

# THE RELATIVE VALUE OF THE DIVISION VERSUS DUPLICATION OF NETWORK TIES FOR INNOVATION PERFORMANCE

## Abstract

Exploiting a unique setting of R&D technologists and managers in a large multinational who are “partnered-up” in their pursuit of innovation, this paper explores under what circumstances technologists and managers benefit from duplicating network ties to the same groups in the organization as their partner, or from dividing the network with their partner by each interacting with different groups. Introducing the concept of *network duplication* – the extent to which two individuals are tied to the same functional groups inside an organization – this paper aims to build and test a theory of the division versus duplication of networks. It advances our understanding of second-order social capital and its role in the interpretation and influencing aspects of the innovation process by shedding light on how network duplication affects technologists’ and managers’ innovation performance. It finds that the merits of a division versus duplication-of-networks approach are contingent on the mutual interdependence of managers and technologists.

## INTRODUCTION

*“Innovation occurs when the what’s needed meets the what’s possible”.*

This is how one of our interviewees, a senior technologist in Jupiter – pseudonym for a large technology-intensive multinational – summarized the quest for innovation in large organizations. Within R&D, it is common for organizations to create dual career ladders (Katz, Tushman, & Allen, 1995), ensuring a division of labor exists between technologists who are tasked with identifying and pursuing novel technological opportunities, and managers tasked to recognize and pursue market or business opportunities for the organization (Blau & Scott, 1962; Gouldner, 1954). These dual career ladder systems allow technologists and managers to specialize in science- or business-specific skill sets respectively and progress their careers along separate paths.

Although an internal division of labor allows employees to exploit individual advantages in skills and expertise and individually better contribute to organizational goals (Lawrence & Lorsch, 1967; Strauss, 1985), it also introduces a mutual dependence between co-workers (Thompson, 1967). Not only do technologists depend on managers’ information, skills and expertise, and vice versa, in their joint pursuit of innovation, they also rely on each other’s ability to effectively mobilize networks. To generate novel ideas and build a structure of support behind them, R&D workers – both technologists and managers – will frequently leverage their network ties to access valuable information and to influence key stakeholders (Burt, 1982; Ibarra, 1993). Particularly in established organizations, successful innovation depends on individuals’ efforts to mobilize intra-organizational relationships to gain legitimacy and acquire the necessary resources for novel ideas to take root (Ancona & Caldwell, 1992; Howell & Higgins, 1990). We argue that the success of an individual technologist’s or manager’s efforts to innovate depends not only on

the configuration of their own network but also that of their partner.

Despite the often taken-for-granted nature of the division of labor in R&D in large corporations (Hoffmann, Hoegl, Muethel, & Weiss, 2016; Katz et al., 1995), prior research has not explored in detail whether and how technologists and managers benefit from each other's networks. Specifically, it is unclear whether they are better able to be innovative when duplicating connections to the same groups inside the organization, or whether they are better off not only dividing the work, but also dividing the *network* they rely on in the conduct of their work. Extant research on social capital predominantly portrays social networks as a resource that provides advantages to the individuals themselves (Burt, 2004; Kilduff & Brass, 2010). Only relatively recently have scholars started to explore the possibility that social networks may have positive externalities, as network advantages may extend to those who are connected to high-social-capital alters (Galunic, Ertug, & Gargiulo, 2012). That is, despite Burt's evidence that the returns to brokerage tend to accrue mostly to the broker and hardly indirectly to those connected to brokers (Burt, 2007), other research has advocated the view that social capital may under certain circumstances spillover to third parties (Brass, 2009; Leana & Van Buren, 1999). In fact, the Katz et al. (1995) original study on dual career ladder systems itself showed that technologists benefitted from having gatekeepers as supervisors. The possibility of second-order social capital effects raises a number of questions about the types of network configurations, and the conditions under which, network advantages spill-over. With respect to collaborating technologists and managers, we are particularly interested in understanding whether individuals benefit more from having connections to the same parties as their partner, or rather from access to complementary connections which they themselves do not have. Accordingly, the central question in this study is whether R&D technologists and managers who depend on each other for

achieving innovative success are better able to benefit from each other's social networks if their networks are targeted at the same or different groups in the organization.

In this paper, we address this question by introducing the concept of network duplication to describe the extent to which the networks of two individuals are oriented towards the same functional groups. We define functional groups as groups in the organizational dual career ladder structure – at different levels of seniority and across both ladders – each holding relevant information or being influential in the innovation process and thus providing a rationale for why technologists or managers would want to connect to them. Network duplication thus characterizes the extent to which two individuals have overlapping networks to functional groups (Blau & Scott, 1962). On the one hand, duplicated connections – i.e. having a partner with ties to the same functional groups in the organization – may be valuable through the redundancy and triangulation opportunities that shared alter groups bring (Ter Wal, Alexy, Block, & Sandner, 2016). We will argue that dual interpretation and dual influencing advantages will, on balance, lead to a positive effect of network duplication on the innovative performance of technologists and R&D managers. On the other hand, there are costs associated with network duplication, as well as intrinsic advantages to the division of network ties that, under certain conditions, may lead to a performance benefit of network division. Specifically, non-duplicated networks between manager-technologist partners may be valuable because it allows them to maximize the benefit from their own and their partner's individual relative advantages in social capital and lead to potential diversity advantages (Burt, 2004; Fleming, Mingo, & Chen, 2007; Hargadon & Sutton, 1997). We will argue that the limits of duplication and the merits of division become more pronounced if the interdependence between managers and technologists is unbalanced, leading to positive performance outcomes for either the manager or the technologist depending

on how the interdependence shifts.

To test the validity of our claims, we exploit the context of R&D partnerships in a large knowledge-intensive multinational, which we refer to as Jupiter. Jupiter operates a dual career-ladder system, with clearly defined managerial and technologist roles and separate promotion paths. R&D technologists and managers in Jupiter are “partnered up” in their quest for generating innovations for the organization. Whilst technologists and managers cover different aspects of the innovation process – i.e. they engage in a division of labor – the partnership model adopted in Jupiter formalizes the expectation they provide input to and feedback on each other’s work on an ongoing basis. We conducted a multi-method study combining interviews, surveys, and archival data to examine our research questions.

### **THE DIVISION OF LABOUR IN R&D**

A critical challenge in corporate R&D is to match advances in science and technology to needs in the market for new or improved products (Van de Ven, Polley, & Garud, 1999). In a bid to orchestrate the match between technological insight and market understanding, organizations typically develop specialized manager and technologist roles responsible for different aspects of that challenge (Blau & Scott, 1962; Gouldner, 1954). R&D units commonly operate dual career ladder structures, with separate career trajectories and promotion pathways for technologists and managers (Katz et al., 1995). Dual career systems separate technologists and R&D managers in distinct functional groups delineated by hierarchical levels. In recognition that technologists and managers have very different skill sets, the dual career ladder system allows technologists and managers to focus their efforts on their respective areas of strength and advance their careers by excelling along different performance parameters (Blau & Scott, 1962; Gouldner, 1954). In this way, functional groups in corporate R&D units foster specialization and thus create a division of

labor between R&D managers and technologists. A similar division of labor often occurs in entrepreneurial teams, such as Steve Jobs and Steve Wozniak at Apple or Rod Canion and Jim Harris at Compaq, that largely mimic manager and technologist roles in corporate R&D.

At the same time, the division of labor between R&D technologists and managers gives rise to interdependencies (Lawrence & Lorsch, 1967). We distinguish two different types of interdependency: knowledge and functional. First, the specialization of technologists and R&D managers in technical and business knowledge domains respectively necessitates coordination between these roles (Postrel, 2002). Neither technologists, nor R&D managers alone have sufficient expertise to achieve innovation on their own. Rather, each depends on the other to contribute complementary expertise to integrate scientific knowledge and business insight. Second, technologists and R&D managers are also specialized in functional terms. For an idea to evolve from inception through to implementation, it requires support to overcome resistance in light of inherent technological uncertainty, and resource provision to enable the research and development activities to be carried out (Howell & Higgins, 1990; Perry-Smith & Mannucci, 2017). It is typically the role of technologists in R&D units to provide legitimacy to new technological directions, which by their very nature are untried and untested (Ancona & Caldwell, 1992; Dougherty & Heller, 1994). By the same token, R&D managers typically play the leading role in amassing the resources required to advance ideas from inception to realized innovations (Perry-Smith & Mannucci, 2017). Thus, corporate R&D is characterized by an inherent interdependence whereby technologists and R&D managers are dependent on each other, yet in different ways.

### **THE ADVANTAGES OF NETWORK DUPLICATION**

In addition to relying on each other, partnered technologists and R&D managers also draw on the

input and support from their broader network of relationships in the R&D unit (Podolny, 2001). For example, other technologists and R&D managers can be a valuable source of information, providing input, advice and feedback on the viability of a project. Likewise, senior technologists can provide influence and informal endorsement for projects, whereas senior managers typically grant formal approval (Gouldner, 1954). That is, each of the functional groups in the dual career ladder structure represent distinct sources of information and influence, hence providing a distinct rationale as to why a focal manager or technologist – or both – should connect to them. We define *network duplication* as the extent to which two individuals have network ties to equivalent contacts, whereby equivalence is defined in terms of membership in the functional groups of the dual career ladder system. As illustrated in Figure 1B, a manager and a technologist who have the same number of ties to each of the functional groups engage in full duplication of network ties. In contrast, as shown in Figure 1A, a manager and technologist having no connections to the same functional groups engage in a full division of networks.

\*\*\* INSERT FIGURE 1 ABOUT HERE \*\*\*

We argue that, on balance, the benefits of duplication generally outweigh those of division. That is, we begin by proposing the advantages of duplication for achieving innovation performance as a baseline, after which we identify the conditions under which the division of ties may be more beneficial. There may be various associated with a duplication of networks, but two advantages of network duplication stand out in particular: interpretation and influence.

First, there may be interpretation advantages for a technologist and manager who work together and both have direct access to the same functional groups. How technologists and managers receive and understand information from functional groups differs for network division versus duplication. Network division creates reliance of the manager on the

technologist's interpretation of information, and vice versa. If one party lacks connections to a particular functional group and only receives information from that group via their partner, that party only obtains the interpreted – potentially biased or colored – information, which is more difficult to challenge or contest (Gavetti & Warglien, 2015). In contrast, network duplication allows both parties to independently interpret information that they each source from a functional group. As a result, technologists and managers have the opportunity to exploit interpretive differences and engage in joint sensemaking of market opportunities and technological solutions (McFadyen & Cannella, 2004). Technologists and managers may have very different interpretive schema and thus would deduce different conclusions or implications from information obtained from the same group (Brewer & Nakamura, 1984; Simon & Feigenbaum, 1964; Weick & Roberts, 1993). They may not only have interactions with different individuals within a specific functional group, but they would also interpret information obtained from the same individuals differently. This helps ensure that partnered managers and technologists develop different, and potentially divergent, perspectives based on interactions with a particular functional group, which form a crucial input for the joint sensemaking process and enable creative abrasion (Leonard-Barton, 1995).

Second, there may be network duplication advantages in the influencing of functional groups in the organization. Since, as Schumpeter pointed out, established organizations in particular 'tend to be conservative', novel ideas typically lack legitimacy and require vigorous championing efforts to move forward (Ancona & Caldwell, 1992; Howell & Higgins, 1990; Mueller, Melwani, & Goncalo, 2012). If technologists and managers seek to influence the same groups in the organization, dual messages about the technological merit and market potential of an idea respectively will reach relevant functional groups. Due to the error-reducing properties of



multi-channel information (Shannon & Weaver, 1948), dual messages from technologists and managers allow members of these groups to triangulate between the manager's and technologist's version of the innovation case being made and form a more complete picture of its potential. Additionally, people tend to grant greater credibility to information, when it reaches them from multiple sources (Centola & Macy, 2007). Jointly attempting to influence the same functional groups in the organization may thus allow the manager and technologist collectively to build greater political clout, and facilitate their joint innovation efforts to receive support or endorsement from relevant functional groups.

Taken together, we expect partnered technologists and managers who engage in network duplication to realize the benefits of dual interpretation and greater influence, which will allow them to achieve higher innovation performance than those partners who divide their networks.

We hypothesize:

*H1a. The greater the duplication in networks between technologists and their R&D manager partner, the higher will be the technologist's innovative performance.*

*H1b. The greater the duplication in networks between technologists and their R&D manager partner, the higher will be the manager's innovative performance.*

### **THE CONTINGENT ADVANTAGE OF NETWORK DIVISION**

Despite the overall advantageous effect of network duplication for managers' and technologists' innovation performance, as hypothesized above, there may be certain costs associated with the duplication of networks. In addition, there may be advantages associated with the division of networks. Below, we will argue that a key condition under which the limits of network duplication occur and the advantages of network division take effect relates to the nature and potential imbalance of the interdependence between technologists and R&D managers working together. We further suggest that the effects of interdependence imbalance are asymmetric –

altering the tradeoffs of network duplication and division for technologists under certain circumstances and for managers under others.

### **Manager technical expertise**

While it is most frequently the case that it is the technologist who predominantly possesses deep technical expertise, R&D managers typically also have varying degrees of technical expertise relevant to their innovation work. In dual-career ladder organizations, a typical stepping stone to becoming an R&D manager is from experience as an R&D scientist or engineer (Katz et al., 1995). We argue that when R&D managers are knowledgeable in the core knowledge domains of the technologist with whom they work, the balance of interdependence is altered.

Although deep technical knowledge makes the R&D manager less dependent on the technologist for scientific expertise, the technologist still relies on the R&D manager for market understanding and business intelligence. Similarly, while the dependence of the R&D manager on the technologist for scientific legitimacy is lessened due to the manager's ability to speak with greater technical authority, the technologist's dependence on the R&D manager for accruing resources is unchanged. In this way, the relation between the technologist and R&D manager transitions from one of mutual interdependence to a relation of power imbalance (Casciaro & Piskorski, 2005; Emerson, 1962) whereby the technologist more strongly depends on the R&D manager than vice versa. Fundamentally, the manager takes on an attribute of the technologist – namely technical knowledge – which makes it possible for the technologist to rely on the manager more extensively. We argue that, as a result, the relative benefits of the division versus duplication of networks change for technologists' innovation performance whilst the benefits of duplication for managers' innovation performance remain unchanged. Specifically, we argue that technologists who work with managers with deep technical expertise will benefit from a

division-of-networks approach, whereas those working with managers with limited technical expertise benefit from a duplication-of-networks approach.

First, the benefits of dual interpretation and influencing described in our baseline prediction are diminished for the technologist if their manager partner has deep technical expertise. Manager technical expertise increases common ground between managers and technologists (Cramton, 2001), which increases the trust that a technologist places in their manager partner's ability to effectively communicate the technical aspects of their joint work to the functional groups to which the manager is exclusively tied. That is, a technically competent manager will be able to judge the technical knowledge that the technologist exclusively obtains from certain functional groups without direct access to the same functional groups. In these circumstances, duplicated connections which would allow for the dual interpretation (Gavetti & Warglien, 2015) offer modest benefit, since sufficient common ground allows the manager to challenge and contest new technical insights, contributing to developing the scientific underpinnings of new ideas and working alongside the technologist in elaboration of the ideas. Likewise, dual influencing by technologists is less necessary if their manager partner has deep technical knowledge. That is, technologists can effectively rely on such managers to vie for their joint work and influence groups they themselves are not connected to, because managers can make a strong case from the market or business perspective *and* a scientific or technological viewpoint without the need of technologists adding their voice directly.

Second, there are certain intrinsic advantages for technologists engaging in a division of networks with a manager partner with deep technical knowledge. We argue that such technologists better redirect the time and energy otherwise invested in the duplication of their manager partner's ties into cultivating or leveraging ties to non-overlapping groups that bring

diversity. That is, there is an opportunity cost associated with network duplication in that spending time and energy on tie duplication comes at the expense of building, maintaining and leveraging connections that maybe more pertinent to one's own role. As Burt (1992: 21) argues, *“some portion of the time spent maintaining ... redundant ... connections can be reallocated to expanding the network”*. In addition, expanding the network – and reaching out to groups the technologist's manager partner is not tied to – is all the more important, the deeper the technological knowledge of the manager. Akin to a closed-specialised network where the risk of groupthink abounds (Janis, 1972; Ter Wal et al., 2016), technologists' duplicated networks with a manager with deep technical expertise may leave insufficient opportunity for diverse inputs and obstruct the divergent thinking required for innovation. Given the importance of diversity as an input for recombination (Burt, 2004; Fleming et al., 2007; Hargadon & Sutton, 1997), connections to non-overlapping groups are thus crucial for the technologist to maintain sufficient diversity in their conversation with their manager partner and secure their leading role in advancing technological innovation.

Taken together, we expect technologists to be better able to innovate through network division with manager partners with deep technical expertise, leading to a negative relationship between network duplication and innovation performance. If manager technical knowledge is shallow, the baseline expectation holds and we predict a positive effect of duplication on technologist innovation performance. We hypothesize:

*H2. The relationship between network duplication and technologists' innovation performance is negative if their manager partner's technical expertise is deep and positive if it is shallow.*

### **Technologist organizational prominence**

Both parties to a relationship may be the source of interdependence imbalance. Next we consider how an attribute of technologists, their organizational prominence, can alter the relative level of dependence in their relationships with managers. We further argue that the resulting interdependence imbalance will again have an asymmetric effect on the tradeoffs of network duplication and division, but in this case for the manager rather than technologist.

The organizational prominence of individuals can substantially vary, depending on their track record and their visibility in the organization or business unit (Sauder, Lynn, & Podolny, 2012). In our context, organizational prominence captures the reputational capital technologists built up through past achievements and experience that they can leverage to legitimize new scientific directions that by their very nature will be at first skeptically received (Mueller et al., 2012). If the technologist lacks the organizational prominence on which the manager depends for legitimizing innovation, the balance of interdependence with the R&D manager is altered. The technologist still depends on the R&D manager for amassing resources, but the manager can less effectively rely on a technologist with limited prominence for scientific credibility. To be clear, technologists with limited prominence do not lack technological competence, but have not yet built up the reputational capital within the organization, for example because they are new to a particular division, they are relatively junior or they have not yet had highly visible achievements. We argue that in cases where managers work with technologists with limited prominence, the manager benefits in terms of their innovation performance from engaging in a division of ties with that partner.

First, the interdependence imbalance renders the dual influencing mechanism associated with duplication less effective for R&D managers. For managers, the benefit of network

duplication rest on the organizational prominence of their technologist partner. That is, managers may more easily convince target groups in the organization of the merits of a novel idea or R&D initiative if the case they are trying to make is supported by the legitimacy that the technologist may bring regarding the scientific underpinnings of the idea (Sauder et al., 2012). In absence of this prominence, the costs of duplication may weigh more heavily. In particular, managers would need to spend time and energy coordinating messages with the technologist to ensure they speak with the same voice when influencing specific groups in the organization.

Second, in absence of the possibility for the manager to leverage the technologist's prominence for legitimizing innovation in the influencing process, the value of diversity for generating novel ideas associated with the division of networks is amplified. In these circumstances, the manager's ability to innovate depends more strongly on the technologist's efforts to capitalize on network connections more directly relevant to the technologist's role as a producer of novel ideas (Fleming et al., 2007). Rather than having technologists with limited prominence duplicate their ties, managers are better off if their technologist partners source information from functional groups they themselves are not connected to or sound out novel ideas with groups in the organization with which technologists can more meaningfully engage.

Taken together, we propose that managers benefit from the division of ties with their technologist partner if that technologist has limited organizational prominence, whereas the baseline prediction of advantageous duplication for managers holds in case of high technologist prominence. Thus:

*H3. The relationship between network duplication and the managers' innovation performance is negative if their technologist partner's organizational prominence is limited and positive if it is strong.*

## CONTEXT

### **The manager-technologist partnership in R&D**

Our study is carried out in Jupiter, a multinational corporation with large R&D operations across the globe. Core to its mission, across its vast range of divisions, is its desire for a competitive edge through a superior science and technology base for its products. We exploit Jupiter's R&D partnership model to investigate the impact of the division versus duplication of networks between technologists and managers.

To better understand the partnership model and the role of managers and technologists, we conducted – in the first stage of the study – interviews with 40 R&D technologists and 30 R&D managers across various locations and divisions of Jupiter, and including people across all levels of seniority. The list of interviewees contained a selection of manager-technologist partners who in recent years had received accolades for exceptionally effective partnerships and a random selection of other technologists and managers. The interviews were semi-structured and lasted between 45 minutes and one hour.

The rationale behind the partnership model, whereby technologists and R&D managers jointly pursuing innovation are assigned to be each other's partners, is to help manage the mutual interdependence that exists between them and to facilitate the coming together of technology and market understanding in the generation of innovation. One of the key features of dual career track systems is that technologists have no administrative and managerial duties so that they can focus on developing and/or championing new technologies and products. This means, however, that technologists do not manage budgets or people. They need to rely on managers to gain access to these resources. At the same time, managers depend on technologists as a constant source of new ideas and their scientific legitimacy for novel technological solutions.

Typically, technologists and managers are partnered up by a common line manager.

Thus, partners are not selected through individual initiative of the individual manager or technologist. Most often, for each technologist there is one or a limited number of potential manager partners – and vice versa – who operate in the same division, with the same job function, and at the same stage of the innovation process. As such, the organization does not allocate managers and technologists on the basis of their past performance, assignment history, expertise or prior networks. Indeed, at the time of our study, the HR function of the organization did not possess a list of the partnerships within the R&D organization, which clearly indicates the lack of strategic oversight by the organization to the issue of matching partners. Partnerships tend to change when either manager or technologist is reassigned to a new role.

The partnership system emerged in Jupiter following success stories where technologists and managers had effectively worked together to generate breakthrough innovation. Senior management in Jupiter felt that formalizing the mutual interdependence relation between technologists and R&D managers in a partnership would help managers to better exploit novel technology in the development of business cases and, conversely, help technologists align their research and development efforts with market needs and strategic priorities. As one peer technologist, who together with her partner received a special accolade for effective partnership, explained:

*My partner, my manager partner has unique skills, I have unique skills and it really is a marriage made in heaven. So I think that's an ingredient for success..., to have good partnerships (...), built on trust and [where] we both see the value that we bring to the table.*

Technologists and managers ought to act as each other's sparring partners, enabling each other to conduct their respective tasks in such a way as to maximize the chances of developing a convincing business case where technological and market opportunities come together. In a joint interview with both members of a partnership, the technologist explained how the partnership



worked as continuous iteration between independent and joint work tasks.

*We have clear differences in what we enjoy doing. For the structural, logistical and managerial aspects of our work [my manager partner] is taking the leadership, most of the times without me being involved. When it's a matter of in-depth research, academic contacts, most of the time I'm leading without mentioning it [to my manager partner], right? Then there is this central pool, right, where the idea, the science, the [market] need, the business opportunity is coming together. [We will be discussing] how are we going to generate that vision into a master plan, and execute [it] later on. So, who is taking the lead at what times is a constant move.*

Managers depend on their technologist partners for input and advice on the science behind the projects they are managing, and often are a source of scientific legitimacy for new directions proposed. One R&D manager explained:

*[My technologist partner] is able to give me, I guess, at least two things. She is able to give me confidence that the programme that we're operating on has got the right degree of technical rigor (...). And the second one is, you know, the thing that the technologist does for me most is helping develop new ideas, new capability, that's what the technologist gives me."*

Conversely, technologists depend on their manager partner for guidance on how technology may relate to market opportunities and business strategy. Technologists also depend on their manager partner for access to financial resources and manpower. One technologist explained:

*But that's where your manager partner can be absolutely critical in supporting you in that. If you're a lone technologist shouting that you want to go off and, I don't know, go to the equivalent of going to the moon, then the reality is, unless you're lucky, it's probably not going to go very far. I don't have any direct people reporting to me. I don't hold budget accountability.*

### **Functional groups in the dual career ladder structure**

We distinguish four functional groups along lines of seniority and career path in the dual career ladder system that play a key role as sources of information or targets of influence. Both the manager and technologist can have connections to members of all groups including their own. Our interviews established these groups were perceived by members of the organization to represent different stakeholder groups that play a distinct role in the innovation process. Both managers and technologists referred to these groups constantly during the interviews and

portrayed them as distinct community-like entities whose information and influence had strong bearing on their own innovative efforts.

The first functional group consists of peer technologists. Although they are entry-level technologists, they typically have at least ten years of experience as R&D professionals prior to starting the technologist path. Since peer technologists represent the pool of R&D staff with the deepest product-specific technology expertise, technologist and manager colleagues alike frequently consult them for their input, advice and feedback on the scientific and engineering aspects that underpin new technologies or product concepts. A senior manager explained:

*Part of [the peer technologist] role is clearly working on the projects and delivering the technology leadership and direction on the project, but part of it is also having the connections as a true subject matter expert. I mean [peer technologists] should be investing in going to conferences or reaching out to the broader technical community. They are clearly a major contributor and technical leader in that project, but they also have this other broader role of building capability. (...) The [peer technologists] are about cracking a tough technical challenge.*

Peer managers form the second functional group. Peer managers – who typically reach this seniority level after more than ten years of research experience – represent a pool of managers whose deep product-specific expertise on market preferences and their experience with building a strong business case for innovative ideas is a valuable resource for their managerial peers and technologists alike. A senior technologist explained the role of peer managers as follows:

*I do believe they [managers] need to be an innovation guide, and at the right level they either need to be helping to direct the strategy and what we [technologists] work on. (...) [Or] they need to be helping with the execution.*

The third functional group comprises senior technologists. Connections to senior technologists are particularly valuable for informal endorsement of new technologies. Senior technologists, represent highly accomplished technical experts with a proven record of turning technological developments into profitable business. Their expert opinion is invaluable for positive

reinforcement of new directions taken. Sponsorship from senior technical experts in the organization will also help accelerate the influencing of relevant senior managers. Despite not having direct decision powers and budgets, senior technologists are perceived as thought leaders who have an influential voice in project decisions. One peer manager explained:

*In every [business unit] there are a few folks that are influential, and who are the thought leaders, and you know what, our managers will be crazy not to listen to those guys because they have a proven track record, they are the people who have delivered some of the biggest innovations in the company.... They have just got that credibility.*

Finally, the functional group of senior managers, typically directors of product groups or R&D sites, represents the organizational decision-making authority for stop-and-go decisions in stage-gate processes and for the control over resources required for R&D professionals to realize the innovations they are seeking to develop (Cooper, 1990). Connections to senior managers are crucial for obtaining formal approval for major project and budget decisions.

## **METHOD**

### ***Data and research design***

After the interview stage of the study, we obtained quantitative data from a survey and HR records. All members of the R&D organization – totaling approximately 600 technologists and 900 managers at peer and senior levels – were invited to participate in a survey, which was piloted with approximately 20 participants across various locations and divisions before launch. Given that some technologists and managers had more than one partner, we asked each respondent to complete the partnership section of the survey for up to two partners. As Jupiter holds no central records of which technologists and managers were partnered up, we were not able to send coordinated invites to partner pairs. Instead, given the anonymity of the survey, we linked manager and technologist responses after the survey was closed, by means of a double-blind algorithm that converted email addresses of the respondent and their indicated partner into

anonymized tokens. The survey was conducted in June 2015 and yielded a response of 43% among managers and a response of 61% among technologists. Our final sample consists of 207 technologists who report on their partnership with their manager partner and 229 managers who report on their technologist partner. Most of the observations in our analyses (80% of technologists and 71% of managers) refer to reciprocated partnerships where people report on each other. The remainder are instances where we have a complete response from a focal respondent's partner (such that we can calculate network duplication), but that partner responded about a partnership with another individual.

We acknowledge that the sample size is much reduced relative to the full set of respondents. To test if the reduction of our sample may introduce bias, we compared our final sample of technologists and managers to the complete response set. We found that our sample of technologists overrepresents those with high innovation performance. We introduce population weights in our regressions (for both technologists and managers) to account for this bias.

Six months after the survey, we obtained the individual innovation rating from HR records for the full population of technologists and managers who were invited to the survey. The rating – awarded over the summer following our survey and relating to individual performance over the time period that our survey covered – was linked to the survey using the same algorithm. That is, an HR representative loaded email addresses and ratings on a purpose-built version of our survey that allowed the email addresses to be converted into the same tokens as generated in the survey responses, without storing the original email data.

### ***Dependent variable***

*Innovation performance* – The dependent variable in our study, both for technologists and managers, is the annual performance rating. Each year all members of Jupiter's R&D

organization are appraised by a committee of line managers, who compare individual contributions within peer groups of seniority and career ladder (i.e. functional groups). Ratings are allocated with a forced distribution across three rating categories, which we use as a categorical dependent variable in our analyses. Importantly, although technologists and managers are rated by the same committee of managers, they do not directly compete for a high rating.

The key performance criterion is the individuals' contribution to innovations that have led to revenue growth or cost reduction, or – for technologists and managers who work further upstream – key learnings in technology or market that have the potential to generate such advantages. Therefore, like the organization itself, we interpret the performance rating as an assessment of innovation performance. Since the development of innovation is at the core of both managers' and technologists' job role, the rating is intended to be awarded for individual contributions to innovations. Although such innovations are often part of successful collaborations, each member of staff is required to document their individual contributions to these achievements in preparation for the performance appraisal meetings. This approach seeks to help the review committee reach an assessment of each person's contribution independent of their partner's or other team members' contributions.

### ***Network duplication***

Ego-network data were obtained from a series of name generator and name interpreter questions on the survey. We used identical questions on the manager and technologist survey. First, we used four name generator questions, adapted from Burt (1992) and Podolny and Baron (1997), to solicit up to eleven names of individuals that respondents relied on in their work over the six months preceding the survey. Second, we used a name interpreter question to obtain the functional group (i.e. level of seniority and career path), and business unit affiliation.

Our main independent variable is the level of *network duplication* between the focal

respondent and their manager/technologist partner. Network duplication is expressed as the regular equivalence between the manager's and technologist's ego network (Borgatti & Everett, 1989) in terms of their connections to the functional groups in the dual career ladder structure. To compute network duplication, we first calculated for both the manager and technologist the number of ties to each of the four functional groups. Then, we calculated the dissimilarity for each of the four tie counts by dividing the absolute difference in the number of ties of the technologist and manager respectively by the sum of the ties (not discounting overlaps). To obtain the network duplication measure we computed the average of the four dissimilarity indices, and subtracted it from 1 to get a measure of equivalence rather than dissimilarity. The measure has a minimum of 0 for partners who have no ties to the same functional groups at all, i.e. who have a complete division of network ties, and a maximum of 1 for partners who have the same number of ties to each of the four groups. In sum, network duplication between two partners  $i$  and  $j$  is a function of the number of ties  $d$  each has to each functional group  $k$ :

$$\text{Network Duplication}_{ij} = 1 - \frac{\sum^k \left( \frac{|d_{ik} - d_{jk}|}{d_{ik} + d_{jk}} \right)}{k}$$

To be clear, network duplication is a measure of regular equivalence, not structural equivalence. It captures the extent to which two individuals have their networks focused on the same groups, not necessarily the exact same individuals. With each of the four functional groups offering a distinct rationale for why it would be meaningful and advantageous to connect to them, our theoretical interest resides in the division of “network labor” between individuals in reaching out to these groups for information or influence. A measure of structural equivalence – which disregards the functional group attribute – would be unable to discriminate whether duplicated or divided ties to specific individuals span boundaries between functional groups.

### ***Moderator variables***

We measure *manager technical expertise* using a question on the survey in which respondents were asked to indicate all expertise areas in which they had relevant expertise, and their level of expertise for all areas selected. The list of expertise areas was based on a company list of over 40 technological areas of strategic importance to Jupiter. Most of these technology areas underpin a range of products. We asked respondents to judge the depth of expertise in each of the areas indicated on a five-point scale ranging from “General awareness” through to “Leading expert”. Manager technical expertise is expressed as the average depth of expertise of the manager in the technology areas indicated by their technologist partner.

To calculate *technologist organizational prominence*, we use a composite measure. Our interviews provided support for three main channels through which members of R&D staff can build up credit, visibility, and legitimacy: (1) through past extraordinary accomplishments that led to faster-than-average promotion, (2) through long tenure in their current unit that help individuals establish their local credibility and influence, and (3) by being in a more senior position which brings greater authority. *Partner organizational prominence* is the sum of three dummy variables, indicating whether the focal individual’s partner got promoted more quickly relative to peers in the same functional group, whether they have been in their current business division for five years or more, and whether they are senior.

### ***Control variables***

The control variables included in our regressions can be subdivided in three main groups: individual, partner, and own network. The controls are identical for the manager and technologist regressions. The first group comprises a range of attributes of the focal individual including personal and job characteristics that may impact their innovation performance. To take account

of unobserved characteristics that may drive innovation performance, we include *speed to promotion* as an indicator of past performance. Specifically, using HR data, we use a binary measure to indicate if an individual got promoted into their current position more quickly than the average among their peers. We also include a dummy for *seniority*, the *number of partners* and for the *research portfolio time horizon* which is the percentage of the respondent's main projects that are long term. *Innovation climate* measures the respondent's perception of the extent to which their work environment is conducive to enabling innovation, using an 8-item scale (Cronbach's  $\alpha=0.82$ ) adapted from Scott and Bruce (1994). We include a measure of *intrinsic motivation*, based on an 8-item scale adapted from Rynes et al. (2004) (Cronbach's  $\alpha=0.63$ ). Finally, we control for the *manager team size* using the count of their number of direct reports. We use the same variable in the sample of technologists as a partner attribute, as technologists may benefit from being partnered up with a manager with more personnel.

The second group of control variables relates to a range of partnership characteristics. We control for the *partner innovation performance*, measured by the current performance rating obtained from HR records, the *partner number of partners*, and the extent of *partner support* that the respondent perceived, using a 6-item scale adapted from a supervisory support scale originally developed by Greenhaus et al. (1990) (Cronbach's  $\alpha=0.92$ ).

The final set of controls includes network variables. We would expect the effects of network duplication to be manifested beyond the effect of the respondent's own network. We control for *degree* and for *closure* – a measure of ego-network density – to test the effect of embeddedness in open or closed network structures (e.g. Fleming et al., 2007).

### ***Estimation***

Given the categorical nature of our dependent variable, we run ordinal probit estimations. Since



the parallel assumption was rejected, we could not run ordered logit models. We cluster the standard errors by functional group, focal respondent ID, partner ID, and line manager ID. We cluster by grade to account for the fact that individuals compete for a high rating within peer groups, which may introduce non-interdependence of observations within functional groups. We cluster by respondent and partner, because some respondents and some partners occur multiple times in the dataset. We cluster standard errors by line manager, as some line managers may be better able to advise their staff – either, managers or technologists – how to best prepare their appraisal documents in a bid to highlight their contributions to the assessment committee.

## RESULTS

Table 1 provides summary statistics for all variables in our study, separately for the technologist and manager samples. Correlation tables are available on request. In order to assess the contextual validity of the network duplication concept, we analyzed the patterns in which technologist and manager partners divide versus duplicate network ties. These analyses – available on request – show that it is an oversimplification to argue that technologists have networks focused on other technologists and managers networks oriented towards other managers. Managers and technologists are also broadly equally likely to have connections to senior managers.

\*\*\* INSERT TABLES 1 AND 2 ABOUT HERE \*\*\*

Interview quotes illustrate why managers and technologies would engage in a division or duplication of network ties with their partner. One technologist explained the rationale for reaching out jointly to peer technologists for early-stage feedback on new ideas:

*I'd start (...) trying to reach out to the people I think are technical kind of resources, if you like, in that area..., not that I'm going to go do it [alone], but we do it as a pair, we do it as a partnership. [It] can be really great to go out and just get a kind of 'we've got this idea, are we really just smoking something strange or are we onto something?' You need to do a bit of a reality check of is this just crazy?*

In contrast, by engaging in a division of networks, manager and technologist partners each focus

on different functional groups from which to obtain input or influence. One peer technologist explained how the division of ties often emanates from an – implicit or explicit – agreement between partners to delegate certain network tasks to one’s partner:

*I’ve been working with [my manager partner] now for a year and a half, he’s completely convinced. He’s happy. He’s supportive. So whenever I have something he says to everyone ‘Hey, Jolene did this great stuff’. So it’s working quite nicely for me because I don’t really have to do the selling job. That’s what my manager partner does.*

### **The contingent effect of network duplication on individual innovation performance**

Tables 2 and 3 present the ordinal probit regression explaining individual innovation performance. Model 1 only includes our control variables. We find that both managers and technologists who see their partner as more supportive tend to perform better, which highlights the importance of effective partnerships for generating innovative outcomes. In terms of the effects of their own social networks on their innovation performance, we find a negative association between network degree – i.e. ego-network size – and innovation performance for technologists and a positive association for managers. Given that large networks require time and effort, technologists’ investments in building and mobilizing large networks may come at the expense of their focus on their core innovation tasks. By contrast, networks are core to the managerial role, and thus larger networks help managers achieve greater innovative success.

\*\*\* INSERT TABLES 2 AND 3 AND FIGURE 1 ABOUT HERE \*\*\*

Model 2 introduces the main effect for network duplication. The coefficient is positive and significant for both technologists and managers and helps improve model fit, indicating support for H1a and H1b respectively. Overall, technologists and managers appear to benefit from a duplication-of-networks approach rather than a division-of-networks approach with their partner. For a standard deviation increase in network duplication the probability of obtaining a top innovation rating increases by 6.3% for technologists and by 5.5% for managers (keeping all

the continuous variables at their mean values and the significant dummies variables at 1). We argued that the overall benefits of duplication are rooted in advantages associated with dual interpretation of information from particular functional groups by both members of the partnership, as well as dual influencing of these groups. Managers and technologists often feel they both need to communicate directly with targeted functional groups they want to bring on board to offer complementary perspectives on the potential of the idea being proposed. In a joint interview with both the manager and technologist, the manager explained that the technologist's message ought to express the scientific vanguard and the manager the business reality, brought together in a single vision:

*We have a common manager and technologist job to do. [Our joint task is] to convince the visions to our management, with reality and science, right? Business reality and factual science. Of the known and the unknown. The given and the uncertain.*

Despite the advantages of network duplication, we argued there are also costs associated to network duplication. For example, seeking to influence the same groups, managers and technologists face the cost of coordinating their message. As a technologist explained:

*We [my manager partner and I] are driving consistent messages. So she [my manager partner] has a different hat on, she's not a technologist, so she has a hat on regarding the risk profile, readiness to market. [But] we need to drive the same message, so it needs to come the same way from my mouth as from her mouth. A general manager, (...) if he's talking with me or with her should not get a different message. As soon as he is getting a confused message, it will be coming to the point where he has an extra reason for not getting involved in the technology.*

We argued that the limits of duplication may surface only under certain conditions, in particular if the interdependence between managers and technologists is altered. In H2 we predicted that, under influence of the manager possessing an attribute more typically associated with technologists – namely deep technical knowledge – the limits of duplication carry more weight and the advantages of network division come to the fore. Hence, we predicted that

technologists benefit in terms of their innovation performance if they engage in a division-of-networks approach with a manager partner with deep technical knowledge, but from a duplication-of-networks approach if their manager partner's expertise is limited. Model 3 in Table 3 tests H2, indicating a negative and significant interaction between network duplication and expertise overlap for *technologists'* performance<sup>1</sup>.

Consistent with our expectations in H2, Figure 2A shows a negative relation between network duplication and technologist innovation performance if they have a manager partner with deep technical expertise. In this case, technologists benefit from a division rather than a duplication-of-networks approach. The relation is positive for technologists with partners with shallow technical understanding, which indicates they benefit more from duplication than division. A manager explained the importance of having sufficient depth of expertise in the areas that their technologist partner is an expert in, in order to represent their joint project in engagements with senior management in which only the manager would be involved:

*I think that [as a manager] you have to take the time to actually invest and understand enough. Now, what's enough I don't know, but to understand enough so you can be supportive of your technologist partner. You can ask them the right questions. (...). Quite often as a [manager] you are there representing a project so I think you have to be able to do a good job of representing the technical breakthrough because if you're in the management review, maybe not everyone is there (...). So I think you have to be able to represent [the project] and be able to get resources and yes, really speak for the team as needed.*

Illustrating the opposite case – where a manager partner lacks technical knowledge - a technologist emphasized the need for network duplication, expressing concern about his manager partner not being sufficiently knowledgeable to solely represent their project to influential audiences in the organization with sufficient depth of understanding:

*They [manager partners] don't have sufficient depth of knowledge of the [business] category and they're not*

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<sup>1</sup> To be clear, we did hypothesize and do not find support for an equivalent effect of technologists' technical knowledge on the duplication-performance relation for *managers*.

*interested in the technology which is really scary. And/or they're too busy and not willing to engage and take the time so [they] don't see the passion. So then it just worries me that, if that's the case, then they're actually being scary because I need to do a double-check to make sure that they're not going out and - because they're the face of the project to a lot of people, that they're not going out and committing things that are technically incorrect, wrong, etcetera, etcetera...*

As a second contingency, we predicted in H3 that if technologists lack an attribute on which their manager partner depends, the interdependence between them is also altered, yet leading to advantageous division of ties for the manager's rather than the technologist's performance. Model 4 introduces the interaction effect of technologist organizational prominence on the duplication-performance relationship. In line with Hypothesis H3, the interaction is positive and significant. Figure 2B shows that the relation between network duplication is negative for managers with technologist partners of limited prominence and positive for those with high prominence<sup>2</sup>. We argued that in the absence of the possibility to leverage their technologist partner's prominence, managers may be better off leaving their technologist partner to invest time in their own work and network, rather than spending time and energy duplicating the managers' connections. One manager explained:

*[As a manager, I have the] critical responsibility to make sure I get the budget secured, I get particularly the resources needed, aligned with business. And give basically [my technologist partner] the time and space to go and really build some of this [technical] capability and deliver the technical depths that are needed. I think part of their role is clearly working on the projects and delivering the technology leadership and direction on the project, but part of it is also having that breadth and depth in terms of connections as a true subject matter expert, and they should be investing in doing that. I know they do. I mean they should be reaching out to the broader technical community [in Jupiter].*

## CONCLUSION AND DISCUSSION

This study has assessed the conditions under which R&D managers and technologists who engage in a division of labor can also benefit from engaging in a division of networks, or from

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<sup>2</sup> To be clear, we did hypothesize and do not find support for an equivalent effect of managers' prominence on the duplication-performance relation for *technologists*.

the duplication of network ties to the same groups in the organization. We find that, although the duplication of networks is generally associated with higher individual innovation performance, the balance shifts in favor of network division for one of the two parties if the nature of the interdependence between them is imbalanced. We believe our study offers four main contributions to research on social networks and innovation in organizations.

First, we demonstrate how individuals' ability to excel in the generation of innovation is not only rooted in the fundamental interdependence between manager and technologist roles (Blau & Scott, 1962; Lawrence & Lorsch, 1967), but also in the collective deployment of their respective networks. In doing so, we have given renewed attention to how an individual's participation and engagement in the dual career ladder in the R&D context shapes their performance, demonstrating how the scientific skills of technologists and business skills of managers come together in the generation of innovation. Our study exposes how the choices managers and technologists make about whether to seek information from the same functional groups in the organization and whether to try and influence the same groups translate into variation in their innovation performance. Technologists who, in the true spirit of dual career ladder models, may prefer to focus on the role of inventor and ties directly relevant to that role, leaving much of the influencing to their manager partner, appear most successful if their partner has sufficiently deep technological expertise. Managers who generally benefit from engaging in duplication of networks with their technology partner, are better off leaving their partner the time and energy to connect to groups they themselves find most useful for the generation of new ideas when their partner is low in prominence.

Second, in demonstrating the performance implications of network duplication versus division, our study extends recent research on second-order social capital (Brass, 2009; Galunic

et al., 2012), showing that, within organizational settings, the benefits of social networks may not be exclusively private. Individuals may not only benefit from having managers or supervisors with connections that offer positive externalities (Galunic et al., 2012), it may also be the connections of peers or co-workers. In contrast to existing research on second-order social capital that emphasizes the value of connections to different groups of alters via co-workers, our study shows that in many situations individuals may benefit from duplicating co-workers' connections to the same groups. In addition, we demonstrated how the relative benefits of duplication versus division are equal for co-workers with relatively balanced interdependence, and asymmetric if that interdependence is unbalanced (Casciaro & Piskorski, 2005). This suggests that neither duplicating nor dividing network ties is an inherently superior approach, but rather depends on the source and nature of interdependence between co-workers.

Third, this study explicates a range of mechanisms through which the division or duplication of co-worker networks conveys performance advantages. That is, we identify a range of benefits and costs of the duplication versus division of network ties for the individual ability to innovate. Network duplication allows individuals to benefit from the dual interpretation and joint sensemaking of information since their co-worker has direct access to information from the same functional groups that is not yet colored or biased by the focal individual (Gavetti & Warglien, 2015; McFadyen & Cannella, 2004). Dual interpretation is particularly advantageous if a co-worker lacks deep expertise in the areas relevant to the focal individual and would find it difficult to challenge their colleague's interpretation and contribute to the discussion without direct input from the same groups. In such cases, the duplication of ties between managers and technologists may be particularly effective, due to differences in how managers and technologists will process and interpret information from the same functional groups in the

organization (Brewer & Nakamura, 1984). Network duplication also enables the dual influencing of specific functional groups inside the organization; key functional groups may be convinced of the potential of a new idea or business case, if they receive multiple, mutually consistent, versions of the same arguments (Centola & Macy, 2007; Shannon & Weaver, 1948). Dual influencing is particularly valuable if a focal individual can leverage the organizational prominence of their co-worker in their efforts to gain legitimacy for novel ideas, something which is of paramount importance in established organizations where such ideas are often widely contested (Ancona & Caldwell, 1992; Howell & Higgins, 1990; Mueller et al., 2012).

By contrast, network division offers diversity advantages. If a manager and technologist who are working together are tied to different groups inside the organization, as a pair they are better placed to bring together diverse perspectives in novel ways than if they were tied to the same groups (Burt, 2004; Fleming et al., 2007; Hargadon & Sutton, 1997). Network division allows two parties working together to focus their respective networks on different parts of the organization – and benefit from potential embeddedness advantages – whilst jointly as a pair safeguarding access to diverse inputs. This advantage is particularly important if the parties working together are more alike. If both the technologist and manager have deep technological knowledge and access to diverse information, it is crucial to overcome excessive convergence and problems of groupthink (Janis, 1972; Ter Wal et al., 2016; Tortoriello, McEvily, & Krackhardt, 2015). The division of networks can also be advantageous due to the costs of network duplication. Duplication is costly due to opportunity cost of having less time and energy to invest in connections more directly pertinent to one's own role (Burt, 1992), and the effort required to coordinate consistency of information sent to the same functional groups, which is key to effective dual influencing (Centola & Macy, 2007). These costs weigh more heavily in



imbalanced relationships where a focal individual cannot rely on their co-worker lacking an attribute on which they depend, such as managers working with technologists with limited prominence.

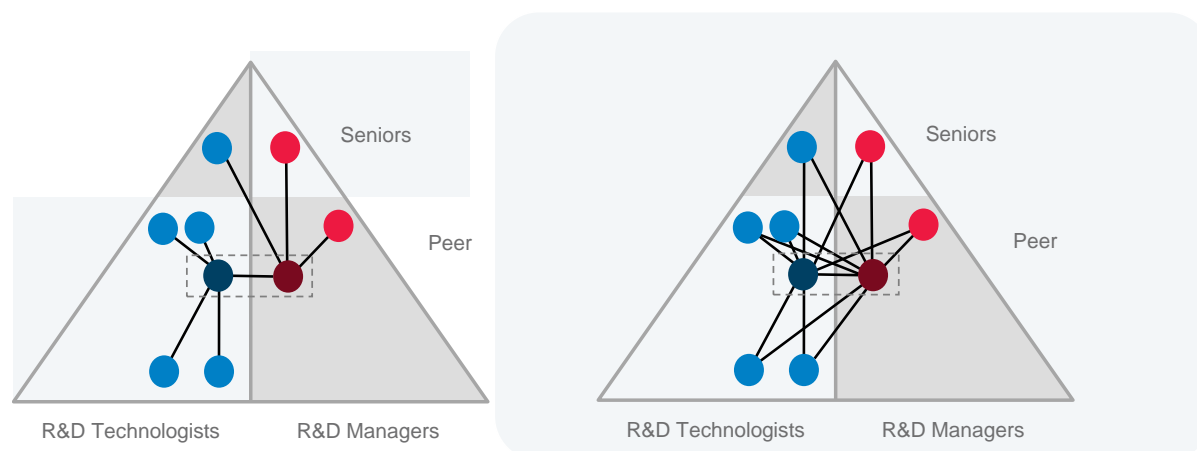
Finally, our study shows that the benefits of networks may not be exclusively defined in terms of the structural advantages such as brokerage or closure (Burt, 2007), but also in terms of the overlay of these networks over the organization's formal structure (Blau & Scott, 1962). Although the advantages and costs of network division and duplication may reminisce of advantages of structural holes versus closed, cohesive networks (Burt, 2004; Coleman, 1990; Reagans & McEvily, 2003; Ter Wal et al., 2016), there is a fundamental difference. Advantages of network duplication and division are defined in terms of overlap in the focus on specific organizational groups rather than overlap in the relations themselves. Akin to the intra-organizational division of labor arising from individuals' specializing in certain *types* of functions regardless of whether they perform those functions on the same projects or tasks, a division of network ties is established if two individuals have a functional specialization of networks in terms of the *types* of individuals they connect to and the types of information and influence they obtain as a result. We take the stance that approaches that ignore the overlay of networks over organizational structures and hierarchies will not be able to get at the core of why it matters whether certain ties are duplicated or divided between co-workers. Defining the division versus duplication of networks in terms of functional groups brings back the focus on how informal social networks and formal organizational structure may need to be considered jointly to explain how intra-organizational social networks may yield individual advantages (McEvily, Soda, & Tortoriello, 2014). In showing how the benefits of intra-organizational social capital are defined in terms of the relevant functional groups that bring interpretation and

influence advantages, we help move the agenda of networks forward, away from full emphasis on informal structure and more attentive to the role of formal roles and hierarchies.

Notwithstanding these contributions, our findings should be understood taking into consideration some of the limitations of our study and the need for future research into the relative value of network division and duplication for innovation. First, given the single organization setup of our study, we cannot directly establish how our study would generalize to other settings. Although the partnership model enables us to observe the interdependence between R&D managers and technologists more easily, it is likely similar dynamics in terms of the value of network duplication versus division occur in other organizations where the independence between management and technologist roles takes different forms. Indeed, it is common to find organizations developing complex employment ladders for different categories of staff, hoping to attain the benefits of the division of innovative labor. It would be useful to explore the networks of paired co-workers in non-R&D settings, where similar dual career structures are often present. For instance, future research could look at the network duplication between members of start-up teams.

Second, our study established that a power imbalance between managers and technologists leads to an asymmetry in terms of how each party benefits from duplication or division. Although the implication of our findings is that organizations may wish to promote balanced partnerships in combination with network duplication, we did not directly examine how patterns of network duplication affect joint performance of managers and technologists, and how overall organizational innovation outcomes may be optimized. Future research may be needed to fully understand how to improve the design of dual career ladder systems and the wider formal organization of innovative labor.

**FIGURE 1: Stylized examples of the division of networks (left) versus the duplication of networks (right)**



The dark blue node and dark red node in the dashed box respectively represent a technologist and manager who work together. The four quadrants represent the functional groups delineated by career ladder and seniority.

**TABLE 1: Descriptive statistics**

		Technologists					Managers				
		N	Mean	SD	Min	Max	N	Mean	SD	Min	Max
Individual	Innovation performance	207	1.83	0.86	1	3	229	2.03	0.84	1	3
	Speed to promotion (dummy: 1=quick)	207	0.70	0.46	0	1	229	0.70	0.46	0	1
	Seniority (dummy: 1=low)	207	0.82	0.39	0	1	229	0.81	0.39	0	1
	Number of partners	207	1.64	0.48	1	2	229	1.68	0.47	1	2
	Research portfolio time horizon	207	0.53	0.33	0	1	229	0.40	0.30	0	1
	Innovation climate	207	2.41	0.96	0.22	5.22	229	2.10	0.90	0.00	4.29
	Intrinsic motivation	207	0.03	1.03	-5.78	1.63	229	0.06	1.01	-2.91	1.64
	Manager team size	207	3.88	0.97	1	6	229	3.67	1.12	1	6
Partner	Partner innovation performance	207	2.02	0.83	1	3	229	1.74	0.85	1	3
	Partner support	207	5.89	1.30	1	7	229	6.21	0.85	2	7
	Partner number of partners	207	2.02	1.20	1	7	229	2.19	1.25	1	7
	Partner technical expertise <sup>1</sup>	207	1.64	1.08	0	5	229	1.58	1.04	0	4.67
	Partner organizational prominence <sup>2</sup>	207	2.11	0.89	0	3	229	1.95	0.85	0	3
Own network	Degree	207	6.96	1.98	2	11	229	6.90	1.80	2	11
	Closure	207	0.38	0.22	0	1	229	0.46	0.23	0	1
Joint network	Network duplication	207	0.52	0.20	0	1	229	0.52	0.21	0	1

<sup>1</sup> This variable measures manager technical expertise for the sample of technologists and technologist technical expertise for the sample of managers.

<sup>2</sup> This variable measures technologists' organizational prominence for the sample of managers and manager organizational prominence for the sample of technologists.

**TABLE 2: Ordinal probit regression explaining individual innovation performance  
– Main effect network duplication (H1)**

		Technologists		Managers		
		Model 1	Model 2	Model 1	Model 2	
			H1a		H1b	
Individual	Speed to promotion	0.258***	0.290***	0.377**	0.393***	
	(dummy: 1=quick)	(0.0939)	(0.109)	(0.148)	(0.149)	
	Seniority	0.597***	0.575***	0.966***	0.911***	
	(dummy: 1=low)	(0.0472)	(0.0562)	(0.114)	(0.130)	
	Number of partners	0.239***	0.241***	0.321	0.324	
		(0.0720)	(0.0717)	(0.243)	(0.239)	
	Research portfolio time horizon	-0.248***	-0.243***	-0.136***	-0.182**	
		(0.0629)	(0.0605)	(0.0447)	(0.0713)	
	Innovation climate	-0.213***	-0.264***	-0.114	-0.125	
		(0.0163)	(0.0359)	(0.0853)	(0.0935)	
Partner	Intrinsic motivation	0.131*	0.129**	0.180***	0.171***	
		(0.0677)	(0.0595)	(0.0215)	(0.0210)	
	Manager team size	0.141***	0.163***	0.525***	0.519***	
		(0.0205)	(0.0160)	(0.0537)	(0.0515)	
	Partner innovation performance	-0.0601	-0.0712	-0.0702	-0.0691	
		(0.0741)	(0.0555)	(0.0558)	(0.0527)	
	Partner support	0.0597*	0.0445	0.192***	0.157***	
		(0.0323)	(0.0340)	(0.0344)	(0.0407)	
	Partner number of partners	0.119**	0.132**	0.0954**	0.108**	
		(0.0514)	(0.0559)	(0.0433)	(0.0516)	
Own network	Partner technical expertise	-0.000869	-0.0130	0.00670	0.00847	
		(0.0276)	(0.0346)	(0.0551)	(0.0519)	
	Partner organizational prominence	0.0445	0.0449	0.0831	0.100	
		(0.125)	(0.130)	(0.169)	(0.167)	
	Degree	-0.0389**	-0.0533***	0.0709**	0.0749**	
		(0.0174)	(0.0151)	(0.0321)	(0.0292)	
	Closure	0.231	0.251	-0.485	-0.504	
		(0.433)	(0.453)	(0.478)	(0.462)	
	Joint network	Network duplication		0.823***		0.684**
				(0.245)		(0.331)
t <sub>1</sub>		1.412**	1.612**	4.755***	4.899***	
		(0.701)	(0.645)	(0.319)	(0.314)	
	t <sub>2</sub>	2.027***	2.236***	5.659***	5.811***	
		(0.665)	(0.605)	(0.317)	(0.341)	
Observations		207	207	229	229	
Log likelihood		-189.29	-187.68	-216.74	-215.32	
Log-likelihood ratio test (df) <sup>a</sup>			3.23 (1)**		2.86 (1)**	

Standard errors in parentheses. Dummies for 6 business units included.

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

<sup>a</sup> Comparing Model 2 to Model 1

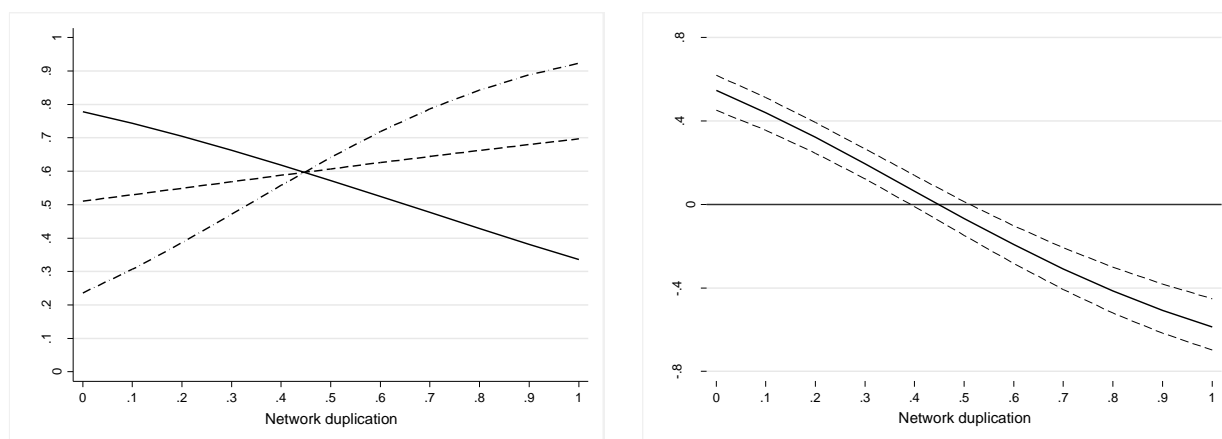
**TABLE 3: Ordinal probit regression explaining individual innovation performance – Contingencies (H2 & H3)**

LEVELS	VARIABLES	Technologists	Managers	Technologists	Managers
		Model 3 H2	Model 3	Model 4	Model 4 H3
Individual	Speed to promotion (dummy: 1=quick)	0.275* (0.153)	0.392*** (0.143)	0.282*** (0.0897)	0.355*** (0.113)
	Seniority (dummy: 1=low)	0.626*** (0.0915)	0.909*** (0.104)	0.581*** (0.0811)	0.815*** (0.150)
	Number of partners	0.267*** (0.0345)	0.331 (0.242)	0.236*** (0.0542)	0.362 (0.240)
	Research portfolio time horizon	-0.345*** (0.0561)	-0.178* (0.0988)	-0.244*** (0.0647)	-0.249*** (0.0453)
	Innovation climate	-0.263*** (0.0325)	-0.128 (0.0880)	-0.263*** (0.0327)	-0.124 (0.0855)
	Intrinsic motivation	0.117** (0.0565)	0.171*** (0.0418)	0.129** (0.0574)	0.166*** (0.0254)
	Manager team size	0.119*** (0.0281)	0.521*** (0.0661)	0.161*** (0.0146)	0.517*** (0.0644)
	Partner	Partner innovation performance	-0.0310 (0.0567)	-0.0674 (0.0540)	-0.0693 (0.0587)
Partner support		0.0240 (0.0284)	0.157*** (0.0476)	0.0448 (0.0317)	0.166*** (0.0434)
Partner number of partners		0.151* (0.0795)	0.107* (0.0572)	0.134*** (0.0503)	0.0887 (0.0547)
Partner technical expertise		0.404*** (0.0486)	-0.00819 (0.237)	-0.0124 (0.0335)	-0.00344 (0.0473)
Partner organizational prominence		-0.0137 (0.140)	0.101 (0.172)	0.134 (0.200)	-0.644*** (0.217)
Own network	Degree	-0.0456*** (0.0133)	0.0752*** (0.0243)	-0.0508** (0.0219)	0.0709** (0.0346)
	Closure	0.180 (0.348)	-0.493 (0.487)	0.250 (0.453)	-0.481 (0.456)
Joint network	Network duplication	2.292*** (0.476)	0.663*** (0.155)	1.194 (1.587)	-1.964*** (0.569)
	Network duplication * Partner technical expertise	-0.893*** (0.133)	0.0104 (0.245)		
	Network duplication * Partner org. prominence			-0.177 (0.628)	1.337*** (0.210)
	t <sub>1</sub>	2.016*** (0.506)	4.890*** (0.355)	1.806*** (0.307)	3.330*** (0.407)
	t <sub>2</sub>	2.657*** (0.470)	5.802*** (0.299)	2.430*** (0.331)	4.267*** (0.423)
	Observations	207	229	207	229
	Log likelihood	-183.97	-215.34	-186.02	-211.79
	Log-likelihood ratio test (df) <sup>a</sup>	4.63 (1)**		7.06 (1)***	

Standard errors in parentheses. Dummies for 6 business units included.

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1 - <sup>a</sup> Comparing Models 3 and 4 to Model 2 Table 4.

**FIGURE 2A: Moderation effect of manager technical expertise on the relationship between network duplication and technologists' innovation performance**

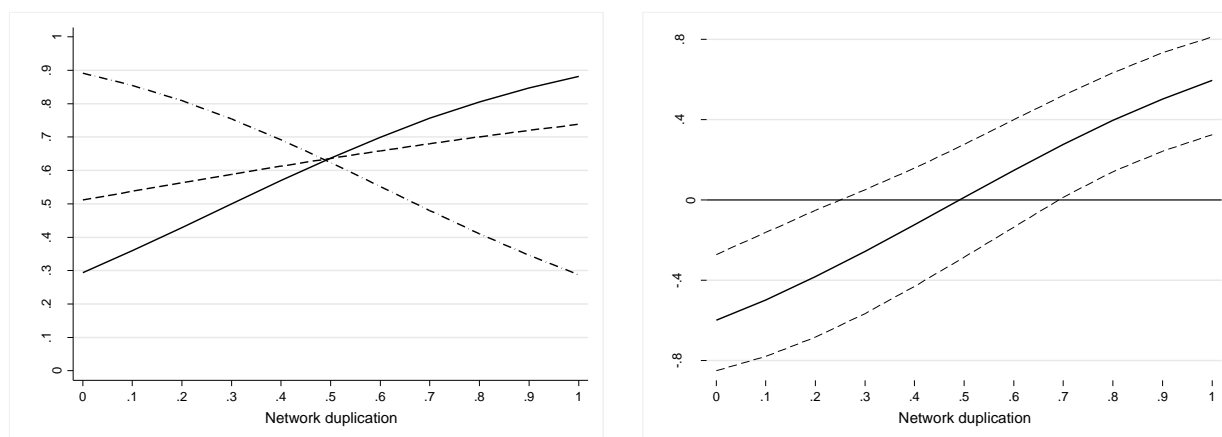


Left: predicted probability of technologist achieving top rating

when manager technical expertise is shallow (0 – dash-dot line), average (2 – dashed line) or deep (4 - solid line)

Right: difference in predicted probability between low and high manager technical expertise, with 95% confidence interval.

**FIGURE 2B: Moderation effect of technologist organizational prominence on the relationship between network duplication and managers' innovation performance**



Left: predicted probability of manager achieving top rating

when technologist organizational prominence is limited (0 – dash-dot line – slowly promoted, low tenure, peer-level)

when technologist organizational prominence is moderate (1 – dashed line – change on one dimension from above)

when technologist organizational prominence is high (3 – solid line – high tenure, quickly promoted – senior-level)

Right: difference in predicted probability between low and high technologist prominence, with 95% confidence interval.

*Graphs in Figure 2A and 2B are derived using the estimates of the partial models setting continuous variables at their sample mean and significant dummies to 1.*

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