TEMPORARY ORGANIZATIONS, SOCIAL CAPITAL AND PERFORMANCE: AN EMPIRICAL ANALYSIS*

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1. Introduction

Organizational literature argues that project-based modes of organizing and controlling work are a response to changing contextual factor (Powell, 1996; DeFillippi and Arthur, 1998). In particular, their fluid and temporary nature is seen as a means of bringing about organizational change as well as responding to the increasingly complex environments that organizations are faced with as a result of the high pace of technological development in many of the innovative sectors. Thanks to their ability to overcome typical permanent organization inertia, achieving organizational change or renewal, project-based organizations (PBO) became more noticeable in a range of industries.

In such organizations, projects do not simply occur against a backdrop of relatively established, routine activities. Instead, they constitute the organization, creating a scenario in which knowledge diffusion and emergent working practices are likely to be the result of a complex interplay between structural and environmental project conditions and the role played by each individual who takes part in the project itself. Within temporary organizations, teams represent group of people with well-specific objectives and in which members are aggregated in order to put together individual and their

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resources. The way in which their tangible and intangible resources are combined with each other is the projects' social capital.

Our assumption is that the peculiar structural configuration of social capital might have important performance implications for temporary projects in project-based organizations. In particular, we analyze the particular structural configurations of projects' social capital, among which we emphasize the role of structural holes (Burt, 1992; Fernandez and Gould, 1994) and network range (Burt, 1992). The occasion to bring these theoretical issues to bear on the actual analysis of social capital of temporary projects is provided by network data that we have collected on two different communities of organizations in the biotech and construction industry.

Our argument proceeds as follows. The first section presents a literature review on project-based organization exploring benefits, drawbacks, as well as the peculiar industries in which temporary project units are widespread. The third section provides information on our research design, and discusses issues related to measures, and model specification. In the fourth section we report the results of our analysis. A final discussion section concludes the paper.

2. Theoretical background

2.1. The project-based organization

The PBO is an organisational form in which the project is the primary unit for production organisation, innovation and competition (Hobday, 2000). In contrast to the functional forms theorised by Fayol, PBO is not suited to the mass production of consumer goods, where specialisation along functional lines confers learning, scale and marketing advantages, but organise their structures, strategies and capabilities around the need of projects, which often cut across conventional industrial and firm boundaries. Because core business processes are organised within project rather than functional departments, the PBO is also an alternative to the matrix form, where business functions are carried out both within projects and along functional lines and the project is the primary business mechanism for coordinating and integrating all the main business functions of the firm. DeFillippi and Arthur (1998) identify project-based enterprises as singlepurpose production organizations that contain all production support functions within a temporary project organisation setting and having no functional division of labour or task coordination across project lines.

The literature has widely investigated that project based structures are especially needed in significantly customized industries, such as film-making and media (DeFillippi and Arthur, 1998; Sydow et Al., 2004), complex products and systems (Hobday, 1998), software development (Ibert, 2004; Grabher, 2004), construction (Bresnen, 1990; Bresnen, et Al., 2004), engineering design (Cacciatori, 2004), biotechnology (Ebers and Powell, 2007).

Numerous benefits have been associated with the adoption of a project-based structure. They refer to the creation and recreation of organisational structures around the demands of each project, allowing better processes control and lead-time reduction (Verona and Ravasi, 1999), higher output quality (Bresnen, 1990), the increasing organizations' ability to respond quickly and flexibly to each customer's needs (Mintzberg, 1983; Hobday, 2000), and much more flexible application and integration of different types of organizational knowledge and skills, learning within the project boundary and coping with emergent properties in production, project risks and uncertainties (Keegan and Turner, 2002; Grabher, 2002).

In such a context prior research has documented that, in comparison to traditional functional or matrix organisations, the PBO is ideally suited to enhance innovation, indeed while the functional matrix embodies an inward-looking, linear form of project management, the PBO embodies a concurrent model of project management which is able to realise innovation in collaboration with clients and suppliers (Hobday, 2000; Pinto and Rouhiainen, 2001).

In spite of such benefits, PBOs present also considerable drawbacks. The PBO is weak where functional and matrix organisations are strong, for example in performing routine tasks, achieving economies of scale, coordinating cross-functional resources, and promoting organisation-wide learning (Hobday 2000). In addition, there are difficulties in organizational learning from project to project given the particular discontinuity of activities carried out in project-based structures (Prencipe and Tell, 2001), because much of the knowledge generated in the project activities is embedded in tacit experiences of the group members and it is difficult to be consolidated and spread outside the single unit project, and because knowledge that is accumulated in the course of a project is at risk of being dispersed as soon as the project is dissolved and members are assigned to different task, team or new deadline (DeFillippi and Arthur, 1998). Projects are often quite different, and solutions developed in the context of one project can seldom be applied to another. Even though projects are autonomous from each other most of the time, inter-project coordination is a desirable thing especially when the adoption of new technologies or development of new project routines could be used and applied elsewhere in other projects of the organization. As a consequence, whether project-based firms live on their ability to mobilise and conduct projects, for organizational performance as well as for that of other projects some key managerial tasks are needed to integrate project-based learning into the organisation (Gann and Salter, 2000).

2.2. Problems of coordination and inter-project relations

Organizational literature has focused on a typical paradox of project-based organisations, the relationship between independence versus authority, two sides of the same coin where if you want to give independence you can not claim authority and direction, because they will be less. According to Foss (2003), in PBO has been often found some difficulty in reconciling the demands of autonomy typical of the project with the exercise of control by the hierarchical management, highlighting a fundamental inconsistency between the high autonomy and delegation-level project and the strong need for control over input and operation of projects. Despite the wide use of the delegation and decentralization of decision-making in companies adopting the model for projects, it is not possible to completely eliminate the lines of authority and hierarchical formal relations within the organisation, but at the same time, however, the authority is a threat to these structures as soon as frustrating attempts to spread democratic forms of coordination, limiting personal initiative and the stimulus for change and violating, therefore, the complex system of complementarity between structure, systems evaluation and incentives that is the basis of organizational decentralised forms (Zenger, 2002).

Organizational projects are highly autonomous units that especially in knowledge-based organizations represent the way through which organizations seek to achieve innovation and new knowledge production. Project units allow dividing labour within organizational boundaries and giving firms the opportunity to focus on fewer but highly customized activities, but producing at the same time high degree of differentiation into organizational sub-systems (Lawrence and Lorsch, 1967). Such differentiation is reflected, for example, in the partial vision of the whole organizational activities, potential conflicts among projects, and different priorities that characterize scheduled activities and the project agenda. This approach to organizational design complicates coordination across projects performing different, well-specialized tasks and activities. In this context, coordination means integrating or linking together different parts of an organization to accomplish a collective set of tasks (Thompson, 1967; Van de Ven, 1976). In sharp contrast, internal learning and knowledge creation via long term changes in explicit and tacit knowledge in their own areas of work is essential for organizations in order to achieve an adequate profitability and to stay competitive in knowledge-based contexts. The activities of each project must be integrated and a high degree of coordination is required to respond appropriately to the environment. However, whether too little integration creates a short-term focus at the expense of long-term innovation and adaptation, extremely high integration and the organization cannot quickly react to environmental changes as well as to customer needs.

Given the above discussion, one fundamental question here is: How does coordination take place within project-based organizations? Staffing solutions enhance collective learning in organizational project teams (Bourgeon, 2007). The diversification of project-team composition and individual characteristics of its members, such as demographic, tenure and competences diversification, is one way through which often firms integrate sub-systems according to the need to coordinate tasks and activities. Yet, rotation of individuals across projects is desirable to reconcile single projects differentiation with knowledge integration at the organizational level. Horizontal structures and coordination roles which emphasize collaborative networks inside and outside of the organization (Hakanson and Zander, 1998; De Meyer and Mizushima, 1989) represent other crucial responses adopted by companies to master, promote and keep the collective learning developed during new projects development.

These are, however, partial solutions. The resolution of typical PBO paradox is to find a considerable organisational stability and coherence in which the project acts as an organizational glue (Gann and Salter, 2000) able to combine each other different operational and coordination mechanisms vital to achieving business goals. To achieve integration effectively, a project needs to establish and maintain relations with other projects within the organization to pull in important informational resources to improve project performance. Tasks and activities carried out at the project level are based on heterogeneous and often complex sets of knowledge and information (Polanyi, 1966). Innovation and technology development rely consistently on the combination and sharing of explicit and tacit knowledge that allow individuals to learn and gain access to experiential knowledge and new techniques and methods developed by colleagues (Cockburn and Henderson, 1998). In addition, due to the extreme specialization of organizational project, there are very few opportunities for project members to keep track of all the developments occurring in different projects of the organization. Under these circumstances, relationships with other projects in the organization are likely to be a valuable resource to have access to updated information relating, for example, to important customers or market conditions.

2.3. Social Capital

Social capital can be defined as that set of resources available to individuals as a function of their location in the structure of social relations (Bourdieu, 1985), and it includes both relationships with others and resources embedded in these relationships (Burt, 1992). Social capital and its effects can be studied at different levels of analysis: individual (Burt, 1997), group (Burt et Al., 2000), organizational and interorganizational (Pennings and Lee, 1999; Chung et Al., 2000). While social capital for individuals and organizations have widely been investigated in terms of benefits that it can produce, so far prior research on PBOs has provided little evidences about the role that social capital plays for single temporary projects. In the present paper, the concept of organizational projects' social capital is similar to that of group social capital, defined as «*the set of resources made available to a group through group members' social relationships within the social structure of the group itself, as well as in the* *broader formal and informal structure of the organization*» (Oh, et Al., 2006: 570).

Within temporary organizations, project teams represent groups of people aimed to achieve well-specific objectives, in which members are aggregated in order to put together individuals and their resources. Among such resources, social capital available through individual members' social relations appears to be of critical importance given the peculiar work performance and work processes at the project-level. In the present paper, we argue – in general - that more project social capital resources will lead to greater effectiveness. Whenever project tasks require new relevant knowledge located outside project boundaries, individuals taking part of temporary projects may be strongly motivated to communicate and exchange knowledge with members that take part to other projects to have access to new knowledge. Project social capital in this context has a double effect: the interpersonal social relationships established across different, well-focused projects enhance the absorption of innovative external information that increases the learn in the area of work and, as a result, the effectiveness of single projects.

2.4. Closure, Range, and Performance

Even though the amount of social capital resources is likely to affect project effectiveness, we hypothesize that the peculiar structural configuration of social capital might have important performance implications for temporary projects in project-based organizations (Hite and Hesterly, 2001).

In the traditional view of social capital, one of the network structural properties that assumes a pivotal role for the production of knowledge for network members is cohesion (Coleman, 1988; Reagans and Zuckerman, 2001). A network can be defined as "cohesive" (or "closed") when all the network members are strongly interconnected, and density -defined as the proportion of possible ties between a set of nodes that actually exist- is normally used to measure the overall level of network cohesion. In highly cohesive networks, each individual is connected to every other, information diffuses rapidly and individuals belonging to same network are likely to share the same knowledge. Cohesion is helpful in promoting the creation of social norms and sanctions within networks to facilitate trust and effective coordination between network members (Coleman, 1988; Granovetter, 1985; Krackhardt, 1999; Reagans and McEvily, 2003). In this vein, a network composed by a close-knit group of project teams is more likely to favour the establishment of norms and to have members who trust each other. A dense strong-closure network would thus benefit from greater cooperation, greater conformity to norms, greater information sharing, and less tendency to engage in competitive behaviors, thereby increasing the willingness of project members to engage in discussion and knowledge exchange. Increasing individuals' access to knowledge is important for the performance of temporary projects as it increases the probability of obtaining specific resources to apply to their context. Highly dense networks provide an arena in which, other than identifying useful ideas and knowledge of network members, project members can use other projects and their own members as resources to augment their own prior knowledge. In this manner, individuals do not just add to their own knowledge stocks but also use others' knowledge to further stimulate the usefulness of their own skills. More formally, we hypothesize:

HP1: The network closure of a temporary project in inter-project interaction is positively associated with its level of performance.

Another important perspective that can be taken into account when exploring the project performance considers the relationship between cognitive diversity and performance of single projects. At an individual level, knowledge diversity is shaped by the project members' background, as well as by their previous work experiences. In social networks, the discussion about the cognitive heterogeneity relates directly to the collaborative ties with other colleagues specialized in different areas of expertise. While similarity in the stock of knowledge owned by individuals can, to some extent, improve communication and commonality among them, heterogeneity enhances the capacity for creative problem solving and allows individuals to share different sets of contacts, skills, information, and experiences (Reagans and Zuckerman, 2001). Burt (1983) translated the discussion about the heterogeneity of social networks into the language of range. Network range is defined as the prevalence of ties that cross institutional, organizational, or social boundaries (Burt, 1992). Relations have range to the extent that they connect an actor with to an extensive diversity of other actors. Actor diversity, indicating network range, does not take into account the number of actors but rather the number of different types of actors. The greater the number of different types of actors to which an individual who takes part to a single project is linked, the greater the diversity of information and social support which the individual can have access to (Burt, 1983). In this paper, we consider network range in terms of the expertise area of each member who composes a temporary project. Each expertise area is a distinct pool of knowledge so that it might reflect the "cognitive diversity" of project teams' interpersonal network. Individuals are chosen and assigned to single projects temporarily on the basis of their specific competences and past experiences. Such capabilities are often represented by the functional units that overall represent the permanent part of the organizational chart. Projects that spread connections across multiple pools bridge holes between projects in the broader "community" of knowledge at the organizational level. As a result, they are exposed to knowledge that is more diverse. Network diversity of single projects is therefore high.

Diversity in social capital is of crucial importance in PBOs. Intense and frequent communication among their members is a high desirable condition within project teams, and typically these are designed with the intent to achieve homophily for individuals pertaining to the same project. Homophily represents the tendency for social actors to interact with, and share opinions and behaviours of, other actors similar to themselves on attributes dimensions such as gender, age, educational attainment, or prior knowledge and experience. Given this, connections with members of other projects that have a different background enhance an individual's capabilities to interpret ideas from people with different knowledge into a way that suits his or her knowledge and experiences. At the same time, through "different" ties, individuals are capable of transferring what they know to others with different backgrounds in an easier manner. The ability to transfer knowledge effectively leads to higher exposure of projects to a broader set of perspectives and cross-fertilization of ideas, and thus to variation in knowledge and problem-solving approaches which can help project teams identify and use multiple knowledge components in their activities. In other words, projects that have exposure to more diverse knowledge through their members' interpersonal networks will have access to more knowledge components and will be able to mobilize and exploit different intellectual resources embedded in the network. As a consequence, it is likely that a large range of their social networks will be associated with higher performances. We hence hypothesize the following:

HP2: The network diversity of a temporary project in inter-project interaction is positively associated with its level of productivity.

3. Methods

3.1 Institutional setting

The relationship between project social capital and performance seems to be particularly salient in the construction and biotechnology industries, as the work performed at the project level in these contexts is likely to be enhanced heavily through information available by others. We chose these two peculiar sectors for a number of reasons that we are now going to explain in more details.

The construction industry is one in which project-based organizational forms have long been taken to be the norm across a significant range of activities (from large-scale, one-off engineering projects, to smaller-scale, more repetitive building work) and is a prime example of a project-based industry, in which new product development (of roads, bridges, offices, housing and the like) involves not only non-routine production processes, but also complex inter-professional and inter-organizational contractual and working relationships that govern project-based interaction (Bresnen, 1990; Gann, 2000; Hobday, 2000; Barlow, 2000). Yet, in this industry project teams are decentralised and heterogeneous because consisting of a mixture of staff from different professional and organizational backgrounds and where the regular secondment and movement of staff between projects is common (Bresnen, 1990). These characteristics make it difficult the possibility that the knowledge obtained from a project can be captured and spread in others, because of the project-specific nature of knowledge produced. Project-based firms often have only patchy knowledge of their own portfolio of projects relying on informal channels of communication between project groups as the principal source of information on their activities (Bresnen et Al., 2004).

The PBO model is also the mode through which biotechnology companies manage their research and development activities. Biotechnology is a high technology industry, characterized by radical innovation, adaptation pressures and frequent alliances between large pharmaceutical firms and new biotechnology firms (Powell et al., 1996). Biomedical innovation has been defined in various ways but here we see it as a process involving the creation and application of scientific and technological knowledge to improve the delivery of human healthcare and the treatment of disease. Biomedical innovation processes have thus been described as typically non-linear or "interactive", comprising complex, uncertain, high risk and iterative cycles of knowledge integration and networking across these diverse groups and organizations (Powell et al., 1996). In this particular context, the adoption of a temporary project structure allows strategic flexibility within organizations undertaking biomedical research and commercialization. Projects integrate the work of employees across disciplinary boundaries, and consist of employees of the different departments. Projects may run for several years and uncertainty pervades the process of discovering, at the outset of a project accurate assessment of costs, duration and outcomes are virtually impossible. Several authors analyze case studies in order to identify mechanisms at the project level that played an important role in shaping innovation processes. Their findings suggest, for instance, that among the different ways in which integrative and relational capabilities might influence innovation processes, one important mechanism is the ability to build upon existing interorganizational and intraorganizational networks to generate resources and buy-in from users. Networks among project teams represent, in particular, an important mechanism through which organizations involved in innovation processes acquire and create relevant expertise.

3.2 Sample and Data Collection

In the present study, the single temporary project is the unit of analysis. Our sample is represented by 107 projects that pertain to 11 organizations involved in the biotech and construction industries. We selected the organizations opportunistically on the basis of a theoretical sampling procedure (Eisenhardt, 1989). In order to generate insights on how the configuration of project teams' social capital relates to project performance, we matched our cases such that they operated under similar conditions and regulatory regimes however differed considerably with regard to performance and social capital structure.

The present analysis is developed either with the support of primary data collected through semi-grounded mode and with the use of secondary data already available. In particular, primary data relate to the collection of information about the structure of single projects social capital. In this vein, preliminary interviews with corporate managers and with project managers allowed us to make assumptions, develop the methodology of investigation, make a pre-test of the subsequently administered questionnaires. A sociometric questionnaire, structured into different sections, was submitted to project managers and team members in order to gather relational data about each investigated projects. In the first section, each project manager was found to indicate inter-project exchanges of resources typically undertaken in the daily project work. We developed a set of questions in order to see how the project units exchange resources, into two main categories: technology resources (equipment, support, products, personnel) and economic resources (money transfer, credit, debit, discounts, etc.). Here it follows an example of the question we asked: "Does your project unit offer product of service to other units? If yes, please indicate the projects within your organization that receive your product or services". A second part of the questionnaire was designed to gather data about technical inter-project relationships within organizations. The employees in each project were given a questionnaire and asked to indicate with whom they usually discussed three predefined matters integral to project activities: (1) the major *source* for the development of the project activities, (2) the current dialogue and *exchange of opinions* about the development of the project, and (3) the *utilization* of specific knowledge to develop specific parts of their work. The questions were followed by a list of all members of other projects within the same organization. We obtained valued relational data between members of each projects, since also the weekly frequency of the interaction was checked[†].

For what relates to performance, while in the case of construction organizations there was consensus by project leaders about on the net profit

[†] Data on the interaction among the projects were collected in two different years. Sociometric data for all construction projects were gathered in 2004, while for biomedical projects such data refer to the year 2001.

margin as good measure of project performance, interviews with managers and senior scientists of biomedical projects revealed that actors in this industry relied on widely applied proxies for the success of biotechnology projects that most prominently include net margin and revenue growth, employment growth, and patenting rate. In spite of this multidimensional performance measure, in the present paper we decided to employ only net margin for the assessment of performance of biomedical projects.

Data on revenues and net profit margins for each project were gathered from internal sources of information available, mostly electronic annual reports. Data on patents and commercialization of IPs of biomedical projects were obtained through direct interviews with project leaders, and later complemented by major sources of patent applications: the European Patent Office (EPO) and the World Organization for Intellectual Property (WIPO). Other archival material available from top managers and project leaders was used to collect additional project data concerning tenure and project teams composition.

3.3 Variables

Dependent variable. Our dependent variable is represented by project performance, measured as the net profit margin expressed as percentage of total revenues in the year 2004 for each project. While such data were gathered directly from archives and annual reports for PBOs in the construction industry, for biomedical research projects we computed this measure in a indirect way. The measure, in particular, was calculated considering project profitability that derives from patent license agreements, i.e. intellectual asset profitability. Concerns may arise here about the fact that revenues tied to IP commercialization and royalties are typically delayed from two to three years after patents received. We addressed this problem by taking into consideration the amount of profit (net margin) expressed as percentage of total revenues lagged of two years, thus allowing to have a comparable measure with that considered for temporary projects in the construction industry.

Independent variables.

Network closure. Our indicator of social closure is network constraint (Burt, 1992). Network constraint (nc_{ij}) is an appropriate indicator to measure the extent to which inter-project collaborations at the organizational level are redundant:

$$nc_{ij} = \sum_{a=1}^{N} v_{ia} v_{aj}, a \neq j$$

where v_{ia} is the strength of the network connection from project member i to individual/alter a, and v_{aj} is the strength of the connection from member a to member j. All connections used for the calculation of this measure are only intra-organizational ties among project members. Network constraint is a triadic closure measure of how much an actor is constrained by its direct neighborhood. Network closure indicates the presence of strong third-party connections around a relationship. Strong third-party ties link member i to member j indirectly to the extent that member i has a strong network link with member a and member a has a strong network link with member j. We summed v_{ia} v_{aj} across all partners a in order to obtain the overall strength of the third-party connections around collaborative relationships. The network closure measure was aggregated to the project level in order to test our first hypothesis. In order to test for the presence of a curvilinear relationship between network closure and performance we also included network closure squared.

Network diversity. Projects are surrounded by a diverse network to the extent that their members spread their network ties across multiple areas of expertise and the connections within contacted areas are weak. Following Burt (1983), we use network range as the indicator for network diversity (nd_i). Network range has two distinct components. The first is a function of how individuals' collaborative ties are spread across different expertise areas. The second is a function of the strength of connections with projects working in those areas. Thus, network diversity is defined as:

$$nd_i = 1 - \sum_{k=1}^{21} v_k v_{ik}^2$$

where v_{ik} is the strength of the network connection from member *i* to area *k*, and v_k describes the strength of the connections between projects in area *k*; v_{ik} is in turn defined as:

$$v_{ik} = \frac{\sum_{j=1}^{N_k} x_{ij}}{\sum_{q=1}^{N} x_{iq,\, q=j}}$$

where N_k is the number of ties that project *i* has with other projects working in area *k*, *N* is the total number of network relationships of project *i*, and x_{ij} is the number of ties that project *i* has with project *j*. Tie strength within area *k*, v_k, can be expressed as follows:

$$v_k = \frac{\sum_{j=1}^{M_k} x_{ij}}{\sum_{q=1}^{S_k} x_{iq,\, q=j}}$$

where S_k is the number of contacts that a given project maintains in area *k*, M_k is the number of projects with expertise in the area *k*, x_{ij} is the intensity of the relationship between a given project in area *k* and any project, x_{iq} is the intensity of the relationship between a project in area *k* and a project working in the same area of research. Therefore, increasing v_k indicates the absence of diverse knowledge inside a knowledge network. We test curvilinear association by including network range squared. For further discussion about this measure please see Burt (1993) or refer to the application provided by Reagans and Zuckerman (2001).

Control variables. We create several controlling variables to capture the effects of other factors that are potentially important to explain temporary projects performance but not theoretically interesting in this study. (1) *Dimension.* The dimension might affect the level of performance achieved at the project level. We control the dimension by considering a dichotomous variable that takes on 1 for those projects whose number of team members was above the median value of the sample, and 0 otherwise for projects below the median. (2) *Duration.* Project duration may affect the level of performance achieved. A dummy variable that considers whether the project has a annual or multiannual duration. This variable takes on 1 for annual projects, and 0 otherwise. (3) *Sector.* A dummy variable was included to consider the different field in which projects run activities. This variable takes on value 1 if the project runs activities in the biomedical field and 0 if, in contrast, it temporary structures relate to the construction industry. (4) *Geographical location.* Since projects here surveyed refer to organizations that operate in different countries (mainly in Italy), we included a dummy variable that takes on 1 for projects pertaining to organizations with the headquarter in Italy, and 0 otherwise.

4. Analysis and results

Ordinary least squares (OLS) regression equations, the results of which are displayed in Table 1, are used to test our hypotheses. Our aim is to determine whether network constraint and network range have an influence on the project performance. We adopt a stepwise approach to model building. In Model 1, we examine the impact of the control variables on the performance of single projects. In Models 2 we include the variables that directly speak about the explanatory power of social capital resources on project performance, focusing our attention on constraint and range. An examination of whether the dependent variables of theoretical interest significantly improve the fit of the previous Model 1 will give an answer to our hypotheses. In a third and final Model we also entered the quadratic terms of the independent variables of theoretical interest to test for a non-linear relation between range and diversity, and project performance.

One concern with dyadic models is that the observations may be interdependent because each actor in the network appears in multiple dyads, creating a common-actor effect. This problem is well known as autocorrelation, and is similar to unobserved heterogeneity in panel data. If this is the case, coefficient estimates will be consistent, but the standard errors may be inflated. There are several strategies for addressing the potential non-independence of observations. Following previous studies, we included a network autocorrelation variable in our regression model (see Lincoln 1984; Gabbay and Zuckerman, 1999; Cross and Cummings, 2004).

Tab. 1 – OLS Estimations

Variable	***Model I***	***Model II***	***Model III***
Constant	-0.22$^{\bullet}$ (0.41)	-0.60$^{\bullet}$ (0.22)	-0.65$^{\bullet}$ (0.42)
Geographic Location	-0.0012 (0.002)	-0.03 (0.11)	-0.03 (0.12)
Tenure	0.38$^{\bullet\bullet}$ (0.10)	0.36$^{\bullet\bullet}$ (0.07)	0.36$^{\bullet\bullet}$ (0.08)
Dimension	0.41$^{\bullet}$ (0.12)	0.43$^{\bullet}$ (0.14)	0.45$^{\bullet}$ (0.14)
Sector	0.10 (0.21)	0.05 (0.08)	0.04 (0.15)
Autocorrelation network		-0.12 (0.17)	-0.13 (0.18)
Network constraint		0.24$^{\bullet}$ (0.11)	0.26$^{\bullet}$ (0.10)
Network constraint squared			-0.25$^{\bullet\bullet}$ (0.05)
Network range		0.14$^{\bullet}$ (0.08)	0.13$^{\bullet}$ (0.06)
Network range squared			-0.08$^{\bullet}$ (1.22)
R^2 (adjusted)	0.172	0.180	0.181
N projects	107	107	107

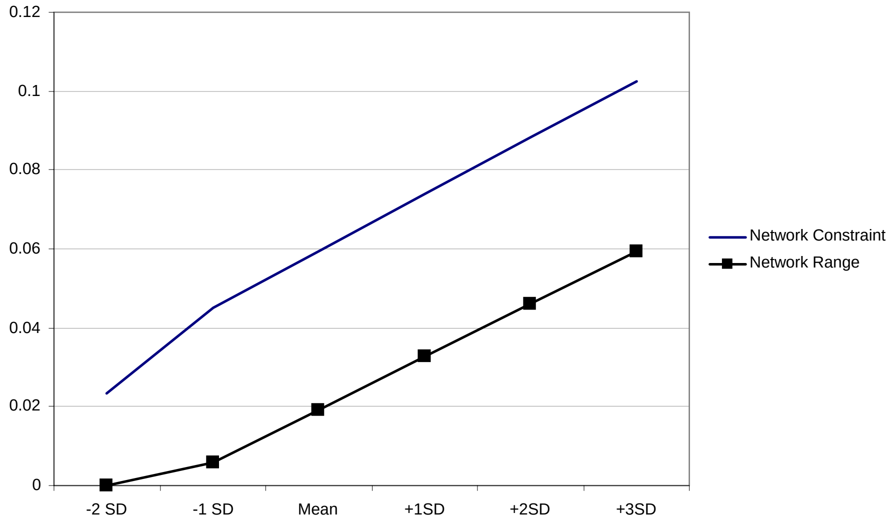
Standard errors in parentheses. $^{\bullet}p < 0.05$; $^{\bullet\bullet}p < 0.10$

Model 1 in Table 1 regresses the project performance on the set of control variables. Overall, the inclusion of the control variables results is a model that is significantly different from a null model. Of the four control variables, two are significant. As expected, surveyed projects characterized by tenure and dimension above the median are more likely to achieve higher levels of performance. This makes sense since tenure indicates the previous experience developed at the project level, which in turn can influence their performance. Also the dimension is positively and significantly associated with performance. Even in this case, it is reasonable to expect that projects composed by a large number of team members perform better, at least in terms of gross profit.

The network hypotheses are tested in the second model. Hypothesis 1 proposed a positive relationship between network closure of temporary project units and their effectiveness. To support such a relationship, the coefficient estimates for closure should be positive and significant with a significant change in the model's explained variance. The results in Column 2 in Table 1 show that the coefficient for network closure is positive and significant. These findings provide strong support to the hypothesis that network closure of single projects within the organization has a positive effect on the level of performance that they achieve. It follows, then, that it is true that cohesive and frequent ties (i.e. strong ties) creates trust and enables greater willingness to transfer knowledge and share information among project units. Column 2 of Table 1 adds also the network range variable to Model 1 in order to test our Hypothesis 2 that relates network diversity of temporary projects. In this case, too, we proposed a positive relationship between network range and performance for single projects. As shown in Column 2, the coefficient for network diversity is positive and significant. These results provide support for the hypothesized positive relationship between network diversity and project performance. This pattern of results implies that the creation of collaborative ties with other units operating in different areas of expertise enriches effectiveness of projects. Results reported in Column 2 also show no significant differences across the control variables entered in the earlier model.

As already mentioned we also entered the squared terms of the independent variables of interest in Model 3. This is done to test whether range and closure might have a non-linear effect on project performance. The results in Column 3 in Table 1 show that the coefficient for network closure is positive and significant, and the coefficient for network closure squared is negative and significant. In a quite similar manner, the results reported show that the coefficient for network diversity is positive and significant and the coefficient for network diversity squared is negative and significant. Overall this suggests that even though high levels of closure and range are positively associated with a higher level of project performance, there are also costs associated to the time and effort that team members devote to communicating what they know, as well as to the redundancy of knowledge exchanged within highly dense networks. After a certain level, greater density produces excessive closure within the network that, in turn, will result in significant incremental costs outweighing the benefits. There are also costs for temporary projects who seek other units to add and integrate new know-how to their knowledge stock. As additional collaborative ties which cut across areas of expertise boundaries are added, the cost of assimilating, absorbing, and combining diverse information eventually begins to outweigh the benefits.

Fig. 1 – Predicted project performance and network range and constraint



Even though such results seem to suggest a curvilinear relationship among performance on one hand, and range and closure on the other hand, Figure 1 shows a graph of predicted project performance for various levels of network range and closure. The relation between constraint and the project performance has a minimum of 0.02 when network closure is two times less than the standard deviation under the mean level. At the mean level the performance is roughly three times the rate when constraint is zero. So increases in network constraint from zero have a strong positive effect on the project performance in the sample. As constraint increases further to reach its maximum theoretical value, the performance rate continues to increase up to its peak (0.1). Figure 1 shows the graph of predicted project performance for various levels of network range. The relation between range and performance has a minimum of 0 when network range is two times less than the standard deviation under the mean level. At the mean level the performance is approximately 0.02. As constraint increases further to reach its maximum theoretical value, the performance rate continues to increase up to its peak (0.06). As our theory predicted, the relationship between network range and closure, respectively, and the project performance is overall positive.

5. Conclusion

Understanding how temporary units coordinate resources and exchange knowledge within project-based organizations is a matter of significant theoretical interest. Drawing from theoretical concepts of social capital theory, the main objective of this work was to explore a strand still little debated by the organizational literature, the role that social capital plays for single temporary projects. We measured the presence and frequency of relationships among 107 projects relating to 11 organizations in biotech and construction industry. In spite of the different interpretation and complex meanings that prior literature has considered of social capital (Tsai and Goshal, 1998), in this paper we focused on the structural aspect of social capital, in particular on the structural network properties which mainly relate to cohesion (Coleman, 1988; Reagans and Zuckerman, 2001) and diversity (Reagans and Zuckerman, 2001).

Cohesion relates to the proportion of possible ties between a set of nodes: in highly cohesive networks, each individual is connected to every other, information diffuses rapidly and individuals belonging to same network are likely to share the same knowledge (Coleman, 1988; Granovetter, 1985; Krackhardt, 1999). Our empirical results show a positive relationship between network closure and project effectiveness. It follows that cohesive and frequent ties creates trust and enables greater willingness to transfer knowledge and share information among project units.

Diversity relates to the peculiar domain of temporary projects and their previous work experiences: it is shown that heterogeneity enhances the capacity for creative problem solving and allows individuals to share different sets of contacts, skills, information, and experiences. Results reported in this study show as there is a positive relationship between network diversity and project performance. This results implies that the creation of collaborative ties with other units operating in different areas of expertise enriches effectiveness of projects.

Even though high levels of closure and range are positively associated with a higher level of project performance, further analysis reveals a moderately curvilinear relationship among performance on one hand, and range and closure on the other hand. After a certain level, if too high, cohesion can generate redundant information, less diversified knowledge and scarce novelty that, we suppose, influence negatively project effectiveness. Similarly, after a certain level, as new additional collaborative ties which cut across areas of expertise boundaries are added, an excessive level of network diversity decreases absorptive capacity, and the cost of assimilating, absorbing, and combining different information eventually begins to outweigh the benefits. Our analysis also showed that among other investigated controlling factors, project dimension and tenure do matter for project performance.

The present study contributes to previous research in several ways. First, it adds empirical evidence on the relationship between social capital of temporary units and their performance by considering the peculiar structure of inter-unit exchange networks. Secondly, it is one of the few studies that examine resource and knowledge exchange at the level of individual project unit, rather than at the organization level. Our findings could be of some interest for project leaders and individuals who manage people working in temporary-based contexts, because they provide important insights about the management of inter-project exchange networks within organizations.

The results of this study must be viewed with respect to a number of limitations. First, most of the data were gathered at a single point of time. While the theory implies causality in a number of relationships studied, this study could not verify the direction of causality. Further, this study was conducted within only two industries. While it enhances the literature in these areas, questions remain open about the empirical extension of our results. Obviously the non-random choice of setting for our study and the specific sample that we have chosen introduce a number of idiosyncratic elements in our design and make its replication in different organizational fields problematic.

References

Barlow J. (2000), "Innovation and learning in complex offshore construction projects", *Research Policy*, 29, pp. 973-989.

Bourdieu P. (1985), *The forms of capital*, in J.G. Richardson (ed.): Handbook for Theory and Research for the Sociology of Education, pp. 241-258.

Bresnen M. (1990), "Project-based learning and the role of learning boundaries", *Organization Studies*, 36(3), pp. 27-41.

Bresnen M., Goussevskaia A., Swan J. (2004), "Embedding New Management Knowledge in Project-Based Organizations", *Organization Studies*, 25(9), pp. 1535-1555.

Burt R.S. (1983), *Range*. In Burt R.S., Minor M.J. (eds), Applied Network Analysis: 176-194. Beverly Hills. CA: Sage.

Burt R.S. (1992), *Structural holes*, Harvard University Press, Cambridge.

Burt R.S. (1997), "The Contingent Value of Social Capital", *Administrative Science Quarterly*, 42, pp. 339-365.

Burt R.S., Hogarth R.M., Michaud C. (2000), "The Social Capital of French and American Managers", *Organization Science*, 11, pp. 123-147.

Cacciatori E. (2004). "Organisational memory and innovation across projects: integrated service provision in engineering design firms". *SPRU*, Paper N°117.

Chung S., Singh H., Lee K. (2000), "Complementarity, status similarity and social capital as drivers of alliance formation", *Strategic Management Journal*, 21, pp. 1-22.

Cockburn I., Henderson R. (1998), "Absorptive Capacity, Coauthoring Behavior and the Organization of Research in Drug Discovery", *Journal of Industrial Economics*, 46(2), pp. 157-182.

Coleman J.S. (1988), "Social Capital in the Creation of Human Capital", *American Journal of Sociology*, 94, pp. 95-120.

Cross R., Cummings J. (2004), "Tie and network correlates of individual performance in knowledge-intensive work", Academy of Management Journal, 47, pp 1451-1492.

De Meyer A., Mizushima A. (1989), "Global R&D Management", *R&D Management*, 19(2), pp. 135-146.

DeFillippi R., Arthur M. (1998), "Paradox in project-based enterprise: The case of filmmaking", *California Management Review*, 40/2, pp. 147-160.

Ebers M., Powell W. (2007), "Biotechnology: Its origins, organization, and outputs", *Research Policy*, 36, pp. 433–437.

Eisenhardt K.M. (1989), "Building theories from case study research", *Academy of Management Review*, 14(4), pp. 532-550.

Fernandez R.M., Gould R.V. (1994), "A dilemma of State Power: Brokerage and Influence in the National Health Policy Domain", *American Journal of Sociology*, 99(6), pp. 1451-1491.

Foss N.J. (2003), "Selective intervention and internal hybrids: interpreting and learning from the rise and decline of the Oticon Spaghetti Organizzation", *Organization Science*, 14, pp. 331-349.

Gabbay S., Zuckerman E. (1998), "Social capital and opportunity in corporate R&D: the contingent effect of contact density on mobility expectations", *Social Science Research*, 27, pp. 189-217.

Gann D. (2000), *Managing innovation in project-based firms. Building Innovation: Complex Constructs in a Changing World*, 218-239, Thomas Telford, London.

Gann D., Salter A. (2000), "Innovation in project-based, service-enhanced firms: the construction of complex products and systems", *Research Policy*, 29, pp. 955-972.

Grabher G. (2002), "The Project Ecology of Advertising: Tasks, Talents and Teams", *Regional Studies*. Taylor and Francis Journals, 36(3), pp. 245-262.

Grabher G. (2004), "Learning in Projects, Remembering in Networks? Communality, Sociality, and Connectivity in Project Ecologies.", *European Urban and Regional Studies*, 11(2), pp.103-123.

Granovetter M. (1985), "Economic action and social structure: the problem of embeddedness", *American Journal of Sociology*, 91(3), pp. 481-510.

Hakanson, L., Zander, U. (1988), "International management of R&D: The Swedish experience", *R&D Management*, 18, pp. 217-226.

Hite J., Hesterley W. (2001), "The evolution of firm networks: from emergence to early growth of the firm", *Strategic Management Journal*, 22, pp. 275-286.

Hobday M. (1998), "Product complexity, innovation and industrial organization", *Research Policy*, 26, pp.689-710.

Hobday M. (2000), "The project-based organization: an ideal form for managing complex products and systems", *Research Policy*, 29, pp.190-241.

Ibert O. (2004), "Projects and firms as discordant complements: organisational learning in the Munich software ecology", *Research Policy*, 33, pp. 1529-1546.

Keegan A., Turner J.R. (2002), *The Management of Innovation in Project-Based Firms*, Elsevier Science Ltd. Pergamon.

Krackhardt D. (1999), "The ties that torture: simmelian tie analysis in organizations. Research", *Sociology of Organizations*, 16: pp. 183-210.

Lawrence P., Lorsch J. (1967), "Differentiation and Integration in Complex Organizations", *Administrative Science Quarterly*, 12, pp. 1-30.

Lincoln J.R. (1984), "Analyzing relations in dyads", *Sociological Methods and Research*, 13, pp.45-76.

Mitzberg H. (1983), *Structure in fives: designing effective organizations*. Prentice-Hall.

Oh H., Labianca G., Chung, M.H. (2006), "A Multilevel Model of Group Social Capital", *Academy of Management Review*, 31, pp. 569-582.

Pennings, J.M., Lee, K. (1999), *Social capital of organization: Conceptualization, level of analysis, and performance implications*, in S.M. Gabbay (Ed.), Corporate social capital and liability, (pp. 43-67), Kluwer Academic, Boston.

Pinto J.K., Rouhiainen P. (2001), *Building Customer-Based Project Organizations*. John Wiley and Sons.

Polanyi M. (1966), *The Tacit Dimension*, Routledge and Kegan Paul: London UK.

Powel W.W., Koput K.W., Smith-Doer L. (1996), "Inter-organizational collaboration and the locus of innovation: Networks of learning in biotechnology", *Administrative Science Quarterly*, 41(1), pp.116-145.

Powell W.W. (1996), "Inter-organizational collaboration in the biotechnology industry", *J. Institutional Theoretical Econom.*, 152, pp.197-215.

Prencipe A., Tell F. (2001), "Inter-project learning: processes and outcomes of knowledge codification in project-based firms", *Research Policy*, 30, 1373-1394.

Reagans R., McEvily B. (2003), "Network Structure and Knowledge Transfer: The Transfer problem Revisited", *Administrative Science Quarterly*, 48(2), pp. 240-267.

Reagans R., Zuckerman E.W. (2001), "Networks, Diversity and Productivity: The Social Capital of Corporate R&D Teams", *Organization Science*, 12(4), pp.502-517.

Sydow J., Lindkvist L., DeFillippi R. (2004), "Project-Based Organizations, Embeddedness and Repositories of Knowledge: Editorial", *Organization Studies*, 25(9), pp 1475-1489.

Thompson J.D. (1967), *Organizations in Action*, McGraw Hill.

Tsai W., Ghoshal S. (1998), "Social Capital and Value Creation: The Role of Intrafirm Networks", *Academy of Management Journal*, 41(4), pp. 464-476.

Van de Ven A.H. (1976), "On the Nature, Formation and Maintenance of Relations Among Organizations", *Academy of Management Review*, pp. 24-34.

Verona G., Ravasi D. (1999), "Core competence per sviluppare nuovi prodotti con continuità", *Economia&Management*, 3-99.

Zenger T. (2002), "Crafting internal hybrids: complementarities, common change initiative and the team-based organization", *International Journal of Economic Business*, 9, pp.79-96.