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More than Network Structure: How Knowledge Heterogeneity Influences Managerial Performance and Innovativeness

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More than Network Structure:

How Knowledge Heterogeneity Influences

Managerial Performance and Innovativeness

This study deals with individual managerial performance, both overall and in generating innovation. While prior work has demonstrated a relationship between network structure and managerial performance, inadequate attention has been paid to network content. We consider several micro-social processes that might account for differences in managerial performance, taken from economic sociology and studies of managers' exploitation of their social networks and derived from work in psychology on the genesis of ideas. We compare the influence of these mechanisms on managerial performance using a sample of 106 middle managers in a European telecommunications company. Our findings suggest that while network structure matters, access to heterogeneous knowledge is of equal importance for overall managerial performance and of greater importance for innovation performance.

Introduction

This paper looks at the relationship between knowledge heterogeneity in social networks and its effect on managers' overall performance and innovativeness. In measuring the relative contribution of knowledge heterogeneity and network structure, independently and jointly, on both overall managerial and innovation performance, we present evidence suggestive of two distinct micro-social processes, one arising from the exploitation of network structure, the other based on exposure to diverse knowledge and its recombination as a wellspring of innovation. In doing so, we provide a more detailed understanding of the mechanisms that underlie earlier results showing a relationship between network structure and managerial performance in general.

Considerable attention has been directed at understanding the influence of social network structure on various individual-level outcomes for employees in the firm. Prior work has dealt with the speed of career advancement (Burt, 1992; Ibarra, 1995; Podolny and Baron, 1997), power and influence in the workplace (Brass and Burkhardt, 1993; Krackhardt, 1990), the instrumental use of network ties in organizations (Lin, Ensel and Vaugh 1981), and compensation levels (Belliveau, O'Reilly and Wade 1996; Burt, 1992). Notwithstanding the significant contribution these studies have made to our understanding of individual-level outcomes, the existing literature is lacking in two important respects.

First, as Ibarra noted a decade ago (1993), there are remarkably few applications of the social capital perspective to managerial innovation and little has changed since she made that observation. Recent, comprehensive reviews of the social capital literature reveal a dearth of studies on this topic, with any attention usually focused on the creativity of artists (e.g., songwriters, photographers) (Adler and Kwon, 2002; Burt, 2000). Relatedly, the considerable literature in organizational behavior on managerial innovation has yet to consider innovation through the lens of social networks. This literature has taken two broad paths. The first focuses on the psychological attributes and personal characteristics associated with creative achievements (Amabile, 1988; Barron and Harrington 1981; Martindale, 1989). The second deals with the broader contextual features that contribute to managerial innovation, such as the availability of complex and challenging jobs (Oldham and Cummings, 1996) and an encouraging and supportive work climate (Scott and Bruce, 1994; Amabile, 1996). A relationally embedded approach to managerial innovation, along the lines suggested by Granovetter (1985), is lacking. Furthermore, recent research on the importance of bringing together diverse knowledge in the pursuit of innovation (Hargadon and Sutton, 1997; Galunic and Rodan, 1998) suggests that combining insights from work on managerial innovation with social network theory is worthwhile. Innovation is an important means of creating and maintaining sustainable competitive advantage, and furthering our understanding of managerial innovativeness may help shed light on a factor that matters for firm performance (McGrath and MacMillan, 2000).

Second, our study addresses an important question unanswered in prior research concerning the relationship between the structure of the network and the distribution and variety of knowledge among actors in it. While prior studies point to the importance of the structure of individual managers' networks, the attributes of the nodes, often referred to as the content of the network, have been under-explored (Podolny, 2001). Traditionally, the configuration of an individual's network, and in particular her access to disconnected contacts, has been associated with two mechanisms that could explain her success. First, having a network of disconnected contacts creates an opportunity for brokering and arbitrage. Such a structural position lends itself to "divide-and-conquer" strategies, boosting political maneuverability, power, and hence success. Second, a network of disconnected contacts has been associated with access to diverse information, which increases both opportunity recognition and provides the object of entrepreneurial brokering activity, and thus raises performance. However, given the likely association between the disconnectedness of contacts and the diversity of their knowledge, an alternative interpretation of earlier findings relating network structure to performance rests in the potential such exposure has in stimulating and catalyzing managerial innovativeness. These causal motors, however, have not been disentangled, either theoretically or empirically.

In recent years the role of knowledge and its exchange has emerged as an important area of inquiry in our understanding of innovation and value creation in the firm (Conner and Prahalad, 1996; Grant, 1996; Kogut and Zander, 1992; Nonaka, 1988; Nonaka and Takeuchi, 1995). While there appears to be a widely held belief that value creation involves knowledge exchange amongst organizational actors, we know relatively little about the influence of network structure and content on this process (Uzzi, 1996). Since the knowledge-based view has placed considerable weight on the role of knowledge in the creation of value, distinguishing these motors is particularly important for this research stream. It also has important implications for management practice. The growing social capital literature may be over-emphasizing exposure to structurally disconnected contacts. If the 'active ingredient' of managerial performance is access to diverse knowledge rather than structurally disconnected contacts, senior managers may need to reevaluate the social interactions and structures they promote, as we develop in our discussion.

Our paper offers an examination of the micro-sociology of managerial performance, integrating social network theory and ideas about managerial innovativeness. While hitherto an association between knowledge heterogeneity and network structure has been an article of faith, by operationalizing the heterogeneity of knowledge accessible through social networks, we are able to both test this assumption and assess the importance of access to heterogeneous knowledge relative to the purely structural benefits these networks provide. As Seibert, Kraimer, and Liden (2001) point out, comparative tests of this sort are rare in the social network literature.

We begin by providing some theoretical background to the social capital approach and distinguish between two key components; network structure and network content. Building on this distinction, we then outline the key resources that are available to a manager through her network, developing hypotheses regarding the way these resources contribute to overall managerial performance and managerial innovation performance. We then describe our empirical setting and data sample. Finally, we present and discuss our results, underlining the value of heterogeneous knowledge to exceptional managerial performance. We end with implications for strategic management theory and practice.

Network Structure and Knowledge Heterogeneity as Managerial Resources

Notwithstanding the growing popularity of the concept of social capital, there is some danger that its popularity may be outpacing its conceptual development. As with all wide-umbrella concepts (Hirsch and Levin, 1999), social capital risks conflating distinct logical processes as it is applied to a wide-range of phenomena (Adler and Kwon, 2002). We will begin, therefore, with a careful definition of the concept and, with social network theory as our point of departure, distinguish between two distinct mechanisms that might influence managerial performance.

Social capital resides in the network of ongoing exchange relations that individuals accumulate over time (Coleman, 1988; Bourdieu, 1986). Like capital of any kind, social capital implies a source of potential value. That source, however, does not emanate from qualities of the individual, as captured by the notion of human capital (intelligence, skills, character), but rather is a function of the social network within which an individual is embedded. Pinpointing the 'active ingredient' of social capital, however, has not been adequately addressed (Adler and Kwon, 2002), and so we return to its social network roots. In general, approaches to social capital fall under one of two main conceptualizations of social networks (Nahaphiet and Ghoshal, 1998). One approach focuses on the network structure. Attributes of network structure that have been the subject of prior work include the centrality of an actor's position (Brass and Burkhardt 1993; Ibarra, 1993), the extent of network closure (Coleman, 1990), and the degree of disconnectedness (or 'structural holes') between contacts (Burt, 1992). The second, and less explored approach considers the content of the network, that is, the characteristics of the nodes and/or the qualitative nature of the relationships (Lawler and Yoon, 1998; Podolny, 2001; Uzzi, 1996). Prior work has tended to focus either on one or the other approach and there have been few empirical attempts at comparison or integration (Rowley, Behrens and Krackhardt, 2000).

However, the specific resources available to an actor through her ties, the content of the network, may be at least as important as network structure in explaining the benefits of social capital (Nahaphiet and Ghoshal 1998; Nohria, 1992). While not denying that the structuralist approach is both compelling and parsimonious, a purely structural view of social capital leaves considerable variance unexplained. In particular, where relationships mediate the exchange of knowledge (Dougherty, 1992; Ibarra, 1993; Szulanski, 1996; Tsai and Ghoshal, 1998) a structural view of network exchange must be augmented by considering the knowledge held by actors in the network. Given the strategic importance attached to knowledge and its circulation within firms (Kogut and Zander, 1992), an approach to social capital that considers network content as well as structure, and parses out their individual contributions, seems appropriate.

The knowledge of actors in a network, however, is seldom directly measured by either perspective, although, paradoxically, it has become an implicit motor of the structuralist perspective. In particular, Burt's (1992) structural hole theory features both an appeal to the brokering opportunities of a network full of disconnected contacts *and* an appeal to the advantages of the diversity of information—and, implicitly, knowledge—that such a position is assumed to afford. Two interlinked mechanisms have been proposed. One relies principally on arbitrage and political maneuverability as a source of advantage. The second suggests that disconnected contacts represent a source of non-redundant information that may be useful in and of itself, or may be brokered between contacts. The popularity of this perspective probably has much to do with this robustness, offering several different mechanisms associated with the same social structure. We propose here another explanation based purely on knowledge rather than the structural characteristics of the network. Our aim is to empirically separate the influence of these different logical motors. It is particularly valuable to do so if we are to examine the influence of social capital on managerial performance from the perspective of the knowledge-based view of the firm, a perspective that naturally leads us to ask the question: how much does knowledge really matter?

Our study draws on both structural and content perspectives in examining the way social networks contribute to managerial performance. Moreover, we will distinguish, both conceptually and empirically, the brokering and political advantages offered by a position replete with disconnected contacts from the innovation related advantages that arise from the knowledge heterogeneity of a manager's network, irrespective of whether his/her contacts are connected or not. We develop each of these mechanisms more fully below, hypothesizing about their impact on managerial performance.

Network structure – the broker's advantage

The structuralist conception of social capital emphasizes the advantages that individuals derive from particular structural characteristics of their networks. The most developed tradition within this perspective considers the consequences of variation in the connectedness of a person's contacts (Burt, 1992; Coleman, 1990; Simmel, 1923), and is most systematically addressed by Burt's seminal work on structural holes. The claim is that a 'network broker' residing within a sparse network of disconnected contacts puts the broker in an advantageous position.

Being in a position that connects two people who are not otherwise connected, (being the *tertius* or broker (Simmel, 1923; Burt, 1992)), engenders competition for the tertius' time, energy, and resources. Contacts need not be openly hostile to each other, only residing in "mutual strangeness" and with the ability to detect the tertius' popularity (Simmel, 1923). The tertius, therefore, enjoys scarcity and the valuable prestige and power it engenders, an all-purpose asset in human action (Cialdini, 1988). Such a position is of value in a wide-range of situations (Blau, 1964).

> The instrumental value of structural holes was further developed by Burt (1992; 2000). He explains that managers in brokering positions are better able to successfully navigate their projects through an organization and, more generally, execute their assigned objectives. They are more effective in how they position and portray their ambitions due to the lower constraint to which they are subject, compared to managers embedded in a closed network. This allows them to gain prestige, enhance their status and amass resources. For example,

managers can employ "multi-vocal" persona or facades (Padgett and Ansell, 1993) to frame issues in such a way so as to both enhance the appearance of competition for their time and resources (and so engender prestige and power) and set expectations favorable to their interests:

> "Even where it doesn't exist, competition can be produced by defining issues such that contact demands become contradictory and must be resolved before [the focal manager] can meet their requests" (Burt, 1992:31).

This is not a mere caricature of a politically dysfunctional organization or manager, but rather a widely manifest human condition that surfaces wherever resource scarcity and diverse preferences exist (Merton, 1957; Pfeffer, 1992). Thus, our starting point is to reprise, in terms of our dependent variables, the findings of earlier studies relating network structure to managerial performance:

Hypothesis 1: A managers' overall performance will be positively associated with the sparseness of his/her network.

However, social structure may influence more than just the execution of routine ongoing tasks. Burt (1992) has argued that part of what leads to managerial success is entrepreneurial behavior. The lack of constraint a sparse network provides should also assist in the pursuit of entrepreneurial activities, for example by facilitating autonomous strategic behavior (Burgelman 1991). As Burgelman suggests, the ability to disguise entrepreneurial activity, which structural holes should afford, may make it possible to pursue initially hard to justify projects for longer, helping to ensure that they are not prematurely quashed. Thus, a sparse network structure should also positively influence managerial innovation.

Hypothesis 2: A managers' innovation performance will be positively associated with the sparseness of his/her network.

In sum, sparse social networks should afford managers greater status and prestige, lower constraint, and more generally, greater political maneuverability. Furthermore, they should allow a manager greater leeway to pursue novel and relatively unsanctioned entrepreneurial activities. The effect of a sparse local network structure should be manifest in both superior overall performance and superior innovation performance.

Network content – the advantages of heterogeneous knowledge

By knowledge heterogeneity we refer to the variety of knowledge, know-how and expertise to which a manager has access through her network. Exposure to heterogeneous knowledge should improve both the creative potential of the focal manager as well as their ability to implement their ideas and to execute complex tasks in general. That is, knowledge heterogeneity is about both the "surface" information—news and gossip—that may influence managerial performance and also the deeper differences in the knowledge of contacts. We begin by considering the advantages of knowledge heterogeneity on overall managerial performance and then turn to creativity and innovativeness.

Aside from political maneuverability, a tertius position has been thought to confer advantage in another way. As Burt (1992:47) points out, "contacts strongly connected to each other are likely to have similar information and so provide redundant [informational] benefits," and so, conversely, disconnect contacts are presumed to be a source of non-redundant information and knowledge. A manager with a sparse network of disconnected contacts is likely to pick up a wider array of information about current events, news and gossip, privileged by both a greater range of information circulating in the organization and the ability to test its accuracy through independent confirmation.

Network structure has been used as a proxy for information and knowledge heterogeneity although the latter is never directly measured. Information and knowledge heterogeneity make it more likely that new opportunities and resources will be discovered more quickly – for example, the appearance of newly available resources or jobs (Granovetter, 1974), allowing one to enter the queue faster, or getting early wind of changes in policy or strategy, prompting one to suitably reposition local strategies and projects. In essence, access to more diverse knowledge allows the broker to be more fully informed. Thus we would expect to see a relationship between the diversity of knowledge and information to which the tertius has access though her network and her overall performance:

Hypothesis 3: A manager's overall performance will be positively associated with the heterogeneity of knowledge present in his/her social network.

Exposure to heterogeneous knowledge should improve not only opportunity recognition and thus be associated with the ability to perform routine ongoing tasks but should also raise the creative potential of the focal manager. Here the argument is not just about access to current information—news and gossip—but deeper differences in the knowledge contacts possess.

Creative leaps, whether small or large, may be thought of as the connection of two or more disparate ideas or concepts within the mind of an individual (Amabile, 1996; Fiol, 1995; Zaleznick, 1985). As Kanter notes:

> "First, there is evidence that many of the best ideas are interdisciplinary or inter-functional in origin as connoted by the root meaning of entrepreneurship as the development of 'new combinations' for they benefit from broader perspective and

> information from outside of the area primarily responsible for the innovation." (Kanter, 1988:164)

This view of creativity is similar in many respects to the Schumpeterian view of innovation, which "consists to a substantial extent of a recombination of conceptual and physical materials that were previously in existence" (Nelson and Winter, 1982; Shane, 2000). For example, Hargadon and Sutton (1997) describe how a California-based product development company, IDEO, consciously attempts to leverage heterogeneity of knowledge in the generation of new ideas. At its brainstorming sessions, the firm not only assembles teams with diverse knowledge but brings to the table (literally) a wide range of different artifacts in which heterogeneous knowledge is embedded. The team is encouraged to recall, exchange, re-contextualize and recombine elements of seemingly disparate and unrelated knowledge in the idea generation process. This process of conceptual integration or 'blending' is described as a fundamental cognitive process in the generation of novel insights (Turner and Fauconnier, 1997; Fauconnier and Turner, 1998). While the quality of the syntheses depends on an individual's cognitive dexterity, it is also influenced by the variety of knowledge that actors have in their possession. This in turn will be a function of the diversity of knowledge to which they are exposed or have access. This fits well with Shane's case studies of entrepreneurs (Shane, 2000) where he finds that the nature and probability of success of entrepreneurial ventures are not simply dictated by personal psychologies, such as tolerance of ambiguity, risk taking, etc., but rather by the existing knowledge to which an entrepreneur has prior access. In short, individual creativity based on the recombination of existing knowledge presupposes that a person has access to disparate elements of knowledge, some of which are likely to have come to her through her network of social relations. Indeed, several empirical studies (Pelled, Eisenhardt and Xin 1999; Pelz, 1956) and reviews (Milliken and Martins, 1996) suggest that knowledge heterogeneity among ones contacts contributes to creativity and innovation.

Knowledge diversity amongst contacts is also useful in the implementation of new ideas, particularly when the tasks involved are multifaceted or complex. It may help managers build a sound causal understanding of the relationships between elements in the complex system that they are proposing and so helping them to navigate a project to a successful outcome (McGrath et al., 1996). Moreover, complex ideas, once generated in the innovating manager's mind, must still be understood and supported by others. Achieving buy-in will be more likely where the focal actor innovating manager can draw on expert advocates, that is contacts who have relevant skills, experience, or know-how to testify to the soundness of particular aspects of a complex new idea, lending their expertise and distinct knowledge to the cause, and so raising its credibility and legitimacy. The more expertise to which the focal manager has access through her network, the more likely it is that she will be able to amass informed and thus persuasive testimony for her project. Furthermore, novel projects require not only advocacy but action. Given the inherent uncertainty related to innovation and the difficulty in determining exactly what skills will be needed to move the project forward, having a wide variety of skills on which to draw as needed will also be advantageous. In short, managers with contacts who are heterogeneous in knowledge and skills will have greater opportunity to accomplish complex tasks. Having heterogeneous abilities on which to draw will be particularly useful where formal resource allocation procedures may be ineffective, for example, because of early ambiguity over the resources required in the development of an innovative idea. Access to diverse know-how and perspectives, therefore, may help nurture and sustain entrepreneurial activity up to the point where more formal mechanisms are activated. Overall, this suggests the following:

Hypothesis 4: A manager's innovation performance will be positively associated with the heterogeneity of knowledge present in his/her social network.

Moreover, there are reasons to expect positive interaction effects between network structure and knowledge heterogeneity for both overall managerial performance and innovativeness. First, as Burt suggests: "Structural holes are the setting for tertius strategies. Information is the substance" (1992, p33). In other words, while a tertius position in the network provides the opportunity for brokering and arbitrage, the 'currency' of these tertius strategies is often information. We should therefore expect that the advantages of knowledge heterogeneity to be more pronounced in the presence of structural holes and the brokering opportunities they provide. Conversely, we expect the advantages of structural holes to be diminished if the contacts between which brokering is structurally feasible are not diverse in knowledge. Hitherto, this contingency relationship has not been tested, possibly because of the empirical difficulty in assessing the diversity of information and knowledge a network affords.

Hypothesis 5: Knowledge heterogeneity and network sparseness jointly and positively influence overall managerial performance.

Finally, returning to Burgelman's notion of autonomous strategic behavior, innovation depends not only on generating new ideas but also protecting them from skeptical scrutiny (1991). Successful managerial innovation will thus depend not only on access to diverse knowledge as a catalyst for new ideas but on a network structure that helps sustain their pursuit long enough for some tangible success to lend the project some inherent legitimacy. Each is necessary but alone insufficient; for successful innovation both must be present. This contingency we capture in our final hypothesis:

Hypothesis 6: Knowledge heterogeneity and network sparseness jointly and positively influence managerial innovation performance.

In summary, this study begins by reexamining existing theory concerning the role of social network structure on two performance outcomes, overall managerial performance and managerial innovation performance. Then, simultaneously with network structure, it tests the effect of knowledge heterogeneity, made available through one's social network, on the same dependant variables.

Methods

The Research Site and Survey Sample

This research relies on primary data collected from a medium-sized Scandinavian telecommunications company. While operating in several countries in Europe, the bulk of its activities are in the provision of domestic wire-line and mobile phone services. At the time of the study, the firm was operating in a liberalized and considerably more competitive market than existed at the beginning of the 1990s, when telecommunication deregulation began in Europe. Its current leading market position, while in part a function of its historic position as the state monopoly provider, was increasingly sustained through the introduction of new products and services. Innovation was thus an important aspect of the firm's strategy.

It was agreed with the company's senior management that the sample would be drawn from managers in the Residential Services division's Product/Project Management and Product Marketing departments. Preliminary interviews were conducted with a number of managers in these departments to assess among other things, the scope of their social networks. We asked the company to identify a target population of managers who had managerial responsibility for people, products or markets, effectively the middle managers of the firm. The company provided us with a list of 159 potential respondents and notified these managers that they would be asked to participate in a computer-based survey. Each participating manager was sent a diskette containing the computer based questionnaire, a letter from the director of the Residential Services division asking them to support the project, a letter from the research team explaining the background and logistics of the survey, an instruction sheet and a pre-addressed envelope for mailing the results directly back to the research team. After one month and again ten weeks following the initial mailing, all who had not responded received a reminder from the project's sponsor in the company. We received sixty-eight responses from the sample set representing a response rate of forty-three percent.

Many respondents identified contacts in parts of the company outside the residential division where the study had been launched. We therefore sought and obtained senior management's agreement to contact those managers in other divisions cited as key contacts by the respondents from the initial sample. A single 'snowball' round (Wasserman and Faust, 1994) of the survey was sent to anyone cited by the respondents in the initial round, an additional eighty managers in total. The majority of these worked in the Network division, responsible for the operation and maintenance of the company's network infrastructure. The snowball round generated forty-four additional responses. In total, we received one hundred and ten responses of which four were incomplete and unusable, leaving one hundred and six respondents in all.

The Survey Instrument

The survey was administered using a Visual Basic survey program tool developed specifically for this project. The first section of the questionnaire elicited general demographic information, including gender, tenure with the company, length of time in current job, and educational history. Respondents were also asked to identify themselves by name from a list of all those in the survey sample.[1] The second part of the survey dealt with the respondent's contact network. This section comprised a name-generator, a series of name-interpreters and two ego-network questions. The name-generator questions, shown in the top panel in Table 1, were similar to those used in prior research (Burt, 1992; Podolny and Baron, 1997). The four types of ties elicited were for social support, innovation, buy-in and task advice networks. The four name-generator screens presented respondents with a list of all the managers in the sample both to facilitate completion of the survey and to reduce ambiguity concerning contacts' identities. Although we provided respondents with a list of names from which to choose, respondents were also able to add contact names. Thus while providing a list of names helped reduce ambiguity, it did not restrict the identification of contacts to those in the initial target sample. Many network studies place a limit on the number of contacts elicited. However, this can lead to the censorship of large ego-networks of well-connected people. We therefore chose not to place an upper limit on the number of contacts respondents were asked to cite.

Table 1 about here

In the name-interpreter section, respondents were asked questions regarding each of their contacts in turn, including the length of their relationship, frequency of contact, average interaction length, and the extent to which they felt each contact was a source of new knowledge or expertise.

From our preliminary interviews we suspected that the managers in the sample would not constitute a closed network, that is, many would cite people outside of the sample. Egocentric data collection techniques were therefore necessary. The ego-network section of the survey comprised two parts. The first recorded the respondent's understanding of the strength of ties between his/her immediate contacts. The question used to elicit the structure of the respondent's network was similar to that used by Burt (1992) and is shown in the upper part of the middle panel in Table 1.

In addition to collecting respondents' assessments of the structure of their networks, the ego-network methodology was adapted to obtain data about perceived differences between contacts' domains of knowledge and expertise. Using the same question format, respondents were asked to assess the similarity or dissimilarity of each contact's knowledge to each of the other contacts in their network. The question used to elicit the similarity of knowledge between each pair of the respondent's contacts is also shown in Table 1. From these data we constructed a knowledge distance matrix. In the next section we explain how we used this to calculate a knowledge heterogeneity measure to which each respondent was exposed through his/her network.

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[1] In the appendix we explain how ego-network data was integrated using name information to reconstruct a more complete picture of the network than ego data alone permit.

Measures

Independent Variables. The independent variables in this study were network-based variables. The structural measures were calculated from a full structural network adjacency matrix, constructed by combining ego-network data and information from cited contacts, as we explain in the appendix. The main network structure measure was *network sparseness* (mean raw score = 0.46, std. deviation = 0.16), calculated as 1-density. Density, a popular measure of structure (see for example, Burt, 2000:35), was calculated as the number of ties between a respondent's contacts (contact-to-contact ties) divided by the maximum number of possible ties between those contacts.[2] Thus, the possible range for sparseness is from 0 (all contacts know one another) to 1 (no contacts know one another), with higher sparseness associated with a greater proportion of primary structural holes, that is a more favorable tertius position. Network size was also included in the models as a measure of political opportunity. Although a cruder measure, its effect needs to be parsed out vis-à-vis density.

The network content variable, *knowledge heterogeneity*, was derived from the knowledge distance matrix. This matrix was constructed using respondents' reporting of the knowledge contribution of each of their contacts and the contact-contact knowledge distances collected using the question from the middle portion of Table 1. The method by which the knowledge distance matrix (the basis for the knowledge heterogeneity measure) was constructed is also described in detail in the appendix. In order to gauge the heterogeneity to which to a particular manager is exposed though interaction with her contacts, it is not enough to know that her knowledge differs from that of each contact; the similarity of one contact's knowledge to another in her network must be taken into account. For example, suppose A has two contacts, B and C, each of whom have very different knowledge than A. The range of knowledge available to A will depend not only on A's knowledge distance from B and C but on B's distance from C, that is on the degree to which these two contacts' knowledge differs. To construct the heterogeneity measure, we began by calculating a value for the 'uniqueness' of knowledge for each member of a person's immediate network. The uniqueness of an individual, *i,* is some function of the uniqueness of each of his or her contacts and *i's* distance from them. We define the uniqueness of each contact, u_i, in *i's* network as given by:

$$\lambda\, u_i = \sum_{j=1}^{n} d_{ij} * u_j$$

Thus the uniqueness of each contact will be found in the solution of the Eigen equation:

$$\lambda\, U = DU$$

The vector U is the eigenvector whose elements are the uniqueness measures for each contact and D is the matrix of contact-to-contact knowledge distances. U holds information about the configuration of the network but not its size or the absolute inter-node separation. Information about the separation of the nodes is held in the Eigenvalue, lambda. Next, we define the heterogeneity of knowledge, h_i, to which i is exposed as:

$$h_i = \frac{1}{N} \sum_{j=1}^{N} d_{ij} \lambda \;\; u_j$$

where d_{ij} is the distance of contact j from i and u_j is *j's* uniqueness score calculated for *i's* N contacts. The 1/N term is included to compensate for the fact that lambda increases linearly with

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[2] We used sparseness rather than density because both sparseness and knowledge heterogeneity were predicted to have a positive influence on our performance measures. The interpretation of interaction effects is easier when both the interaction variables are positively associated with the dependent variable.

network size. The heterogeneity measure (mean raw score = 8.98, std. deviation = 5.28) has relatively intuitive properties; it increases linearly with the distance between contacts and with the distance between *i* and any of her contacts and is a monotonically increasing concave function of network size.

Both network sparseness and knowledge heterogeneity were standardized to allow us to compare their relative impact on the two performance measures. This was also necessary in order to allow us to inspect and meaningfully interpret any interaction effects between network density and knowledge heterogeneity, owing to the high correlation between the interaction term and the component variables[3].

Dependent Variables. Individual performance was measured using a survey completed by a team of two senior managers in the company. These managers were our internal sponsors and liaisons, the director of the residential division and the head of residential project management. They were asked to do their evaluations separately and confer on places where their assessments differed. They were told that they could use secondary resources and peers where necessary and to focus on the preceding twelve months. Each of the survey respondents was evaluated on six subjective items (see bottom panel, Table 1), four relating to general aspects of managerial task performance (Tsui, 1984) and two dealing specifically with innovativeness. A principal component factor analysis of the four Tsui items yielded a single factor with an Eigenvalue greater than one and a strong Cronbach alpha (0.93). This factor was labelled *overall managerial performance* (the standardized factor score was generated using STATA's principal component factor analysis procedure (StataCorp., 1999).

[3] Mean-centred variables are commonly used for interaction analyses (Jaccard, Turrisi, Wan 1990).

Our second measure, *managerial innovation performance* measure was constructed from the last two items (bottom panel, Table 1): item 5, an assessment of individual creativity and item 6, a measure of implementation effectiveness. Because these are antecedent to the latent construct, managerial innovativeness, it is appropriate to create a formative index rather than a reflective scale (Bollen and Lenox, 1991; Diamantopoulos, 2001). With formative measures, "causal indicators of the same concept can have positive, negative, or no correlation" (Bollen and Lenox, 1991:307) since the presence of one indicator does not guarantee the presence of the other (in this case there was a correlation of 0.29 $p<.05$). Thus "…using internal consistency as a criterion can have dire consequences." (Bollen and Lenox, 1991:307). Rather than using a linear combination of the two indicators, we formed our measure of managerial innovation performance by taking the square root of the product of items 5 and 6, thus capturing the necessity of the joint presence of creativity and implementation skills for innovation to take place (Farr and Ford, 1990). To facilitate comparison of beta coefficients across performance models we also standardized the managerial innovation performance measure.

The senior managers' assessment of managerial performance was conducted nine months after the majority of surveys were returned. The purpose of collecting performance data much later than the network data was to improve the confidence that the direction of causality ran from independent to dependent variables rather than the other way around (Davis, 1985). The use of senior managers' assessments as the measure of managerial performance was determined by the company's and its trades union's privacy policy regarding personnel data, which prevented the sharing of personnel files with anyone outside the company. Nonetheless, as several other researchers have noted, managerial performance is often measured through superior assessments

(Bretz, Miklovich and Read, 1992; Mehra, Kilduff M and Brass, 2001) and represent a reasonable reflection of true performance (Arvey and Murphy, 1998).

Control Variables. Respondents who began working for the company while it was still a state monopoly may have been socialized into norms and values that were out of place in the competitive environment in which the company now operates. Employees who joined the company before 1970 (there were seven in our sample) even retained their civil service pensions. We therefore controlled for company tenure, the length of time in years the respondent had been with the company. We controlled for job tenure, the length of time a manager had been in her current job, to account for the possibility that those new to a job might perform less well than those who had been in their position for some time. We included a dummy variable to control for gender. Seniority was included as a control in case the higher-ranking managers in the sample were better known to the senior managers who carried out the performance evaluations, potentially leading to an upward bias in their performance ratings. Seniority was measured on a four-point scale based directly on the company's internal seniority scale. Differences in education were accounted for using a three category ordinal scale; zero for education to high school level, one for a degree or equivalent and two for a post-graduate degree or equivalent. Since the company was in a relatively high technology field, we added a dummy variable to indicate whether the respondent had pursued mathematics, science or engineering related subjects during their higher education (Math or Science=1). To parse out the effect of intrinsic and extrinsic motivation, two individual-level attributes commonly associated with creativity, we included measures developed by Amabile (Amabile *et al.*, 1994) for each of these constructs.

A person's ability to exploit their network position, and so improve performance, may depend on the accuracy of their perception of the network in which they are embedded (Krackhardt, 1990).

Krackhardt suggests using the "S_{14}" statistic to assess accuracy of respondent perception of their network context (Gower and Legendre, 1986; Krackhardt, 1990). The S_{14} measure was calculated by comparing all the instances in which either member of a particular contact-contact dyad reported by a respondent were also respondents themselves and could thus corroborate the ego-reported relationship. S_{14} was used to control for the respondent's awareness of his or her network context. We also included dummy variables for each respondent's departmental affiliation, in order to control for performance differences that may have arisen from the different opportunities and context each department offered its members. We used the STATA 6 'rreg' procedure to test our multivariate regression models: rreg not only produces robust estimates of the standard errors, required given some heteroscedasticity in the data, but also produces better estimates of the model coefficients when there are a few extreme outliers[4] and which would otherwise dominate the estimation. (StataCorp, 1999; Berk, 1990; Goodall, 1983).

Results

An analysis of variance showed no significant differences between the initial respondents and the snowball round for any of the independent variables of interest in the study. Although snowball-round respondents were more likely to have math and science degrees (they came mainly from departments in which there were a higher-than-average numbers of science graduates), since the Math or Science control variable had no impact on any of the managerial performance measures, we do not suspect any systematic bias in the sample that would affect our findings. Testing for non-respondents bias was difficult the only data on both respondents and non-respondents we

[4] There were conspicuous outliers in terms of total network size, number of key contacts and the interaction term for sparseness and knowledge heterogeneity. OLS and rreg regressions, in which these variables were included, produced noticeably different results; when omitted, both procedures produced almost identical results. This suggests that outliers in these variables were distorting the OLS estimation.

were able to obtain concerned age, sex and tenure. Moreover, we had data on only 39 of the 93 non-respondents and age data for only 88 or our 106 respondents. While there was no significant difference between respondents and non-respondents in terms of sex, there was a significant difference between the two groups in terms of tenure ($p<0.005$) and age ($p<0.05$). The average tenure of respondents was 11.4 years compared to 16 for non-respondents. The respondents' average age of 42 was slightly lower than that of non-respondents for whom the average was 46. Moreover, there was no significant relationship between tenure and sparseness or knowledge heterogeneity, suggesting that while the sample may differ from the population in terms of tenure, this does not necessarily suggest that they differ in terms of our two key network related measures. The main concern regarding non-respondents is that they may differ from the observed population along dimensions which may be linked to the dependent variable and for which the study does not control. We therefore took care to measure and include a long list of control variables (gender, tenure, job tenure, seniority, level of education, science or math education, intrinsic and extrinsic motivation and the accuracy of perception of network structure) to give at least some reassurance that our models provide estimates of effects that are *net* of the important ways in which non-respondents might differ from respondents. Though we could not control for age in the regressions since we had only age data on 88 of the 106 respondents, age and tenure were significantly correlated. Thus, if there were an age-based effect this ought to show up in the tenure coefficient given the correlation between these two variables. We ran the regression models on the subset of 88 data points for which we had age data and added age as an additional control variable. In the innovativeness models, age was significant while tenure dropped from significance, suggesting that age rather than tenure was associated with declining innovation performance, but that the effect was controlled for to some degree by tenure. Importantly, when the models were run on the sub-sample of 88 observations, controlling for age, all the relationships found in the full sample remained.

There was considerable variation in the accuracy with which respondents perceived the networks in which they were embedded. Two respondents had negative scores on the S_{14} measure; in other words were wrong in their assessment of ties between their contacts more often then they were right. The average proportion of correctly identified ties and correctly identified missing ties was 66%. This highlighted the need to include S_{14} as a control variable in the models. However, inaccuracy in assessing network ties had no correlation with performance and was not significant as a control variable.

Table 2 shows the descriptive statistics for the variables used in the models. Of the six dummy variables for departmental affiliation, four showed a significant relationship to performance. Network division managers were rated poorly on both performance measures while managers in the IT services division were deemed to be better on both dimensions. Managers from Product Management and HR were rated as better overall performers but not as particularly innovative. Gender, Job Tenure, Education level, and Math/Science specialization had no influence on either of the performance measures. Intrinsic motivation contributed to innovation performance but not to overall performance. Company tenure was associated with both performance measures, with managers who were relatively recent hires performing better then older hands. Turning to the network variables, network size and sparseness both showed the expected positive associations with the two performance measures. Knowledge heterogeneity is positively associated with overall performance at the 0.05 level of significance and to innovativeness at the 0.01 level.

Table 2 about here

The results of the regressions are shown in Table 3. Overall Managerial Performance is the dependant variable in Models 1-4 while in Models 5-7, Innovation Performance is the dependant variable. Model 1 includes only the control variables. Interestingly the association between performance and tenure seen in the correlations disappears, probably because of the association between tenure and the network division and the latter's negative relationship with overall performance. The significance of the departmental dummy variables suggests that resources and opportunities for contributions may not be uniform across departments. The inclusion of these controls ensures, however, that the impacts of network structure and access to knowledge on performance are net of the differences in opportunities between departments, as well as controlling for any other sources of bias that might favor one department over another in the performance survey.

Table 3 about here

Model 2 adds network size and sparseness. As Hypothesis 1 predicts, sparse networks have a significant and positive impact on overall managerial performance ($\beta=0.35$, $p=0.013$). As prior studies suggest (Burt, 2000), structural holes are more prevalent in the networks of better performing managers. For example, moving from a network where three quarters of one's contacts know each other to one where only a quarter know each other results in a one standard deviation increase in performance. Model 3 adds knowledge heterogeneity. We also add the number of key contacts to control for the possibility that the heterogeneity effect might be simply a function of the number of key contacts, with which the heterogeneity measure is correlated. Neither total network size nor the number of key contacts is a significant predictor of performance when network structure is included[5]. As predicted in Hypothesis 3, knowledge heterogeneity has a positive and significant influence on managerial task performance (β=0.27, p=0.045). Of interest is the relative magnitude of the effect of network structure versus knowledge heterogeneity (whose coefficients can be directly compared in all models as the betas are standardized). As Model 3 shows, the impact of sparseness on managerial task performance is similar to that of knowledge heterogeneity (β_{khet}=0.31, p=0.022 vs. $\beta_{sparseness}$=0.27, p=0.045 respectively, and p[β_{khet}=$\beta_{sparseness}$]=0.827). In Model 4, we include an interaction term, the product of knowledge heterogeneity and network sparseness. As Hypothesis 5 suggested, when a manager has both a sparse network and access to heterogeneous knowledge, there is an additional contribution to overall performance (β=0.17, p=0.018), while the main effects of sparseness and knowledge remain. In summary, this suggests first, that for overall managerial performance, network structure and access to diverse knowledge are of roughly equal importance and second, that they are complementary.

Models 5-7 focus on Managerial Innovation Performance. As for Overall Managerial Performance, tenure was important; longer tenured managers were significantly less innovative than the company's more recent hires. Thirty-two years of additional tenure reduces innovativeness by one standard deviation. Model 5 suggests weak support for Hypothesis 2, that having disconnected contacts contributes to innovativeness (β=0.27, p=0.089). However, once

5 In a model in which only the controls and network size were included, network size was significantly and positively related to performance. However, when the measure of network sparseness is added, size ceases to be a significant variable. Since size is negatively related to network density, it would seem as though size entered alone was acting as a proxy for network structure.

we include knowledge heterogeneity (Model 6), the impact of network sparseness diminishes and falls from significance (β=0.18, p=0.238). Knowledge heterogeneity is significant, supporting Hypothesis 4, and with a substantially larger coefficient (β=0.44, p=0.001) than it showed for overall performance. Finally, Model 7 adds the interaction term, which is significant (β=0.23, p=0.004) confirming Hypothesis 6 that the combined presence of both structural holes and knowledge heterogeneity is beneficial to performance, while the main effect of knowledge heterogeneity remains.

In sum, while knowledge matters for overall performance, its influence is about the same as that of network structure. However, where managerial innovativeness is concerned, knowledge heterogeneity has a more pronounced and significant effect than it did in the case of overall performance. Moreover, the fact that sparseness falls from significance when knowledge heterogeneity is added to the model suggests that network structure alone is of little benefit; it must be accompanied by knowledge heterogeneity. Interestingly, the converse is not true; knowledge heterogeneity is useful for managerial innovation even when networks are dense.

Discussion

The purpose of this study was to develop our understanding of the micro-sociology of overall managerial performance and managerial innovation performance. Using social network methods and building on its theory, we have developed a finer-grained assessment of how the social and knowledge context within which a manager is embedded contributes to his/her performance. Our intent is to provide much needed detail and nuance to the importance placed by the knowledge-based view on the circulation and exchange of knowledge within firms. In particular, we set out to explore the value of maintaining a network rich in heterogeneous knowledge, above and beyond the value of a network structure rich with structural holes and the political advantages that such sparse networks offer. In other words, we sought to answer the question: How much does knowledge really matter?

To begin with, our findings are consistent with those of prior research in showing that network structure plays an important role in individual performance (Burt, 2000). A manager embedded in a sparse network is likely to benefit from the political maneuverability such a network position affords; a bridging position is associated with higher overall managerial performance (H1). However, our results add to this previously established result. They indicate that network content also matters—the variety of knowledge to which managers are exposed is an important ingredient in both overall managerial performance (H3) and especially in innovation performance (H4). The relative magnitude of this impact is particularly noteworthy. While access to diverse knowledge and network structure both have comparable impact on overall managerial performance, access to diverse knowledge matters much more for innovation performance than it does for overall performance. The standardized coefficient for knowledge heterogeneity is markedly higher for innovation performance than for overall managerial performance (64% increase in influence between Models 3 and 6 and 61% gain between models 4 and 7). This suggests that the value of access to diverse knowledge is greater where managers are engaged in activities in which the generation of novelty matters. It also offers justification for the implicit importance the knowledge-based view places on knowledge exchange and diversity as a precursor to knowledge creation (Kogut and Zander, 1992; Hargadon and Sutton, 1997; Galunic and Rodan, 1998; Hansen, 1999). This literature has identified knowledge and its management as important to firms. However, it has so far lacked more nuanced empirical insight into how knowledge actually matters.

This does not negate the value of network structure. For overall performance sparse networks provide an advantage independent of knowledge heterogeneity, and this main effect remains in the interaction model (Model 4). Thus, not only is the main effect of network structure a factor in overall performance, it is also a useful complement to knowledge heterogeneity in both overall performance and innovation performance. Our findings suggest that a sparse network structure is not a universal panacea. The fact that structure ceases to be significant for innovation when knowledge heterogeneity is introduced suggests that sparseness, because of its correlation with knowledge heterogeneity, may have been acting as a proxy in Model 5 and was capturing variance that was more appropriately attributable to the influence of knowledge. This speaks directly to the different proposed mechanisms. When both the main effects of structure and content persist after the interaction term is introduced, as is the case with overall performance, it would seem that each contributes absent the presence of the other. Structure may help performance even when there is no heterogeneity in knowledge while knowledge may help even when there are no holes to be bridged. This seems to fit nicely with the mechanisms Burt describes – the creation of competition (purely structural), opportunity recognition (purely informational) and the brokering of information (jointly contingent on access to diverse information a network structure to exploit it).

However, when we consider innovation performance, the fact that structure only matters in the presence of knowledge heterogeneity would seem to be consistent with a different explanatory mechanism. Here idea generation (purely knowledge based) and implementation of those ideas (jointly contingent on knowledge heterogeneity, the catalyst for new ideas, and a network structure useful in protecting their early development) would seem to be the prime candidates to explain this pattern of results.

Moreover, our findings caution us not to simply presume that sparse networks are perfect surrogates for knowledge heterogeneity—they are not. Although the correlation between network sparseness and knowledge heterogeneity is significant (0.21, $p<0.05$), there is a considerable amount of variance in knowledge heterogeneity not explained by network structure. While knowledge diversity is more likely to come from disconnected contacts, knowing the structure of a manager's network does not tell us everything we need to know about the distribution of knowledge within it. In other words, there is no guarantee that by building a sparse, disconnected network a manager will also be gaining access to heterogeneous knowledge. This is an important insight given the tendency of the social network literature to presume that network structure and knowledge diversity are closely linked, a point highlighted by our finding that knowledge heterogeneity matters to performance even while controlling for the influence of network structure. In short, having a sparse network clearly matters, but we should not confound this with the distinct benefits of access to diverse knowledge through one's network.

Our findings also add evidence to the literature broadly collected under the banner of organizational diversity, a literature that also carries implicit claims about the value of diverse knowledge. While some prior studies have shown that diversity can be a hindrance and source of conflict for individuals, groups, and firms (Hambrick Cho and Chen, 1996; Miller, Burke and Glick, 1998), others have suggested that it can be beneficial (Pelled, 1999; Watson, Kumar and Michealsen, 1993) though perhaps contingent on other factors, such as a strong, underlying collectivist culture (Chatman et al., 1998). In part, the lack of a clear picture in the diversity literature may stem from the different aspects of diversity being measured and their distance from the underlying mechanisms presumed to explain managerial or organizational behavior. For example, Kilduff, Angelmar and Mehra (2000) recently found that demographic diversity was not a good indicator of cognitive (or knowledge) diversity, the latter reflecting, in essence, the variety of attitudes, perspectives, and even know-how available to an actor or group. Yet demographic diversity is a common proxy for cognitive diversity (Finkelstein and Hambrick, 1996). So, while cognitive diversity is an evidently useful underlying motor for theorizing about managerial and organizational behavior, we see the need to be cautious about what proxies are used to measure such diversity. Our study avoids demographic proxies for diversity and instead taps more directly the knowledge diversity available to managers.

Implications for Strategic Management Practice

A manager or Human Resource executive reading the emerging managerial literature on social capital will generally conclude that 'networking' is a good thing (Baker, 1994), and, particularly, that building a network of people who do not know each other is particularly advantageous. This is because they are led to believe that a whole host of advantages will fall into place as they assemble disconnected contacts. Our study should temper this conviction, or at least should make us aware that assembling a network of disconnected contacts does not necessarily lead to a network that is also heterogeneous in knowledge. The importance of this insight is particularly salient if we consider the costs of such networking. At a personal level, building and maintaining a network with disconnected contacts is certainly not costless. The manager-as-network-entrepreneur will need to constantly open new ties to retain tertius advantages, given that structural holes have a tendency to close (Burt, 2000). Maintaining a network full of structural holes requires time and effort. While we do not dispute that a network of disconnected contacts does offer advantages, given that their maintenance is not costless, managers should consider an alternative criterion for their networks, that may entail lower maintenance costs and, depending on the context, higher gains. Recognizing that disconnected contacts are no guarantee of knowledge heterogeneity, managers should consider building networks with an eye to the knowledge diversity they might provide rather than structure alone.

At an executive level, building internal structures and processes that promote networking amongst subordinates but do not really contribute to the gathering of distinct alternative perspectives and sources of know-how may be missing the point when it comes to managerial performance and innovativeness. Our results suggest that senior managers should find ways of encouraging employee access to distinct areas of competence, not just ‘disconnected’ people, particularly if they value innovation. For example, job rotations for junior executives that require them to spend time in each of several functional areas would allow a manager to build ties to people with very different knowledge and perspectives from her own. Our study also implies the relevance of looking beyond social networks for ways of linking employees to diverse knowledge. With the popularity of web-based technologies and knowledge management systems, as well as the availability of numerous educational opportunities (e.g., executive education seminars and alumni networks), it is certainly possible for managers to access diverse knowledge through other sources. Of course, the knowledge at the end of many of these inanimate sources is often human (e.g., effective knowledge management systems are as likely to connect managers to other managers as to documents), and so they are probably more a tool for usefully influencing building of social capital rather than an alternative to it. Nonetheless, it would be useful if future studies contrast the influence on managerial innovativeness of social networks versus relatively inanimate sources of diverse knowledge. Such research should be particularly relevant for CIOs, providing a comparative assessment of the value of different tools for broadening employee’s access to expertise and its concomitant influence on performance.

Limitations and Future Directions

First of all, unlike Burt's high tech company, the managers in this firm are not operating in a matrix management reporting structure, that is one where "the information access, timing, referral, and control benefits of structural holes should be especially valuable." (1992) Since our firm does not employ a matrix organization, it might be argued that there is less scope for the effects of structure to be manifest, and so its relative influence may be underestimated. That structural effects are found here represents a conservative test of the effect of structure. However, since matrix structures are less fashionable than they were a few years ago, our firm's more hierarchical organization is representative of the structure of a large number of firms. Nonetheless, this is a study of a single company in a high-tech industry and the results may not generalize to other industries or companies. Furthermore, given the Scandinavian cultural setting of this firm, employee attitudes regarding collectivism versus individualism may make the results, if not idiosyncratic to the company, at least peculiar to this part of Europe. Chatman *et al's* (1998) findings suggest that people in collectivist cultures—within which this firm is located (Hofstede, 1997)—will benefit more from heterogeneity than individualist cultures. If this is the case, the impact of knowledge heterogeneity may be less pronounced in settings that are more individualistic, while the influence of structure may be more pronounced. Further studies are therefore needed to increase the generalizability of our findings.

Future studies should further refine the measurement of this study's key constructs and possibly include others. First, company policy prevented our obtaining personnel records, and in particular any of the company's standard metrics regarding individual performance. Clearly, future studies might try to gather more objective measures of managerial performance. Second, while we believe our methodology is unique in the way it operationalizes the knowledge diversity accessible to an actor—i.e., that which is available through one's network—future studies should continue to develop the detection of knowledge diversity. For example, in their assessments comparing the knowledge diversity of their contacts, respondents are asked to think about a broad range of knowledge, some of it tacit and so more difficult to pinpoint. While our methodology benefits from the availability of reference points in the questioning—respondents are asked for comparative assessments, or knowledge differences, between individuals, not the codification of the actual knowledge—future studies should continue to refine this measure. For example, the inclusion of well-established cognitive mapping procedures (Huff, 1990; Laukkenen, 1994; Markóczy and Goldberg, 1995) could be used in the future as another means of assessing the knowledge distances between individuals. Finally, we need to be careful not to presume that the potential access to diverse knowledge through a social network will always result in its appropriation by a manager. Knowledge can vary in its transferability (Teece, 1977), and the quality of interpersonal relations may play a facilitating role in the exchange of this knowledge (Szulanski, 1996). While it seems clear that higher quality relations should boost knowledge access, future studies might expand the scope of the present research by examining the moderating role of relational quality to knowledge heterogeneity and its influence on performance.

Conclusion

Herbert Simon once wrote:

> "What an individual learns in an organization is very much dependent on what is already known to (or believed by) other members of the organization and what kinds of information are present in the organizational environment…Individual learning in organizations is very much a social, not a solitary, phenomenon."(Simon, 1991:125, parentheses in the original)

We could easily extend this to managerial performance more generally, recognizing that whether to generate useful novelty or execute tasks and strategies, managerial performance is socially embedded and dependent on the knowledge of others. We couple to this thought the awareness by managers and scholars alike that as innovation becomes increasingly central to gaining and maintaining competitive advantage, firms must develop and encourage outstanding managerial performance in this regards in order to prosper. Yet, we still know far too little about that which Simon describes as the "social phenomenon" behind this outcome.

Our study contributes to strategic management thinking by making theoretical, methodological, and practical inroads to this problem. Our study extends and refines current theory in highlighting two distinct mechanisms associated with manager's performance, one associated with network structure and the other with the diversity of knowledge to which managers have access. By parsing apart the influence of network structure and network content, we offer a more nuanced view of the benefits of a manager's social network structure to her performance. We also contribute to the growing literature on knowledge and organizations, detailing and expanding the causal motors by which heterogeneous knowledge is important for managerial performance. Our concern for both knowledge and networks led us to introduce a unique way of using network methods to study the knowledge diversity of interpersonal networks. Finally, our study should be of considerable practical concern for managers. It not so much underscores the importance of networking, or helping subordinates to network, but offers findings that should make managers more informed in this process. Networking is too often seen as either banal advice or a distasteful exercise, rife with uncomfortable political and moral overtones. Our study at least points to the substantial creativity and innovation benefits available through a network that specifically hones in on knowledge heterogeneity. If future work continues to support the importance of managerial access to heterogeneous knowledge and adds further nuances to its successful use, senior executives will be better informed to successfully invest in and manage the knowledge of the firm. In conclusion, we hope that this work will motivate other studies of knowledge and networks within firms, and so further build the micro-foundations of strategic advantage.

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Appendix

Construction of the Matrices

Our measures of network structure were calculated from a single binary choice adjacency matrix, **A**, in which a tie from *i* to *j*, is indicated by $A_{ij}=1$. The knowledge heterogeneity measure was calculated from a knowledge distance matrix, **D**, in which D_{ij} is the reported dissimilarity between person *i*'s knowledge and person *j*'s. Both matrices were constructed using both the respondents' reporting of their relationship and knowledge distance from their key contacts and on respondents' assessments of the relationship and knowledge distance between each pair contacts they identified. This latter information was elicited using ego-network collection methods. We were able to combine ego data and respondent's direct reporting because we collected all the contact names.

Both the knowledge distance matrix and the adjacency matrix were constructed in a similar fashion. The starting point was to build a list of respondents' names and the names of all those they cited. Into this matrix the respondent's reporting of his/her direct relationship and his/her reporting of relationships between contacts was placed. The identification of a contact was taken as a binary indication of the existence of an outbound tie to this person. Ego-network data regarding the ties between the contacts each respondent identified were combined with the respondents' key contact data. In building the adjacency matrix, directly reported tie information was given precedence over ego-network data. The specific rules used in combining the two sources of data are illustrated as follows. Suppose *i* cites *j* as a key contact and is cited by *k*. Using ego-data alone would show *i*'s overall network comprising only *j*. However, because *i* has been identified by name, *k*'s citing of *i* can be used to improve the picture of *i*'s overall network.

By combining directly the reported tie with ego-network data, we would record *i* as having one outbound tie to *j*, but two ties in total, an outbound tie to *j* and an inbound tie from *k*.

Suppose further that *i* also cites *p* and *q*, who are not respondents. *i* says that he believes that *p* and *q* know one another and this we accept at face value since *p* and *q* are not respondents. He also indicates a relationship between *j* and *p*. However, if *j* does not report an outbound tie to *p*, we accept *j*'s report of the *j*->*p* tie over that of *i*. Thus instead of using *i*'s testimony to set A_{jp}=1, this cell is set to 0. However since *p* is not a respondent we accept *i*'s assessment of the directed tie *p*->*j*. Finally, where several respondents report a relationship between *p* and *q* (i.e., two non-respondents) we used the average of these data. Ego-network data was collected on a three point Likert scale (see Table 1), 0 representing the absence of a tie, 1 representing a relationship that is neither distant nor close and 2 the presence of a strong tie. A tie was deemed to exist when the average value of all reporting concerning this tie exceeded 0.5. Thus if one person indicated that the tie was neither distant nor close and a second that there was no tie, the average would be 0.5 and no tie would be imputed. If one person indicated that the tie was neither distant nor close while a second reported it as close, the average for the tie would be 1.5 and a tie would be recorded. If two out of three respondents asserted a weak tie between, the average would be 0.66 and a tie would again be recorded.

Knowledge distance information was treated in a similar manner but with some important differences. First, knowledge differences were measured using a four point Likert scale, with 1 indicating highly similar knowledge and 4 extreme dissimilarity. Second, the matrix is symmetric since it seems to make little sense to say that *i*'s distance from *j* is different from *j*'s distance to *i*. Thus, when two respondents cited each other, and indicated different knowledge differences, the average of the two was used. Third, no precedence was given to respondent reported difference between the respondent and her contacts over her reporting of distances between his/her contacts. For example, suppose *i* reports her distance from *j* as 3, and *j* his distance to *i* as 2. *K*, who cites *i* and *j*, considers they are very similar in knowledge and rates the distance between them as only 1. The elements D_{ij} and D_{ji} in the knowledge distance matrix would in this case be set to 2, the average of all three pieces of data. We considered that in estimating knowledge similarity or differences, if *k* knows *i* and *j*, there is a case to be made that her assessment is less valuable than *i*'s or *j*'s of each other. However, a counter argument might be made that *k*'s assessment of *i* and *j*'s knowledge similarity is more objective than that of *i* or *j*. We therefore decided to privilege neither source and weight them equally.

Table 1
Key Survey Questions

<table>
<tr><td colspan="2">Eliciting the respondent’s contacts – part of main survey sent to targeted sample of middle managers.</td></tr>
<tr><td>Advice contacts</td><td>“Getting your job done on a daily basis as a manager often requires advice and information from others. Who are the key people who you regularly turn to for information and work-related advice to enhance your ability to do your daily job?”</td></tr>
<tr><td>Innovation contacts</td><td>“Some contacts are particularly useful in helping you to be creative in your job, such as helping you to generate new ideas. Who are the key people that help you the most to formulate new ideas?”</td></tr>
<tr><td>Buy-in contacts</td><td>“New ideas often require support from others without which you cannot proceed. Who are the key people that provide essential support to new initiatives?”</td></tr>
<tr><td>Social support contacts</td><td>“Most people rely on a few select others to discuss sensitive matters of personal importance - i.e., 'confidants' on whom they rely for personal support. Who are the key people in your work environment that you regard as your most important source of personal support?”</td></tr>
<tr><td colspan="2">Eliciting network structure (sparseness) and content (knowledge heterogeneity) – part of main survey sent to targeted sample of middle managers.</td></tr>
<tr><td>Structure
(3 point Likert scale)</td><td>How well do your contacts know one another?

The next set of questions deals with the relations BETWEEN each of your contacts.
Chose 'Especially close' if there is a close relationship between the person named in the question and the person you are considering from the list underneath.
Chose 'Distant' if the person named in the question and person you are considering from the list underneath rarely work together or are total strangers as far as you know.</td></tr>
<tr><td>Knowledge heterogeneity
(4 point Likert scale)</td><td>How similar is your contacts' knowledge?

The next set of questions deals with relative similarity or difference in knowledge between your contacts.
Chose 'Very similar' if the knowledge of the person named in the question and person you are considering from the list underneath is very similar, for example an football player and the football-team coach. Here the two people should have a great deal of work related knowledge in common.
Chose 'Very different' if the knowledge of the person named in the question and person you are considering from the list underneath is very different, for example an airline pilot and a computer scientist. In this case, the two people should have almost no work related knowledge in common.</td></tr>
<tr><td colspan="2">Assessing managerial performance – survey sent to two senior managers asked to assess the performance of the managers who responded to the main survey.</td></tr>
<tr><td>(7 point scale)</td><td>“Please write the number from the 7-point scale that best corresponds to your assessment of this manager’s performance over the last 12 months.
1) Overall, to what extent is the manager performing his/her job the way you would like it to be performed.
2) To what extent has she/he met your expectations in his/her roles and responsibilities?
3) If you had your way, to what extent would you change the manner in which he/she is doing the job?</td></tr>
</table>

	4) To what extent are you satisfied with the total contribution made by this person? 5) To what extent is this person particularly creative: someone able to come up with novel and useful ideas? 6) To what extent is this person good at implementing novel ideas?”

Table 2
Mean, Standard Deviations and Correlations of Variables

	Variable	Mean	StdDev	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	Overall Perf.	.00	1.00																					
2	Innovation Perf.	.00	1.00	.70**																				
3	Gender	.80	.40	.08	.06																			
4	Company Tenure	11.36	8.68	-.28**	-.29**	.09																		
5	Job Tenure	3.42	4.12	-.17†	-.05	.04	.39**																	
6	Seniority	4.07	.71	.09	.17†	-.09	-.04	-.11																
7	Education	2.09	.64	.02	.13	.07	-.26**	-.05	.09															
8	Math & Science	.72	.45	.00	.12	.48**	-.06	.05	-.03	.22*														
9	Intrinsic	.00	1.00	.13	.23*	-.03	-.09	.11	.08	.18†	.04													
10	Extrinsic	.00	1.00	.05	-.13	-.09	.05	.10	-.22*	-.19†	-.07	.00												
11	S14	.90	.13	-.02	-.04	-.06	.07	.14	-.04	-.01	-.09	.05	.00											
12	Dept. - R&D	.10	.31	-.07	.04	.01	-.06	.19†	-.03	.00	.15	.12	-.02	.04										
13	Dept. - Network	.38	.49	-.29**	-.27**	.19*	.40**	.22*	-.13	.10	.32**	-.02	.13	-.12	-.26**									
14	Dept. - Prod. Mgt	.31	.47	.20*	.10	-.28**	-.15	-.22*	.02	-.13	-.35**	-.03	.01	-.08	-.23*	-.52**								
15	Dept. - Finance	.02	.14	.13	-.07	.07	-.03	-.06	-.01	.09	-.07	.09	.04	.11	-.05	-.11	-.09							
16	Dept. - HR	.02	.14	.23*	.04	.07	-.01	-.07	-.01	.09	.09	.09	.12	.03	-.05	-.11	-.09	-.02						
17	Dept. - IT/IS	.03	.17	.22*	.29**	.08	-.06	.01	.15	.06	-.02	.03	-.15	.13	-.06	-.13	-.11	-.02	-.02					
18	Network Size	25.81	13.99	.36**	.33**	.04	.17†	-.06	.10	-.11	.01	.14	-.07	.03	.00	.01	.16	-.02	-.01	.10				
19	Network Sparseness	.00	1.00	.38**	.41**	.29**	.06	.01	-.05	.02	.26**	.25*	-.24*	.08	.21*	-.10	-.06	-.01	.09	.09	.68**			
20	No. of Key Contacts	11.75	6.72	.21*	.15	.00	-.03	-.10	.05	-.27**	-.04	.03	.13	.04	.25**	-.10	.00	-.11	.11	-.09	.25*	.23*		
21	Knowledge Het.	.00	1.00	.24*	.27**	.11	-.07	-.09	-.01	-.09	.08	.09	.07	.05	.19†	-.02	-.06	-.11	.09	-.09	.11	.21*	.80**	
22	K-Het X Sparseness	.21	1.11	.10	.14	.02	-.15	-.06	-.13	.04	.06	.06	.08	.03	.25*	-.07	-.01	-.04	-.04	-.17†	-.15	-.10	.24*	.23*

† $p < 0.1$, * $p < 0.05$, ** $p < 0.01$

Table 3

Multivariate Regression Models

Overall and Innovation-related Managerial Performance

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
	Overall managerial performance				Innovation performance		
Constant	-0.703	-0.4291	-0.3109	-0.2622	-0.1549	0.0229	0.0568
	(0.833)	(0.891)	(0.883)	(0.839)	(1.002)	(0.981)	(0.908)
Gender (male=1)	0.0686	0.112	0.0695	0.0026	-0.0941	-0.1746	-0.2669
	(0.216)	(0.237)	(0.226)	(0.216)	(0.266)	(0.251)	(0.233)
Company Tenure	-0.012	-0.0326**	-0.0297*	-0.0231*	-0.0304*	-0.0309*	-0.0315**
	(0.011)	(0.012)	(0.011)	(0.011)	(0.013)	(0.013)	(0.012)
Job Tenure	-0.0068	-0.002	0.0024	0.0015	0.0338	0.043†	0.0488*
	(0.021)	(0.022)	(0.021)	(0.02)	(0.025)	(0.023)	(0.022)
Seniority	0.0634	0.1015	0.1093	0.136	0.1624	0.2065	0.2793*
	(0.109)	(0.122)	(0.117)	(0.113)	(0.137)	(0.13)	(0.122)
Education	0.092	0.0076	0.0268	0.0748	0.1304	0.134	0.0924
	(0.13)	(0.139)	(0.139)	(0.133)	(0.156)	(0.154)	(0.143)
Math & Science	0.0669	0.0107	0.0216	-0.0499	0.2435	0.2661	0.2286
	(0.207)	(0.225)	(0.216)	(0.206)	(0.253)	(0.241)	(0.223)
Intrinsic	0.1123	0.0467	0.0123	-0.016	0.1097	0.0777	0.0452
	(0.077)	(0.085)	(0.082)	(0.078)	(0.096)	(0.091)	(0.085)
Extrinsic	0.0593	0.1778*	0.1746*	0.1684*	0.0677	0.0735	0.0677
	(0.08)	(0.088)	(0.085)	(0.08)	(0.099)	(0.094)	(0.087)
S_{14}	0.226	0.1231	0.0336	-0.107	-0.7334	-0.8605	-1.0665†
	(0.586)	(0.624)	(0.596)	(0.567)	(0.702)	(0.662)	(0.614)
Dept.- R&D	-0.2505	-0.3622	-0.373	-0.4769	-0.6468†	-0.5574	-0.6322†
	(0.32)	(0.344)	(0.34)	(0.327)	(0.386)	(0.378)	(0.354)
Dept.- Network	-0.2284	-0.0519	-0.0806	-0.0546	-0.5254	-0.5181	-0.431
	(0.277)	(0.315)	(0.301)	(0.286)	(0.354)	(0.334)	(0.309)
Dept.- Product Mgmt	0.3282	0.5688*	0.5605*	0.5226*	-0.0696	-0.028	-0.0424
	(0.245)	(0.279)	(0.266)	(0.252)	(0.314)	(0.295)	(0.273)
Dept.- Finance	0.8919	0.9431	1.116†	1.1467*	-0.6872	-0.4124	-0.2481
	(0.581)	(0.621)	(0.594)	(0.566)	(0.699)	(0.661)	(0.612)
Dept.- HR	1.5191*	1.302*	1.2891*	1.3756*	-0.2951	-0.198	0.0162
	(0.596)	(0.633)	(0.61)	(0.582)	(0.712)	(0.678)	(0.629)
Dept.- IT/IS	1.3117**	1.1886*	1.2782*	1.4261**	1.1666†	1.3037*	1.5297**
	(0.481)	(0.522)	(0.498)	(0.476)	(0.587)	(0.553)	(0.515)
Network Size		0.0016	0.0047	0.0041	0.01	0.0172†	0.0194*
		(0.009)	(0.009)	(0.009)	(0.01)	(0.01)	(0.009)
Network Sparseness		0.3542*	0.3134*	0.359**	0.2706†	0.1775	0.2205
		(0.14)	(0.134)	(0.129)	(0.157)	(0.149)	(0.14)
Number of Key Contacts			-0.0179	-0.0268		-0.0397†	-0.0496*
			(0.021)	(0.021)		(0.024)	(0.022)
Knowledge Heterogeneity			0.2704*	0.2878*		0.4429**	0.4643**
			(0.133)	(0.126)		(0.148)	(0.136)
Knowledge x Sparseness				0.1725*			0.2291**
				(0.071)			(0.077)
R-squared	0.2421	0.4025	0.4446	0.4688	0.4108	4707	0.5122
Adjusted R-squared	0.1158	0.2871	0.3218	0.3438	0.2970	0.3538	0.3974
Model degrees of freedom	16	18	20	21	18	20	21
Prob. > F	0.0007	0	0	0	0.0002	0	0

N = 106, † $p \leq 0.1$, * $p < 0.05$, ** $p < 0.01$, two tailed tests, robust standard errors in parentheses, STATA 'rreg' procedure.