stepwise procedure. The equations are presented so as to facilitate the comparison between the effects of characteristics of i, j and k on i's performance levels. For example, Model 2 shows that, at the time of the study, the fact that i's extended opportunity structure includes dual alters specialized in epidemiology (coefficient 21, 64, standard error 10,93) is likely to increase i's performance significantly during period 2. Model fit: F=3.7, p=0.0019 for Model 1; F=3.43, p=0.0016 for Model 2. Non significant variables that are retained in both final models are variables that nevertheless improved model fit. N=93 for Model 1, N=58 for Model 2. Significance levels for p-values: * < 0.05;   **<0.005;   ***<0.0005.

Figure 1: Organizational extension: Closing a dual 3-path by adding indirect contacts from one's boss's network to one's own.
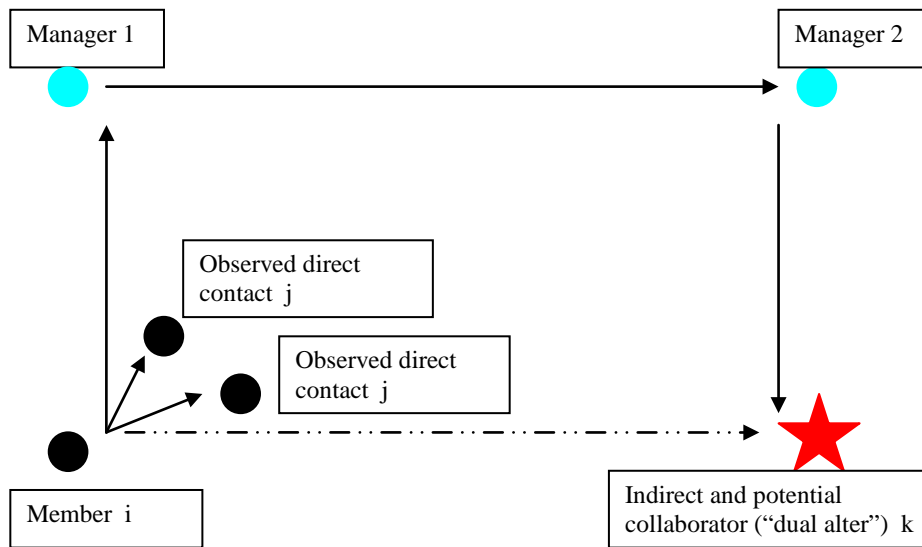

Legend: Star is an indirect contact of Member i, called 'dual alter' k of i, reachable via i's and k's managers and embedded brokerage (as defined in the text). He/she is part of Member 1's potential relational capital accessible through direct tie with Manager 1 (based on common affiliation) and indirect tie with Manager 2. The dotted edge represents a potential collaboration tie. Other black dots represent direct contacts j of i, as observed in his/her actual self-reported network.

Figure 2: Moving means of Impact Factor scores (1996-2005) for six groups of performance levels for 126 researchers in the population
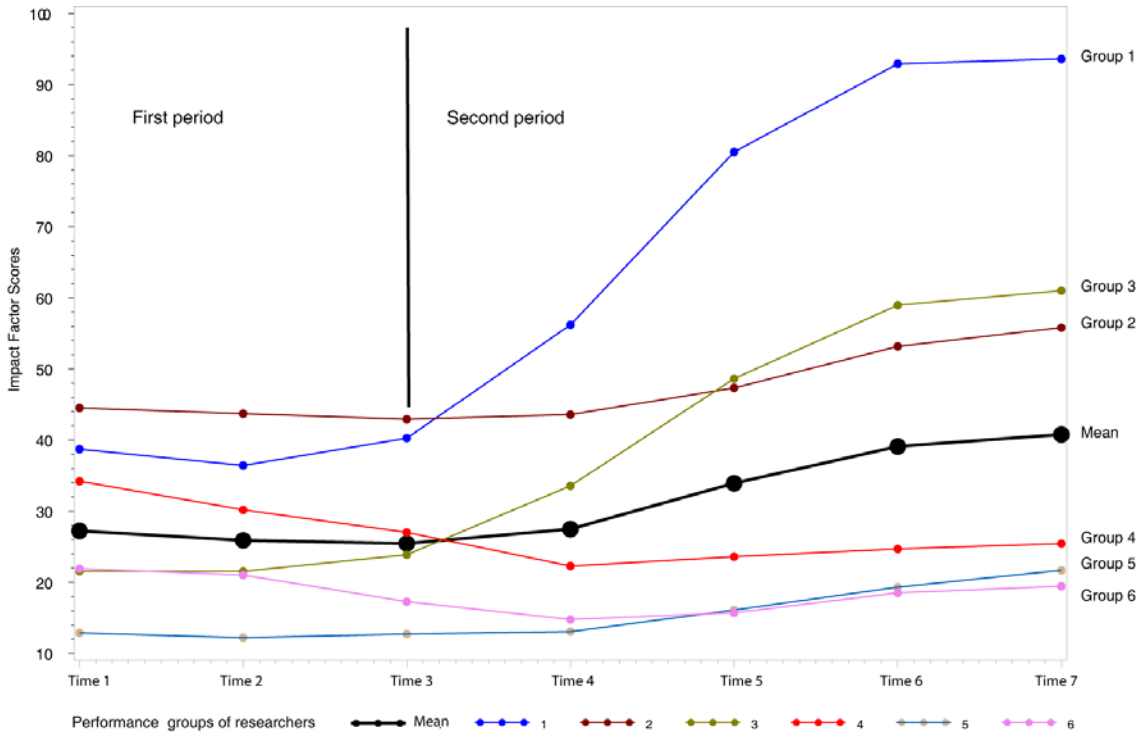

Legend: Each group clusters researchers who experienced similar evolution of their impact factor scores over ten years. For example, Group 1 members have impact factor scores which started below Group 2 at the beginning of the measurements (Time 1) but reached the highest level at the end of Period Two. Observation of the networks took place during Time 3 and separates the two periods.

Figure 3.1: Complementarity of resources: Comparison of standardized average outdegrees (in each of the five advice networks observed) of focal actors i, of their direct contacts j, and of their dual alters k, in performance group 1 (the top of the top)
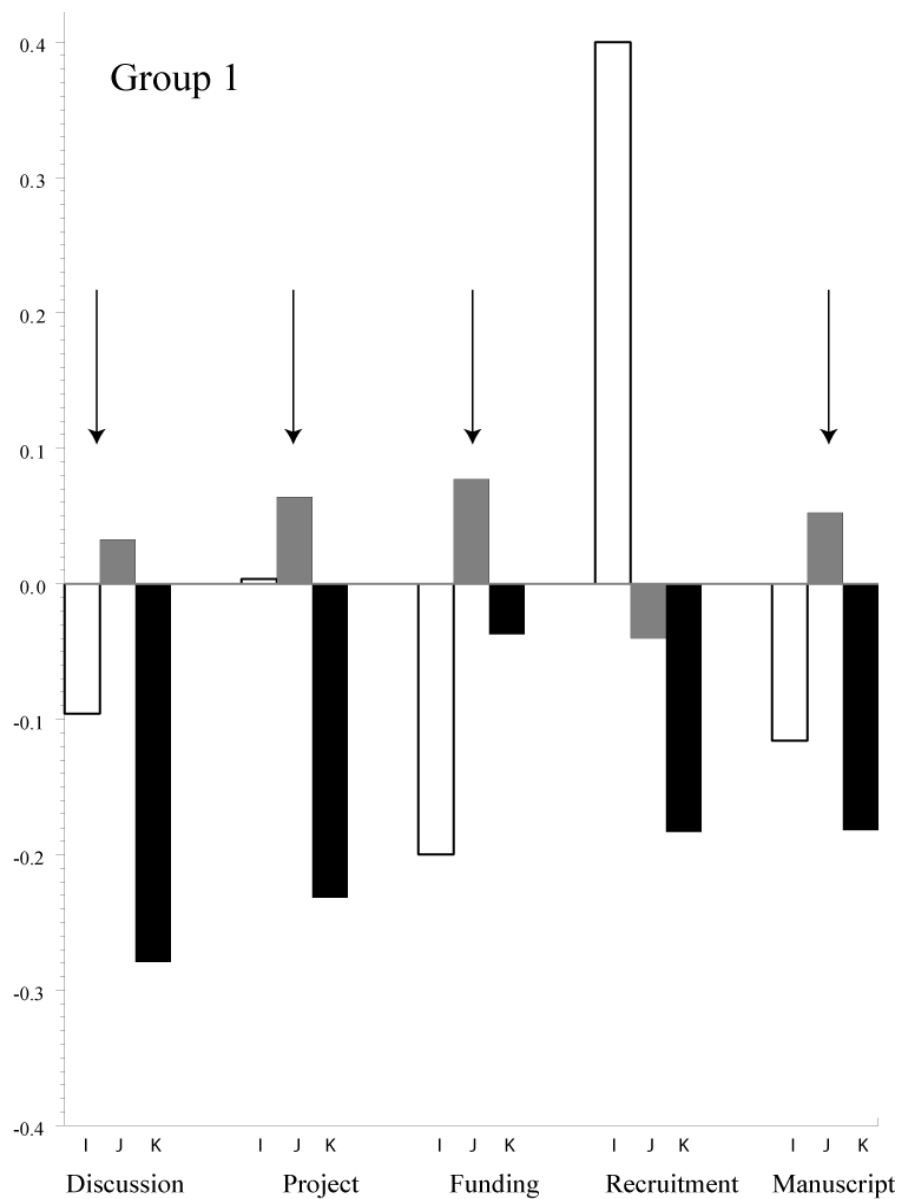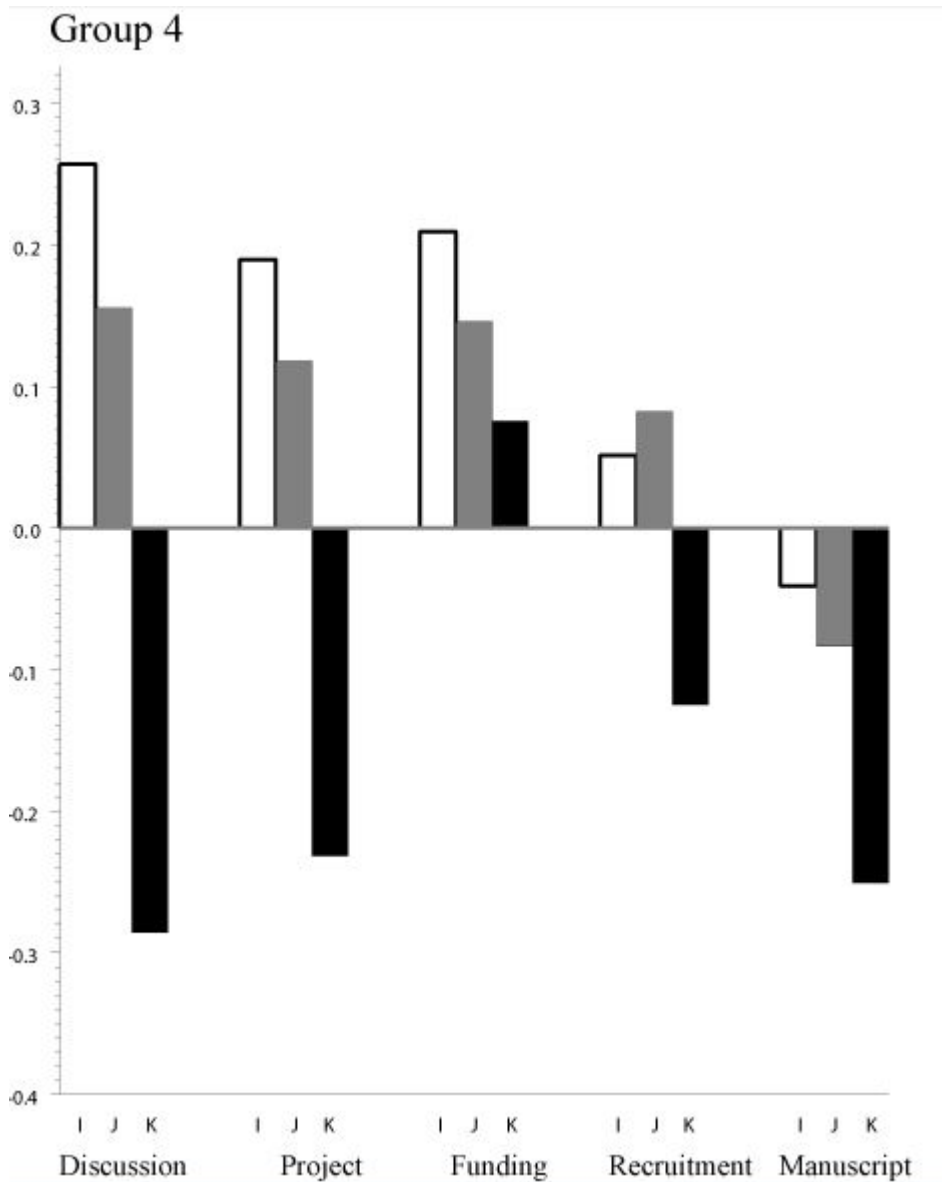

Legend: Group 1 members, the highest performers, are below average (white columns) in number of contacts who can provide insights with respect to a new line of research (Discussion network), with respect to funding, and with respect to manuscript reading before they submit the manuscript to a journal. To some extent their direct contacts (grey columns) are rich in four out of five resources (Discussion, Project reading, advice related to Funding, and advice concerning Manuscript reading). Their indirect contacts k (black columns) are all relatively poor with respect to all resources Selecting among dual alters only those with indegrees and outdegrees equal or superior to that of the mean values for direct j contacts shows, for example, that groups 1 (the top performers) had dual alters that are not complementary in the resources they provide.

Figure 3.2: Complementarity of resources: Comparison of standardized average outdegrees (in each of the five advice networks observed) of focal actors i, of their direct contacts j, and of their dual alters k, in performance group 3
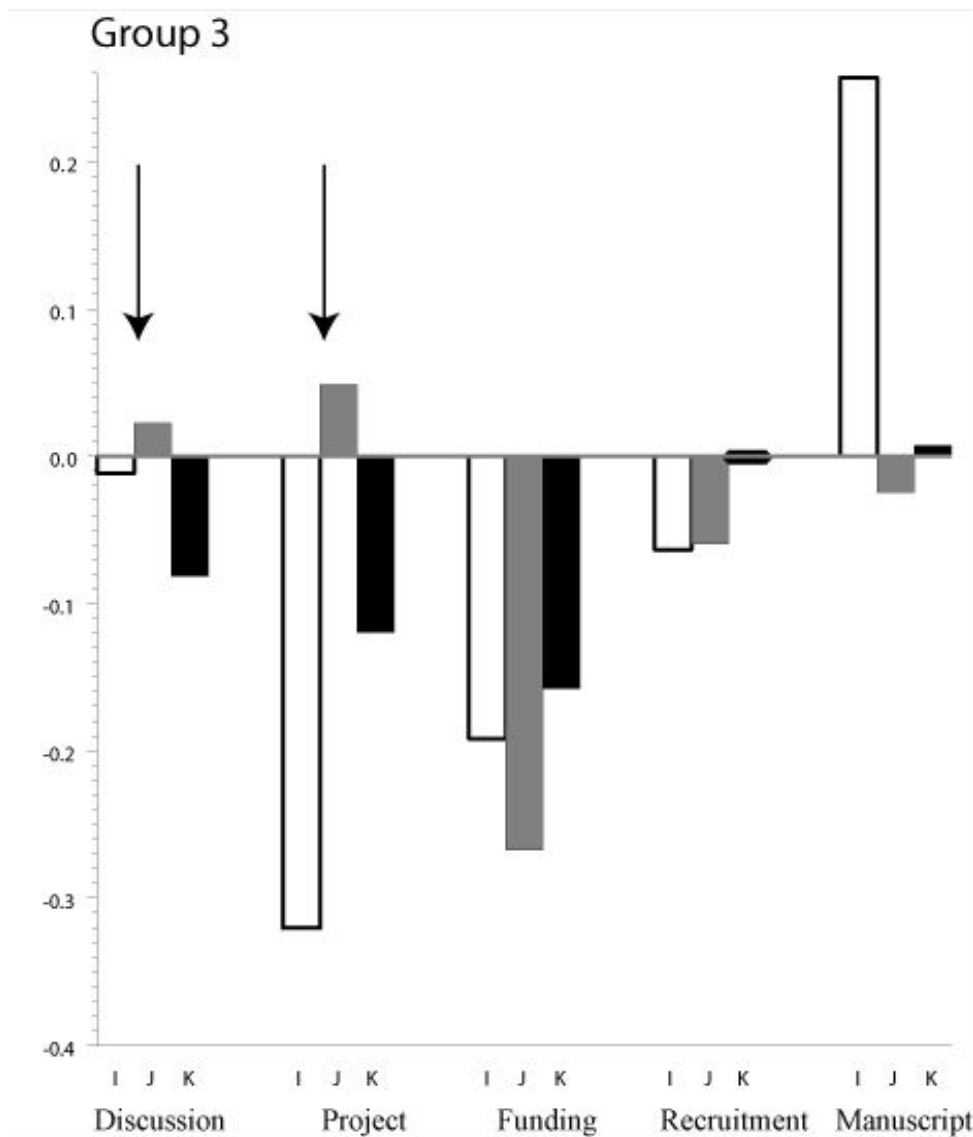
Legend: Group 3 members, the only group that catches up with Group 1 members over time, , are below average (white columns) in number of contacts who can provide insights with respect to a new line of research (Discussion network), with respect to funding, but highly above average with respect to manuscript reading before they submit the manuscript to a journal. In three kinds of resources (Project, Funding, and Recruitment), indirect contacts k (black columns) are relatively less poor than i.

Figure 3.3: Complementarity of resources: Comparison of standardized average outdegrees (in each of the five advice networks observed) of focal actors i, of their direct contacts j, and of their dual alters k, in performance group 4.

Legend: Group 4 members, among the lowest performers in this population, are above average (white columns) in number of direct contacts who can provide insights with respect to a new line of research (Discussion network), with respect to funding, but not with respect to manuscript reading before they submit the manuscript to a journal. Their direct contacts (grey columns) are also rich in four out of five resources (Discussion, Project reading, advice related to Funding, and advice concerning recruitment). Their indirect contacts k (black columns), however, are almost all very poor with respect to all resources except advice concerning where to get funding.

Online Supplement for accepted ESR manuscript "Network Lift from Dual Alters: Extended Opportunity Structures from a Multilevel and Structural Perspective"
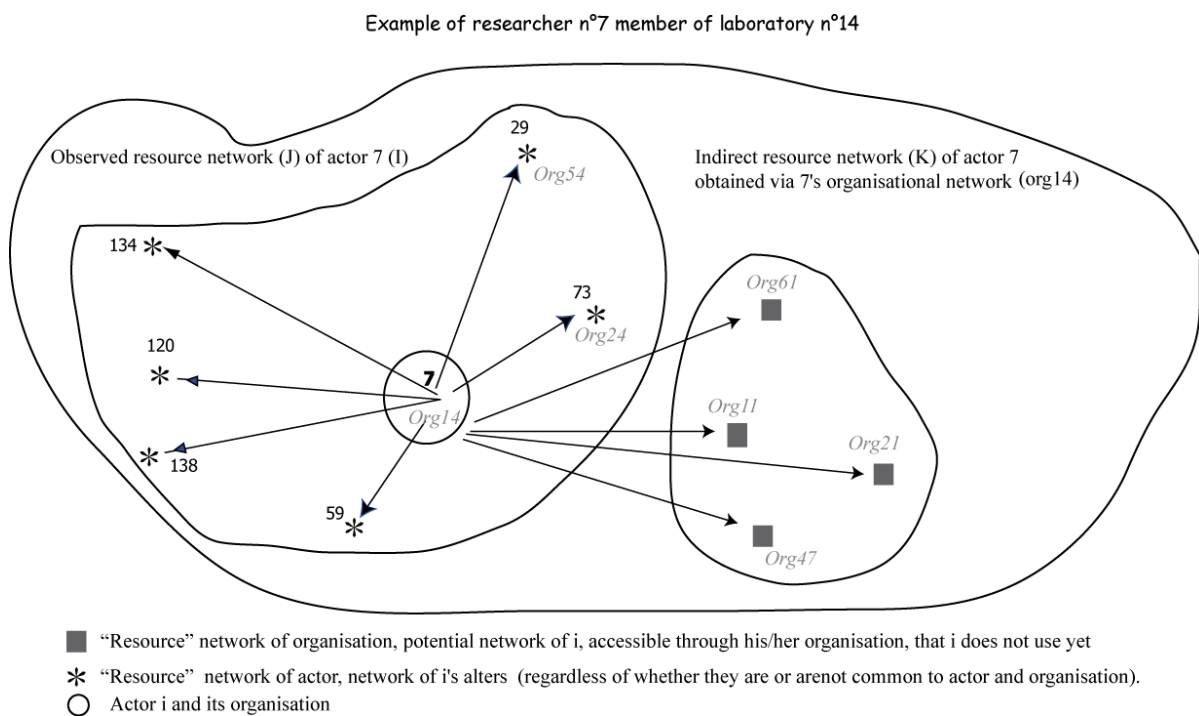
Visualizing relative utility and complementarity of resources provided by selected dual alters

To visualize the articulation of individual and organizational networks, we identify for each individual actor: 1) His/her contacts j who are both his own personal direct contacts and persons who belong to the organizations with which his/her own organization has inter-organizational ties; and 2) His/her dual alters k who are reachable through the managers of their organizations who could provide access to new and complementary resources.

Online Supplement Figure 1 visualizes these combinations of the two networks.

Online Supplement Figure 1:
Combining an individual network and an organizational network. The extended network including observed (j) and dual (k) ties of focal actor i

Example of researcher n°7 member of laboratory n°14

■ "Resource" network of organisation, potential network of i, accessible through his/her organisation, that i does not use yet

✱ "Resource" network of actor, network of i's alters (regardless of whether they are or arenot common to actor and organisation).

○ Actor i and its organisation

This extended context is the latent structure that can, under circumstances specified in the article, lift actors' individual performance. This extended context either provides (or fails to provide) individuals with the extra relational capital and resources that they need in order to carry out their tasks or bounce back.

Online Supplement Figure 2 presents two contrasted correspondence analyses positioning groups of i, j and k (dual alters) in the same space. In the first map, all indirect contacts k of i are included, as in Model 1 of Table 1 in the paper. In the second map, as explained above, we assume that all j are useful to i (since they were cited directly by i) but we only keep in this analysis rich indirect k contacts, i.e. dual alters with high prestige (indegrees) and high access to resources (outdegrees at least as high as the average j contact), as in Model 2 of Table 1.

The striking outcome of these correspondence analyses is that they clearly visualize the difference between access to dual alters 'in general', as differentiated from access to 'rich'

dual alters. On the first map, dual alters k can be found near the top performers (groups 1 and 2). As shown in Table 1 models, these are the researchers with most potential resources, regardless of their class (BFBP, etc.), performances, or specialties. On the second map, compared to the first, the small black squares topple over from the left to the right of the map.

As seen in our discussion of relative utility, not all actors with dual alters have high performance levels. Rather it is appropriate to focus on the effects of the latent and expanded network that is accessible through indirect contacts rich in complementary, non-redundant resources (relative to the focal actor's resources) with respect to multiplexity. Selecting among dual alters only those with indegrees and outdegrees equal or superior to that of the mean values for direct j contacts changes entirely the position of these dual alters. This shows, in particular, that groups 1 and 2 (the top performers) had many dual alters, but that these dual alters did not provide them with resources that they did not already have. Recall that in the paper we measure complementarity as the result of two requirements: firstly, focal actor's resources in a group that are below the mean ; and secondly alters' resources for this group must be above the mean ; if they are not, resources are considered redundant and unhelpful in terms of providing network lift. In other words, as measured here, complementarity is not a purely individual variable but a measure of redundancy or non redundancy of resources at the level of performance groups. Indeed groups 1 and 2 did not have rich dual k contacts; they had probably contacted them already in the past. They no longer need poor dual alters since they already have all the resources they need in their direct contacts (as also shown in Table 1 of the paper).

In contrast, rich dual k appear in the proximity of groups 3 and 5 principally. Groups 3 and 5, the "catchers up", do have rich dual alters that are resourceful and prestigious, who can provide them with complementary resources, i.e. resources that they do not already have. Group 5 members are thus particularly helped by the centrality of their laboratory. Access to these dual alters is thus likely to have been helpful with respect to their performance increase. For group 4 and 6, however, who have the lowest performance levels and lack of access to rich dual alters. In these maps, as also shown in the models, the BFLP are close to groups 4 and 6 and to their lower performance levels during the second period. They have access to redundant resources and thus do not benefit from network lift. Their extended network will not give them access to BFBPs who share, but perhaps access to BFBP who exploit.

In sum, the contribution of the extended network of dual alters is thus relative to the nature of resources that the actor already has in order to perform his/her tasks. In order to provide lift, the multilevel network must provide dual alters, but also relative utility of the resources that they make available. Therefore, as mentioned in the paper, reintroducing the content of the network as well as multiplexity to explain the relative contribution of each network is highly illuminating because it helps with differentiating extended networks and dual alters that provide new and complementary resources from networks that provide redundant "more of the same" resources.

Network lift from dual alters for each performance group (identified in Figure 2 in the paper): correspondence analyses showing the differences between having access to many dual alters k as opposed to having access to *rich* dual alters k

Groups 1 et 2 have many indirect contacts(k)

Groups 3 et 5 have the **RICH** indirect contacts (k)

○   Performance group of (i)

◇   Fish and Pond of (i) (supplementary variables)

■   Indirect contacts (k): their class, performances, specialities

∗   Direct contacts (j): their class, performances, specialities