NETWORK EFFECT ON THE PERFORMANCE OF JOINT R&D PROJECTS

N. Arranz and J.C. Fdez de Arroyabe

Abstract

The purpose of this paper is to investigate how network position can influence the performance of joint R&D projects and how the specific objectives of a project can mediate this relation. These aspects are examined by studying the network position and objectives of joint R&D projects developed within the European networks of excellence. Results highlight that while structural embeddedness exerts a clear influence on the performance of exploitation projects, the effect of degree centrality has a lower impact on exploration projects due to the redundant information that this location implies. Similarly, junctional embeddedness positively affects exploration project performance, while the heterogeneity of partners involved in a betweenness centrality position does not favor the performance of exploitation projects. This paper contributes to social capital theory by showing that the effect of a particular network position on performance depends on joint R&D project objectives.

INTRODUCTION

Joint R&D projects are becoming a viable alternative to the traditional firm-based model, and the proliferation of cooperation has been one of the more enduring features of the organization environment over the last two decades. Increasingly, joint R&D projects have become the fundamental way to generate and to transfer innovations to useful technology, products, or services (Sctock and Tatikonda, 2000; Thamhain, 2003; Pek-Hooi and Roberts, 2005). In fact, researchers have increasingly moved form the dyadic level to a network level analysis in order to understand the nature, effects and interdependencies of such networks (Gulati, 1998; Ahuja, 2000; Koka and

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Prescott, 2002). Such research has focused on the notion of social capital to explain the nature and benefits to firms provided through these networks. Moran (2005) pointed the different levels in which has been studied the impact of social capital on performance, and emphasized that these analyses ranging from the individual and small groups to larger organizations and even communities and nations. Prior research on interfirm agreements has also highlighted that network effect (Ruef et al., 2003), or embeddedness (Granovetter, 1985), affects economic and innovative performance. By their nature, network effect has been found to have a significant impact on the development of joint R&D projects as well as on their success (Grewal et al., 2006).

The evolving structure of the relationships between the heterogeneous partners involved in a joint project—the social capital involved in the system—provides a focus in which organizational researchers have highlighted the importance of embeddedness, or the architectural nature of partners’ relationships (Granovetter, 1985; Grewal et al., 2006). Thus, Ruef et al. (2003) define the “network effect” as the relations among partners and projects that provide partners with access to information and perhaps embedded resources (Portes, 1998; Moran, 2005). The impact of network effect on performance has been studied at multiple levels using different measures of performance. In general, it is accepted that social capital and the resulting network embeddedness have a significant impact on project performance. However, this is a complex relationship and it is not so clear how the network embeddedness of both projects and partners influences project performance. Thus, Burt (1992) pointed out the benefits of access to non-redundant contacts in order to obtain novel information, and Coleman (1988) argued that the location or form of embeddedness allows the actors to access different types of information which have a different impact on the performance of actors. Rosa et al. (1999) and Koka and Prescott (2002) showed that high network embeddedness implies that partners may be exposed to too much information, leading to cognitive overload and poorer work performance. More recently, Grewal et al. (2006) argued that social capital varies across projects and developers and that it plays a critical role in their success. Therefore, the research question to analyze is how location or network embeddedness impact on project performance.
Several theoretical variants of embeddedness can be found in the literature. Following Grewal et al. (2006), we focus on two key dimensions of embeddedness – structural and junctional – as a way to capture and integrate its cumulative effect on joint performance. These two forms of embeddedness bring different types of information and resources to both the project and the project manager. Structural embeddedness captures the centrality of the project and the project manager; hence a central position provides access to a large amount of information derived from the interconnection with many nodes of the social network. Junctional embeddedness assesses connectivity; consequently a central location provides the project and the project manager with access to information which some authors call quality information as a result of its bridge effect between groups of projects not directly interconnected (Koka and Prescott, 2002). Accordingly, we argue that higher values of any of the two locations or forms imply greater embeddedness and social capital.

To understand how network embeddedness is associated with performance in joint R&D projects, we argue that the effect of embeddedness on performance is contingent upon network structure and project objectives. Thus, following Grewal et al. (2006), we examine the embeddedness-performance relationship by simultaneously examining the project / partner’s embeddedness and network structure and objectives. By considering a project / partner’s network structure, we are able to specifically answer our research questions: Under what conditions will structural or junctional embeddedness provide a significant impact on project performance? How might the different objectives of the project (exploration/exploitation) influence this network position-performance relation?

The central tenet of our argument is that social capital varies across projects and partners and that it plays a critical role in the performance of joint R&D projects. To examine this, we focused on the European networks of excellence as our research setting. The networks of excellence of the Sixth Framework Programme provide an ideal setting because these are designed to strengthen excellence in R&D by integrating a critical mass of resources and expertise which are networked around different joint R&D projects. A network of excellence is, therefore, an instrument for strengthening excellence by tackling the fragmentation of European research, aimed at
creating a durable integration of the research capacities of the network participants while advancing knowledge on R&D topics. By simultaneously investigating the project / partner’s position and network embeddedness in European networks of excellence, our paper advances a theory of competitive positioning in the management of networks and provides a more defined understanding of how European networks perform.

THEORY AND RESEARCH HYPOTHESES

Network embeddedness

The concept of embeddedness, according to Zukin and DiMaggio (1990), comprises four broad categories: cognitive, cultural, political and structural. In this paper, we focus on what these authors refer to as structural embeddedness which they define as the conceptualization of economic exchange in the pattern of ongoing interpersonal relations. However, this concept has different theoretical variants. Thus, Uzzi (1996, p.675) suggested that ‘structural embeddedness focuses on the relational quality of inter-actor exchanges and the architecture of network ties’. Nahapiet and Ghoshal (1998) and Krause et al. (2007) pointed out that structural dimension results from the structural configuration, diversity, centrality and boundary-spanning roles of network participants. According to this perspective, Tsai and Ghosal (1998) highlighted that structural dimension includes social interaction, and recognized that the resulting interactions due to the location of an actor’s contacts in a social structure provide certain advantages. Gulati (1995, 1998) explained that structural embeddedness or positional perspectives on networks go beyond the immediate ties of firms and emphasize the informational value of structural position that the nodes occupy in the network, using the terms structural and positional embeddedness interchangeably. To capture the architecture of network embeddedness, Grewal et al. (2006, p. 1045) proposed three subconstructs: structural, positional and junctional embeddedness. ‘Structural embeddedness captures the extent to which an actor is entrenched in a network of relationships’; ‘positional embeddedness appraises the extent to which an actor is connected with other structurally embedded entities’, and ‘junctional embeddedness assesses the extent to which an actor connects with other
actors’. These authors explain that each form of network embeddedness allows the network nodes to access or spread information with different characteristics. Thus, *structural embeddedness* enables the node to access more/less information, i.e., a node very well connected with others which receive a great amount of information. *Positional embeddedness* makes reference to the information received or sent by the node, i.e., a node closely connected with a central nucleus of nodes, allows it to access/send important information. Finally, *junctional embeddedness* allows the node to access higher/lower quality information depending on its network position, i.e., a node which serves as bridge between two important clusters of the network. Our focus here is on *structural* and *junctional embeddedness*, that is, on quantity information vs. quality information as a way to capture and integrate the cumulative effect of embeddedness in joint project performance.

**Project objectives**

Joint R&D projects may have different objectives and hence, develop different activities, so the need for information and resources in each case may differ. As noted above, we analyze two broad categories of projects, exploration and exploitation projects. The distinction between exploration and exploitation goes back to Holland (1975) and was later developed by March (1991). As March (1991) pointed out, R&D comprises a great spectrum of projects, from those whose objectives are exploitation, that is, the refinement and extension of existing competencies, technologies and paradigms, to those whose objectives are exploration, that is, the experimentation with new or uncertain alternatives. While exploitation involves using existing information to improve efficiency and returns from present strategies, competencies, and procedures, exploration entails searching and experimenting to find emerging innovations that will produce future profits.

Thus, exploitation can be characterized as a process of routinization, which adds knowledge base and competence to the existing firms without changing the nature of activities. Exploration, in contrast, can be characterized as a break with an existing dominant design that shifts away from existing rules, norms and routines, in search of novel combinations. Gilsing et al. (2008) point out, from the firm’s perspective, that
exploration tasks involve the creation of technological knowledge which is new to the
term. Two characteristics, therefore, may possess the information in an exploration
project: heterogeneity which allows partners to access novel information, and non-
redundancy which avoids the overload of the information processing capacity and
facilitates the ability to detect new alternatives. Since these two projects are quite
different and require different resources and partners, we expect that structural
attributes of networks will have an unequal impact on the formation and the
performance of each network of projects.

**Structural embeddedness and project performance**

When the structural embeddedness of a project is high, projects are connected to
larger number of partners which allow to access to greater resources. Grewal et al.
(2006), point out that the complex tasks associated with R&D development can be
spread over more developers, resulting in better organization, and hence higher
performance. On the other hand, structural embeddedness of a project implies that
projects have access to a large amount of information. However, this information is
not free of redundancies, which may hinder the ability to search for new alternatives
(Koka and Prescott, 2002). Hence, the influence of structural embeddedness should be
negative as it ensures a greater quantity of information, and the value of project
embeddedness should decline due to the homogeneous and redundant information.

In the case of a project manager, the structural embeddedness is higher when the
project manager works on more projects. This large number of linkages implies that
the project manager may be exposed to too much information, which may lead to
cognitive overload and poorer work performance (Rosa et al., 1999; Gilsing, and
Nootenboom, 2006). Grewal et al 2006, point out that access to a greater quantity of
information can be important in the case of mature or incremental R&D projects.
Nevertheless, when the project manager is engaged in multiple projects, the different
ways of managing these projects will result in the enrichment of its coordination role
thereby increasing the project performance. Therefore, we propose:
Hypothesis 1a: The structural embeddedness of a project / project manager will positively influence the project performance of some projects and negatively influence the performance of others.

In the performance of the exploration and exploitation projects, we should note that in exploration projects, the influence of structural embeddedness will be less positive than in exploitation projects. While structural embeddedness ensures a greater quantity of information, this position may saturate the project/project manager’s ability to create new alternatives as a result of the large amount of information received by participating in multiple projects. Therefore, the value of project/project manager structural embeddedness should decline in exploration projects due to the homogeneous and redundant information managed. Accordingly, we propose:

Hypothesis 1b: The likelihood that structural embeddedness positively influences project/project manager performance will be higher in exploitation than in exploration projects.

Junctional embeddedness and project performance

When the junctional embeddedness of a project is high, this implies access to different flows of information through partners who have participated in mutually unconnected projects (Gulati, 1995; Hargadon and Sutton, 1997; Gilsing and Nooteboom, 2006). This provides, on the one hand, access to heterogeneous information, and on the other, non-redundant information which as March (1991) points out, are the conditions needed to create new knowledge. Following Gilsing et al, (2008), the interconnection with different projects allows partners to access alternative ways of thinking and enables them to create new combinations for new uncertain alternatives. In sum, the influence of high junctional embeddedness should be positive as it tends to facilitate the fundamental process of searching for new alternatives, which may lead to improved project performance. Nevertheless, other studies highlight the positive effect on performance that past experiences and the trust level achieved between partners have in the development of projects (Poppo and Zenger, 2002; Liu et al., 2006). Therefore, from this latter point of view, junctional embeddedness may affect negatively the project
It is the project manager who plays the key role of coordinating the overall project. Thus, the junctional embeddedness of project managers allows them to access different flows of information as they act as a node of connection between mutually unconnected projects (Hargadon and Sutton, 1997), and hence, to have the possibility of receiving heterogeneous and non-redundant information. This will encourage the project manager to create or rethink alternatives through the information received and due to the central role that s/he plays, leading to improved project performance. Koka and Prescott (2002), and Gilsing et al. (2008) point out that higher quality information available to the manager results in greater technical solutions and will increase the likelihood of the success of the project. Nevertheless, the junctional embeddedness of the project manager will hinder his/her coordination tasks as a result of managing mutually unconnected projects. Therefore, we propose:

Hypothesis 2a: The junctional embeddedness of a project / project manager will positively influence the project performance of some projects and negatively influence the performance of others.

In exploitation projects, the influence of junctional embeddedness should be less positive than in the case of exploration projects, as a result of the low level of relationship between partners: on the one hand it increases the difficulty of creating a cooperative climate and the existence of trust between the partners, which may hinder the performance of the project; and, on the other hand, it hinders the interaction between partners, and affects the transmission and the appropriability of knowledge. Accordingly, we propose:

Hypothesis 2b: The likelihood that junctional embeddedness positively influences project / project manager performance will be higher in exploration than in exploitation projects.

DATA AND MEASURES

Data collection

To test the above hypotheses, we collected our data from the FP6 Networks of Excellence database. Networks of excellence have played a prominent role in overcoming the fragmentation of the European research system and strengthening the
European position in specific research areas. The creation of these networks was supported with European financing, but their activities have not become dependent as a result of this support. In fact, the European funding has complemented resources deployed by the participants, taking the form of fixed grants for integration. Networks have therefore carried out “clusters” of integrated projects in different research areas. These are long term and have a multidisciplinary nature, and the participants have been paid on the basis of the degree of integration achieved and the number of partners actively participating in the network, rather than as a result of R&D output.

Networks of excellence involve at least three legal entities from three different Member States or Associated States, though in practice the number of participants is substantially higher than three and generally no fewer than six. Larger networks might involve hundreds of researchers. Others might be of a much more limited size, on the basis of the goals pursued and the critical mass needed to achieve these goals. The dataset provides detailed information on 247 research projects and 2,770 participants. The 247 projects were distributed over 7 priority areas with a clear preponderance in the area of Information Society Technologies.

To evaluate the consequences of different location or form embeddedness in joint project performance, we rely on two-mode affiliation networks (Faust, 1997; Grewal et al., 2006) based on partners and projects, and two types of projects, exploration and exploitation projects. Joint R&D projects are developed by partners who are related to one another because they work together on projects, and projects are related to one another because they share partners. We use the project as the unit of analysis (because R&D projects have different partners) and assess partner embeddedness by measuring the embeddedness of the project manager (Grewal et al., 2006).

Following the methodology proposed by Grewal et al. (2006), we constructed two affiliation matrixes. The first matrix for exploration projects with 431 rows (partners) and 67 columns (projects), and a second affiliation matrix for exploitation projects with 310 rows (partners) and 95 columns (projects), providing an appropriate sample of projects to represent the EU Networks of Excellence (Cordis, 2004).
Measures

Independent variables

To capture the network embeddedness of projects and project managers we consider a network to be a set of points, called nodes or vertices, with connections between them, called links, ties or edges. Two-mode Affiliation networks allow one to study the dual perspective of the project and the project manager.

Following Grewal et al. (2006), we consider an affiliation network $A$ in which the rows represent the partners and the columns represent the projects with 1 when a partner belongs to a project and 0 otherwise. Thus, we can obtain the valued matrixes for partners ($X^{pi}$) and projects ($X^{pj}$) as:

$$X^{pi} = AA'$$
$$X^{pj} = A'A$$

where $A'$ is the transpose matrix.

The network embeddedness, which is determined by the diverse measures of centrality, examines the different contributions/receptions of each partner/project to the network. These measures have been used by Gulati and Gargiulo (1999), Wasserman and Faust (1999) and Grewal et al. (2006) in the context of network analysis.

1. For structural embeddedness we use the degree centrality (Grewal et al. 2006). Degree centrality (Faust, 1997) for partner $i$ is defined as $C_D(X^{pi})$ and for project $j$ is defined as $C_D(X^{pj})$ such as

$$C_D(X^{pi}) = X^{pi}_{ii}$$
$$C_D(X^{pj}) = X^{pj}_{jj}$$

where the network has $i$ partners and $j$ projects; the degree centrality for a partner $i$ is the $i$th diagonal element of $X^{pi}$, and in a similar manner is calculated for projects.

2. For junctional embeddedness we use betweenness centrality (Grewal et al. 2006). For calculating betweenness centrality, that is, the shortest path between two partners or projects, Freeman (1979) proposes a two-step procedure. First, calculating ‘partial betweenness’ ($p_i$) of partners, that is, the number of pairs of partners whose geodesic paths contain the partner $i$; and then using this partial betweenness to calculate partner betweenness. Betweenness centrality for partner $i$ is then given as
\[ C_B(X_{pi,j}) = \sum g_{jk}(p_i)/g_{jk} \]

where \( g_{jk} \) is the number of geodesic paths between partners \( j \) and \( k \), and \( g_{jk}(p_i) \) is the number of geodesic paths between \( j \) and \( k \) that contain \( i \), with \( j<k \).

The measures have been processed by UCINET software version 6.118 (Borgatti et al., 2002).

**Dependent variable**

Network performance was operationalized using a selection of performance indicators marked by the European Commission (Cordis, 2004) of what could be expected from a networking aiming at achieving a satisfactory level of integration at the end of the funding period. To evaluate this variable, the European Commission relied on project managers’ evaluations using a five-point Likert scale (5= completely achieved, 4= mainly achieved, 3= partially achieved, 2= scarcely achieved, 1= not achieved at all). The scale item reflected: (1) the communications inside the network; (2) the sharing and common management of equipment, installations, and infrastructures; (3) the common management of human resources; (4) the common knowledge management; (5) the network management; and (6) the continuity of the network after the conclusion of the Community’s funding period.

**RESULTS AND DISCUSSION**

Table 1 presents the correlation coefficients for all variables used in this study and Table 2 reports the regression results.

Table 2 presents the results of the estimation. We estimated five different model specifications taking into account both exploration and exploitation projects. Model (M1) contains the dependent variable as a function of the degree centrality for both the project and project manager in exploitation projects, and betweenness centrality for project and project manager in exploration and exploitation projects. Model 2 captures the dependent variable as a function of the degree centrality for project and project manager in exploration projects, and betweenness centrality for project and project manager in exploration and exploitation projects. Model 3 captures the dependent
variable as a function of the degree centrality for project and project manager in exploration and exploitation projects, and betweenness centrality for project and project manager in exploitation projects. Model 4 captures the dependent variable as a function of the degree centrality for project and project manager in exploration and exploitation projects, and betweenness centrality for project and project manager in exploration projects. Model 5 captures the dependent variable as a function of the degree centrality for project and project manager in exploration and exploitation projects, and betweenness centrality for project and project manager in exploration and exploitation projects. Model fits are acceptable with significant chi-square values ($p < 0.001$) and $R^2$ values ranging from 0.372 to 0.501.

From the results of Models 1, 2, 3, 4, and 5, positive relationships were found between degree and betweenness centrality of the projects in exploration and exploitation projects and their performance. However, our results do not confirm these positive relationships between location, in the case of the project manager, and performance, which supports the hypotheses 1a and 2a. In fact, in exploration projects, we observe a significant positive relation between the location of the project [degree centrality ($\beta = 0.156; p < 0.10$), betweenness centrality ($\beta = 0.417; p < 0.01$)] and its performance. Similarly, we observe a significant positive relation between the location of the project manager as betweenness centrality ($\beta = 0.301; p < 0.05$), and performance. On the other hand, in exploitation projects, we find a positive and significant relation between degree centrality in the case of project ($\beta = 0.212; p < 0.05$), and project manager ($\beta = 0.335; p < 0.05$), and performance. Similarly, our results show a significant positive relation between the location of the project as betweenness centrality ($\beta = 0.118; p < 0.10$), and performance. These findings are consistent with previous studies (Grewal et al., 2006) which suggest that the location of projects and project managers has a different impact on the performance of projects, as a function of the kind of projects considered; it also corroborates the contingency character of the form of embeddedness.

Following Liu et al. (2009), the critical test of the relationship is used to examine the differential effects that the project and project manager locations (centrality/betweenness) have on performance (Hypotheses 1b and 2b). We examined
these effects through the proportion of variance explained by these mechanisms. Firstly, we determined whether degree centrality influences project/project manager performance in exploration and exploitation projects (Hypothesis 1b). Thus, we obtain $\Delta R^2$ as follows from the regression results of Model 5 and Model 1: $\Delta R^2_{\text{Model5-Model1}} = R^2_{\text{Model5}} - R^2_{\text{Model1}} = 0.501 - 0.428 = 0.073$. Here $\Delta R^2_{\text{Model5-Model1}}$ represents the proportion of the variance of performance of exploration projects that can be explained by project and project manager degree centrality. Similarly, $\Delta R^2_{\text{Model5-Model2}}$ represents the proportion of the variance of performance of exploitation projects explained by project and project manager degree centrality. In order to determine which locations are perceived to have a greater impact on improving the performance of exploration and exploitation projects, we determined the balance of proportion of the variance explained by each location. Since $\Delta R^2_{\text{Model5-Model3}} > \Delta R^2_{\text{Model5-Model4}}$, we can conclude that degree centrality has greater impact on exploration than exploration projects, which corroborates Hypothesis 1b. Thus, we can observe the positive and significative impact that the structural embeddedness has on exploration projects, which confirms that the redundancy of the information has less impact on the performance of exploitation projects than on exploration projects.

Similarly, we have determined project/project manager performance both in exploitation and exploration projects (Hypothesis 2b). We obtain $\Delta R^2$ as follows from the regression results of Model 5 and Model 3. Here $\Delta R^2_{\text{Model5-Model3}}$ represents the proportion of the variance of exploration projects performance that can be explained by the project and project manager betweenness degree. Similarly, $\Delta R^2_{\text{Model5-Model4}}$ represents the proportion of the variance of exploitation project performance explained by project and project manager degree centrality. Since $\Delta R^2_{\text{Model5-Model3}} > \Delta R^2_{\text{Model5-Model4}}$, we can conclude that betweenness centrality has greater impact on exploration than exploitation projects, which corroborates Hypothesis 2b. Thus, we can observe the positive and significative impact that the junctional embeddedness has on exploration projects, which confirms that the heterogeneity of partners has a positive impact on the performance of the exploration projects but not in the case of exploitation projects.
CONCLUSION

This research analyzes the effects of the location of projects/project managers on the performance of R&D collaboration networks. Our empirical analysis improves our understanding as to how the form of embeddedness impacts on the performance of exploration and exploitation projects. Thus, it extends social capital theory to analyze the impact of the network effect on project and project managers by taking into account the different objectives of joint R&D projects. Consistent with the social capital theory our results confirm that project and project manager embeddedness have a differential impact on the performance of exploration and exploitation projects, which corroborates the contingency nature of the network effect. From an empirical point of view, our analysis offers evidence regarding the performance implications of the structural and junctional embeddedness in R&D projects. Although previous research has highlighted the positive contribution of network embeddedness to the performance of partnership relationships, our results suggests a need to explore more carefully and predict more cautiously the effect of network embeddedness on project performance.

However, this study is not devoid of limitations which should be addressed in future attempts. Furthermore, one should be cautious in generalizing the findings. First, we used only R&D projects developed within the framework of EU programs devoted to promoting partnerships, thus we cannot substantiate our claims and findings beyond these sponsored projects. It therefore seems useful to consider other types of projects in transversal and longitudinal studies as well, which could provide new evidence into the effects of the evolution of interorganizational relationships on R&D. Future research efforts directed at studying the network effect in joint projects in other contexts and locations would also be interesting. Moreover, future research should examine other dimensions of embeddedness to look for additional factors which might offer new insights from a social capital perspective.
REFERENCES


### Table 1. Pearson Correlation Matrix

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
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<tbody>
<tr>
<td>1. Degree centrality exploration project</td>
<td>-0.305</td>
<td>0.037</td>
<td>0.015</td>
<td>0.166</td>
<td>-0.091</td>
<td>0.079</td>
<td>0.002</td>
<td>0.201</td>
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<tr>
<td>2. Degree centrality exploration project manager</td>
<td>-0.102</td>
<td>0.163</td>
<td>0.028</td>
<td>0.017</td>
<td>0.155</td>
<td>0.050</td>
<td>0.136</td>
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<td>3. Degree centrality exploitation project</td>
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<td>0.099</td>
<td>0.019</td>
<td>0.015</td>
<td>0.070</td>
<td>0.325</td>
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<tr>
<td>4. Degree centrality exploitation project manager</td>
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<td>0.158</td>
<td>0.123</td>
<td>-0.073</td>
<td>0.187</td>
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<tr>
<td>5. Betweenness centrality exploration project</td>
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<td>0.124</td>
<td>0.173</td>
<td>0.390</td>
<td></td>
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<td>6. Betweenness centrality exploration project manager</td>
<td>-0.128</td>
<td>0.142</td>
<td>0.270</td>
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<td>7. Betweenness centrality exploitation project</td>
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<td>0.125</td>
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<tr>
<td>8. Betweenness centrality exploitation project manager</td>
<td>-0.104</td>
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<td>9. Performance</td>
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</table>

### Table 2. Results of regression analyses predicting social impact in exploration/exploitation joint R&D projects.

<table>
<thead>
<tr>
<th>Measure</th>
<th>Variable Type</th>
<th>Variable Name</th>
<th>M1</th>
<th>M2</th>
<th>M3</th>
<th>M4</th>
<th>M5</th>
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<tr>
<td>Degree Centrality</td>
<td>Exploration</td>
<td>Project</td>
<td>-0.173*</td>
<td>0.110*</td>
<td>0.141*</td>
<td>0.156*</td>
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<tr>
<td></td>
<td></td>
<td>Project manager</td>
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<td>0.092</td>
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<td></td>
<td>Exploration</td>
<td>Project</td>
<td>0.234**</td>
<td>-</td>
<td>0.199*</td>
<td>0.189*</td>
<td>0.212**</td>
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<td></td>
<td></td>
<td>Project manager</td>
<td>0.273**</td>
<td>-</td>
<td>0.299**</td>
<td>0.304**</td>
<td>0.335**</td>
</tr>
<tr>
<td>Betweenness Centrality</td>
<td>Exploration</td>
<td>Project</td>
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<td>0.389***</td>
<td>-</td>
<td>0.376***</td>
<td>0.417***</td>
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<td>Project manager</td>
<td>0.291**</td>
<td>0.256**</td>
<td>-</td>
<td>0.250**</td>
<td>0.301**</td>
</tr>
<tr>
<td></td>
<td>Exploration</td>
<td>Project</td>
<td>0.133*</td>
<td>0.125*</td>
<td>0.110*</td>
<td>-</td>
<td>0.118*</td>
</tr>
<tr>
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<td>Project manager</td>
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<td>0.097</td>
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<td>0.036</td>
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<td>0.372</td>
<td>0.341</td>
<td>0.454</td>
<td>0.501</td>
</tr>
</tbody>
</table>

*p < 0.10; **p < 0.05; ***p < 0.01