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TECHNOLOGICAL INNOVATION TODAY: OLD WINE IN NEW BOTTLES?

"In other words, 21st-century organisations are not fit for 21st-century workers."
Hindle 2006:4

Few would argue against the proposition that successful innovation lies at the heart of today's knowledge economy. Knowledge is held to be the key to economic growth in all societies, particularly within the advanced industrial states (Brint 2001; Powell and Snellman 2004). In 2006, the European Union set itself the objective of becoming "the most competitive and dynamic knowledge-based economy in the world," and the Lisbon Council Policy Brief followed rapidly with a study on "defining the role of human capital in economic growth." Part of this involved the construction of The European Human Capital Index, with the express intention of using the findings to generate policies that would lead to sustained knowledge creation and innovation across the continent (Ederer 2006). On the other side of the Atlantic, in its latest "research announcement," the IBM Center for Innovation unveiled the "Topics of Special Interest 2006–2007." Not surprisingly, key among those topics are "human capital management" and new ways of organizing for solving routine and complex problems. Companies are openly engaging in a fierce battle for talent, knowledge, and brainpower, and they are not hesitant to pay whatever price this new global market demands so long as it increases the likelihood of successful innovation. Segal reports that "In 2002, the U.S. R&D total [spending] exceeded that of Canada, France, Germany, Italy, Japan, and the United Kingdom combined . . ." and in 2004 the total expenditures on R&D in the United States were expected to reach $290 billion (2004: 3). Between 1996 and

2002, the pharmaceutical industry alone doubled its spending on R&D to $32 billion. Yet during the same period of time, the number of new drugs brought to the market fell from fifty-seven to seventeen (Canner and Mass 2005: 17). Some estimates suggest that, on average, as many as 80 percent of the innovative projects in North American companies fail either entirely or in part. Furthermore, these results are not confined to the United States. An analysis of fifty innovative projects in Dutch companies found that only one in five projects turned out to be viable (Carr 1996; Cozijnsen, Vrakking, and van Ijzerloo 2000), and this disheartening trend has not changed since 1980 (Page 1993).

This book is yet another attempt to offer a fresh perspective on how success in projects in knowledge-intensive organizations can be promoted given the contemporary challenges facing these organizations. While building on the vast body of rich theoretical and empirical insights generated by previous research, the book bridges the literature on innovation; social networks; and projects, teams, and small-group studies.

The recent thinking on innovation stresses two central features relevant to the innovative process: "first, that [it] involves the coordination and integration of specialized knowledge and, second, that it requires learning in conditions of uncertainty" (Castellacci, Grodal, Mendonca, and Wibe 2005: 94). These two features are the forces behind the fast-changing and highly uncertain environment in which knowledge-based organizations operate. As a result of the unprecedented pace at which technical and scientific knowledge has been generated in the past decade, the degree of specialization and fragmentation has increased too. General biomedical knowledge, for instance, doubles every twelve months. There are now four different databases that store three billion bytes of information in that field alone. Such trends impose substantial demands on companies to organize their laboratories and teams in ways that maximize the acquisition, targeted sharing, and utilization of the knowledge that is critical to the survival of the organization. Knowledge, however, resides in the minds of individuals, as well as being embodied in various routines, relations of power, and systems of meaning that people resort to in their daily work. As such, it does not easily lend itself to codification and, consequently, its retrieval and transfer is not a small and trivial matter. Another factor that complicates the ability of both individuals and organizations to process knowl-

edge has to do with the fact that knowledge is dynamic and therefore elusive as it evolves over time. The implications of this only increase in number with the advent of a global economy that creates R&D settings that are geographically dispersed, and, at the same time, functionally organized. One plausible consequence of these trends is that innovation can originate from any place in the company in geographical, functional, and hierarchical terms, given proper support. In consequence, to manage innovation is to perpetually attempt to manage both knowledge and uncertainty.

The question then is what can be done to reduce the uncertainty and arrange for the coordination and integration of highly specialized and widely dispersed knowledge? That the structure of a system has the ability to encourage certain patterns of interaction as well as outcomes while constraining others is one of the main tenets of social science. In view of this, Fagerberg's suggestion that we need to explore the answers to two main questions if we are to attempt to unravel the complexities surrounding the management of technology and innovation seems promising. They are "Is the potential for communication and interaction through existing linkages sufficiently exploited? Are there potential linkages within the system that might be profitably established?" (2005: 13). These questions, he states, apply to both systems and social networks. To understand how technological outcomes can be shaped, then, one must focus on the manner in which unit structures—both formal and social networks—affect the ability of an organization to effectively locate, access, and transfer critical knowledge in conditions of uncertainty. Do these structures act separately or in interaction? If the latter, how? In what manner can an R&D organization make best use of its human and social capital to achieve technological success? Can social relations be managed to the benefit of technological success? Is it possible to design technical projects that draw on the advantages of the formal and social network structures while avoiding their downsides? These are the questions that lie at the center of this book.

Despite groundshaking changes in the nature of work and authority patterns (Barley and Kunda 2004; Brint 2001; Kleinman and Vallas 2001; Vallas 1999), experts acknowledge that "today's big companies do very little to enhance the productivity of their professionals. In fact, their vertically oriented organizational structures, retrofitted with ad hoc and matrix overlays, nearly

always make professional work more complex and inefficient" (Hindle 2006: 4). Twenty-first-century organizations may need to devise yet another design form that reflects and accommodates the nature of the profound changes taking place in knowledge enterprises. This new design is likely not only to entail changes in the way in which positions and job descriptions are conceived but to require a considerable adjustment in the behaviors and attitudes of their occupants. For instance, most specialists would agree that the benefits of designing a decision-making process in a manner that individual team members can and will contribute to are practically immeasurable. This will involve the creation and maintenance of a different organization though; one in which there are new and meaningful ways of rewarding knowledge workers, particularly given the trend toward flat structures and the increased reliance on teams and project-based work;[1] one in which flexibility and perpetual change in the composition of the task environments may become the only constant. In light of this, a major emerging issue in contemporary R&D organizations is not just how to design formal channels to best navigate knowledge and information but, equally important, how to guide the informal relations between managers, scientists, engineers, and technicians with whom a large part of the knowledge and expertise resides.

This book is based on the premise that, although it is the individuals in possession of specific talents and skills who come up with novel ideas and connect the dots between remote and seemingly unrelated bits of knowledge and information, technological innovation is a process that takes place in a social setting. Hence, my interest is in the factors that enhance and constrain this social process. In particular, I am concerned with the conditions that create social dynamics that enable individual actors in groups to access and recombine knowledge in novel ways, so that the organization can then bring that knowledge to fruition. To this end, I pay special attention to the role of formal and social network structures as conduits of knowledge and information exchange as well as channels of decision making. My specific focus is on R&D projects and teams. Such teams, of course, do not exist in a vacuum. They are embedded in an R&D organization, a company, and, by extension, an industry (Ancona 1990). With this in mind, I examine the technical projects as part of their immediate organizational context, culture, and processes. My investiga-

tion is informed by structuralist approaches in the research on technological innovation, project management, and team and small-group studies.

RESEARCH ON TECHNOLOGICAL INNOVATION

The topic of technological innovation has been fascinating generations of scholars, managers, and policymakers ever since Schumpeter's influential *Theory of Economic Development* appeared in English in 1934. In it, he argued that the survival of firms, as well as that of society, is dependent upon their ability to continuously find new uses for existing resources and to recombine them in novel ways.

Information channels are the basis for any social action (Coleman 1988). Accordingly, technological innovation has been understood as a process, the result of which is the successful transfer of an idea into a new product or process that has social and market value (Allen 1977; Kerssens-Van Drongelen, Weerd-Nederhof, and Fisscher 1996; Van de Ven 1986). Hence, technological innovation is the result of information- and knowledge-processing activities that take place in an organizational context. These go beyond the generation of a creative idea in the minds of single individuals and proceed in stages (Ebadi and Utterback 1984). As innovations are conceived and accomplished by people within organizations, then both the individuals and the organizations are essentially information-processing units (March and Simon 1958). These units digest the scientific, technical, managerial, and contextual information acquired by and transmitted to the R&D staff through external and internal communication channels within the organizations (Allen, Tushman, and Lee 1979; Ancona and Caldwell 1992; Tushman 1978). Those organizations capable of effectively sharing knowledge are, by and large, seen as pregnant with innovative capacities. Knowledge, however, just as information, is often "sticky," as Von Hippel (1994) aptly terms it, and therefore it is shared reluctantly and spreads with difficulty.

Despite intense scrutiny and a large number of empirical studies, the process and the outcome of technological innovation remain to a great extent enigmas. The management of technological innovation appears to be more of an art form than the rationally planned and methodically executed endeavor that managers and stockholders want it to be. This notion is supported by

the inconsistent findings concerning the ability of organizations to be reliably successful at that process (Damanpour 1991; Drazin and Schoonhoven 1996). In a recent and comprehensive review of the state of the empirical investigations on innovation, Fagerberg concluded that "in spite of the large amount of research in this area during the past fifty years, we know much less about why and how innovation occurs than what it leads to." (2005: 20).

A principal problem in innovation studies is that of understanding how innovation happens and how to organize for success. That design is a primary vehicle for shaping an organization's ability to achieve its goals is hardly a new insight. Chandler identified two main aspects of design, irrespective of whether it is "formally or informally defined": "It includes, first, the lines of authority and communication between the different administrative offices and officers and, second, the information and data flow through these lines of communication and authority" (1962: 14). Much of the attention in this regard has been centered on structure and the investigation of the effect of the formal organization on the behavior and outcomes of individuals and firms (Dougherty 2001; Lam 2005).

For nearly the first six decades of the twentieth century, research on innovation proceeded in parallel with organization theory and, hence, it was preoccupied with articulating overarching general principles and discovering the "one best way to organize." It was in the 1960s when the contingency tradition developed in the work of Woodward (1958), Burns and Stalker (1961), Thompson (1967), and Lawrence and Lorsch (1967) as a reaction to this monocausal model. In this perspective, organizational structure is shaped by the nature of the technology and then, in turn, shapes the relationships between people in the work processes. Following on the assumption that organizations can be conceived as systems and subsystems, each of which has its own characteristics, the contingency approach provided us with the insight that the system and its subparts are likely to benefit from different ways of organizing. This was first articulated and empirically verified by Lawrence and Lorsch (1967) in their seminal work on differentiation and integration mechanisms used in different organizational functions (such as sales, production, marketing, and R&D) in six plastics firms. Another celebrated classic is Burns and Stalker's 1961 study of the relationship between firms' innovativeness and

organization design in twenty British electronics and rayon firms. They argued that organic (decentralized and less formalized) structures are more conducive to technological innovations, particularly to those of a radical nature, as they are better able to respond rapidly to the ever-changing environment. In contrast, mechanistic (bureaucratic and highly formalized) forms tend to be innovation-resistant.

Accordingly, the literature on the management of technological innovation has examined various structural aspects and the conditions under which they affect the ability of both individuals and organizations to make discoveries. Prominent among these are centralization, formalization, horizontal and vertical integration, and the stage of industry development. The research informed by this tradition mostly relied on large surveys and statistical methodology to infer the effect of different structural arrangements on performance. Ultimately, it produced numerous valuable insights, and, much to the dissatisfaction of the managers of technology, one broad but frustratingly vague design rule: "it all depends."

As a result, a number of design approaches have been tried in an effort to increase the likelihood of technical success. Among those are the adoption of the matrix and various team-based designs, personnel rotation and the periodic retraining of technical personnel, and the selection of individuals with superior technical skills. To these must be added the identification of creative individuals with specific personality traits and the assignment of them to key decision-making positions. However, the record of success resulting from such measures has been inconsistent. The lack of consistent findings from this period has been largely attributed to the exclusive focus on the investigation of the formal structural attributes to the neglect of the role of the human agents in the process and the relations that they enter into (Barley 1990).

This void has been filled by another structuralist approach—the social networks perspective. Its origin can be traced to Simmel's work on dyads and triads (1902), but it was Granovetter's seminal article (1985) that carved a prominent place in social research for the individuals and the social relations that they establish and maintain. This perspective, too, looks at the linkages between positions and people to explain outcomes. Unlike the traditional structuralist approach, which views performance as a function of the relationships

prescribed by an organization chart, the social networks model seeks to capture the *actual* patterns of linkages and relations. It is based on the premise that the actors' behaviors can be understood through the informal structural configurations—such as friendship, advice, and collegial networks—that they are a part of, and the positions they occupy within them. In network terms these are positions of high or low respect, high or low status, and informal power (Burt 1992). At the center of the social network analysis is an examination of the forms and content of the stable patterns people develop in their relationships, as well as the effects that these create (Tichy 1980). Power and influence, in this perspective, come from the "actors' positions in the actual patterns of interaction that define a social network rather than from their positions in the formally defined vertical and horizontal division of labor" (Ibarra 1993: 476).

The social network literature has been prolific. It is replete with empirical evidence of the advantages that the informal structures offer over the formally prescribed rules and behaviors (Burt 2000; Hansen 2002). Likewise, the effect of social networks on outcomes has been the subject of numerous investigations. Social networks have been found to help coordinate critical task interdependencies (Blau 1955; Gulati and Gargiulo 1999; Pfeffer and Salancik 1978); to ease access to information and speed up the information exchange (Granovetter 1995; Ingram and Roberts 2000); to serve as webs of idea generation and create opportunities for learning (Hage and Hollingsworth 2000; Podolny and Page 1998); to increase learning rates (Argote, Beckman, and Epple 1990); and to produce economic benefits (Uzzi 1999). Furthermore, social networks have been shown to generate social capital (Bourdieu 1986; Lin 2001). Generally, those who occupy a more central position in the social network possess greater social capital. Scholars have identified several mechanisms through which social relations create capital assets (Burt 2000; Coleman 1988; Nahapiet and Ghoshal 1998). Among those are trust and trustworthiness; the power of social norms and sanctions; expectations that obligations will be honored; and a source of identity.

Despite consistent evidence of the connection between social networks and these themes, though, the promise and pertinence of which should be obvious to the study of innovation, "relatively few studies . . . link informal ties to the innovation process. . . ." (Powell and Grodal 2005: 70). Mote, too, observed

that "[w]hile the role of social networks in scientific research and R&D is recognized, it has often been overlooked in favor of the formal structure of the research organization" (2005: 97). What is more, the vast majority of those are conducted at the interorganizational level. Here, network dynamics have been effectively employed to explain performance and the evolution of technological fields (Fleming and Sorenson 2000; Powell, Koput, and Smith-Doerr 1996). For instance, in their 1996 analyses of biotechnology firms between 1990 and 1994, Powell and his colleagues found that an industry characterized by rapid technological development and a complex and expanding knowledge base had the locus of innovation not in individual firms but in networks of firms. They described these as networks of learning, expressed through large-scale, interorganizational collaboration. In another biotechnology study on the sourcing of scientific knowledge, Liebeskind, Oliver, Zucker, and Brewer (1996) reached a similar conclusion. In a more recent longitudinal study of chemical companies, Ahuja (2000) investigated the role that three aspects of a firm's position in an industry network—direct ties, indirect ties, and structural holes—play in the organization's ability to generate innovations. He found that each structural aspect offers a distinct contribution to innovation output. Finally, Johnston and Linton conducted research on the implementation of environmental technology in eighty-three North American firms from the electronics industry. They found that "interfirm networks composed of both suppliers and competitors were significantly correlated" with the implementation of the technology (2000: 465).

Research at the level of the firm has not been as voluminous as that conducted at the interorganizational level. Those studies that focus on intraorganizational social networks have found that central positions, and the ability to connect effectively to others within the company, grant access to knowledge and as a result improve the capacity of the organization to innovate (Ancona and Caldwell 1992; Hansen 2002). Furthermore, informal structures have been shown to be a powerful mechanism in the creative process, as central network positions generate opportunities for expanding one's communication network (Allen 1977; Ibarra 1993; Tsai 2001).

While this has been very helpful, it can be argued that research at the business-unit level does not capture the intensity and richness of interpersonal

relations in groups and on projects in which collaborative work takes place. As a consequence of the smaller size and the frequency of the interactions at this level, it is only logical to expect that the stable patterns of social relations that people establish are likely to create their own distinct dynamics and, as a result, to play a role in shaping group outcomes in their own specific ways. Teams and groups, though, have received surprisingly little attention in the network literature. In recognition of this fact, Oh, Labianca, and Chung (2006) argued the case for developing a multilevel model of group social capital. Among those relevant studies is the one conducted by Hansen, Mors, and Løvås (2005), who looked at how networks in new-product development teams affect the sharing of knowledge. In another study, Reagans, Zuckerman, and McEvily (2004) compared the effectiveness of two project team staffing approaches—one that focuses on the team members' demographic characteristics and the other on members' social networks. Borgatti and Cross (2003) examined how relational characteristics influence the individual's information-seeking behavior in groups. And Rulke and Galaskiewicz (2000) studied MBA game teams to investigate the joint effect of the distribution of knowledge and the social network structure of a group on its performance. Nevertheless, few of those investigations have had at the center of their exploration the effect of social networks on the outcomes and performance of teams and groups.

One such example of applying the social network approach at the group level is the study by Sparrowe, Liden, Wayne, and Kraimer (2001) who explored the relationship between various dimensions of the social network structure and the performance of both individuals and teams in thirty-eight work groups. Interestingly enough, they found that the same network structural characteristics affect the performance of individuals and groups differently. For instance, their results show that there is a positive relationship between occupying a central position in an advice network and an individual's performance. At the group level, however, the density of advice networks was not linked to productivity, whereas network centralization was actually found to hinder performance, particularly on complex tasks.

What is even more surprising is that the research investigating the link between informal ties and the outcomes of technical projects has been, by and large, missing from the social network literature. In fact, there are a handful

of studies that have explored this connection for R&D projects and teams. My investigation joins those few (Hansen 1999; Reagans and Zuckerman 2001; Rizova 2002, 2006a; Smith-Doerr, Manev, and Rizova 2004). In a study of 120 new-product development projects, carried out by forty-one divisions of a large electronics company, Hansen found support for his hypothesis that "weak interunit ties help a project team search for useful knowledge in other sub-units but impede the transfer of complex knowledge, which tends to require a strong tie between the two parties to a transfer" (1999: 82). Research on 224 corporate R&D teams conducted by Reagans and Zuckerman (2001) demonstrated that both high network density and high network heterogeneity explained team productivity. Smith-Doerr, Manev, and Rizova (2004) subsequently revealed how managers' positions of centrality in social networks shape the social construction of the outcome of innovation projects.

All in all, current research on social networks has produced consistently valuable knowledge about how the structure of social relations affects innovation at the inter- and intraorganizational levels. From these studies, it is also clear that there is a far more sophisticated and subtle understanding of how innovations arise out of the complex interaction between social networks and social capital within R&D projects. Given the nature of the challenges that today's knowledge-based organizations face, the changing structures and authority patterns in knowledge-intensive organizations (Kleinman and Vallas 2001), and the heavy reliance on team and project-based work (Griffin 1997), the overlook of R&D teams and projects by the network literature is puzzling. This book tries to rectify the deficiency.

A critical aspect of employing social networks to understanding actors' performance and outcomes is the recognition that they are multifaceted and operate on different levels depending on the type of relations that individuals maintain (Burt 1983; Hansen, Mors, and Løvås 2005; Tichy, Tushman, and Fombrun 1979). However, for the past three decades, the main focus of social network studies has been on the structure of the networks, to the neglect of the importance of the type of ties and their content (Adler and Kwon 2002; Monge and Contractor 2001). "Traditionally," Cross and Sproull observe, "network research has assumed that relationships can be appropriated for different purposes (e.g., friends can be sought for work-related information), and

so it is unnecessary to distinguish between kinds of ties or specify content in networks" (2004: 447). Similarly, the research on innovation has, generally, adopted this broad view and looks at the overall impact of social networks. It has been only very lately that this has begun to be seen as a potential impediment to furthering our understanding of the work dynamics in knowledge-based organizations.

Although not directly linked to the study of innovation, research conducted by Cummings (2004) and Cross and Sproull (2004) represent two empirical investigations in this direction. These studies identify several specific types of information in terms of content that people seek and share in work environments in order to accomplish their tasks. Moreover, Nebus (2006) argues that the network literature has exhibited a bias toward predicting outcomes by looking at a network's structural characteristics, while neglecting to attend to the question of how people form such networks in the first place. In particular, he contends that future investigations of knowledge-intensive environments ought to pay close attention to advice networks and calls for building a theory of how the latter are initially generated. At its core is the need to look at the processes through which individuals develop advice networks and the motivation behind their preferences for sources of work-related advice.

In conclusion, the review of the scholarship on innovation demonstrates that, in addition to paying attention to formal design characteristics, it is critical not to exclude from the analysis the impact that the informal structures exert on the process and the outcomes of technological innovation. Furthermore, the understanding of the role that social networks play will benefit not only from extending their investigation to the team and project levels, but also from studying both the structure and the content of various types of social relations. These include advice networks, the content of which reflects the work in an R&D environment. It is precisely how my study differs from the existing investigations that employ social networks to investigate technological innovation. Specifically, by examining the effect of two work-related advice networks, *technical* and *organizational,* which I constructed to denote the content of critical knowledge and information that is sought and exchanged in R&D organizations (Rizova 2002, 2006a), my book addresses Powell and Grodal's call for future research to "offer a more compelling analysis of the

specific ways in which networks shape innovative outputs" (2005: 79). To date, my research is the only empirical investigation to look at two complementary work-specific advice relations in the study of innovation and R&D projects.

RESEARCH ON PROJECT MANAGEMENT, TEAMS, AND SMALL GROUPS

The Literature on Project Management

A natural source of insights into R&D projects is the extensive body of literature that encompasses research on project management, teams, and small groups. Compared with the empirical investigation of technological innovation at the organizational and individual levels, R&D projects and teams have received somewhat less attention (Anderson and King 1993). The focus of studies on innovation at this level has been directed toward three major areas: the structural characteristics of teams, projects, and small groups; the climate conducive to group innovation; and the group processes themselves. Studies on successful innovation at the project level, in a manner similar to those at the organizational level, have also tended to produce conflicting results and to be inconclusive. One plausible explanation is that this could be a result of the lack of consensus on what "project success" actually means. As Griffin and Page argued, "[s]uccess is not just elusive; it is also multifaceted and difficult to measure" (1996: 478). Research has provided evidence that the definition and measurement of success are contextual (Balachandra and Friar 1997; Olson, Walker, and Ruekert 1995), and they could depend, among other factors, on the kind of strategy adopted (Griffin and Page 1996) and the type of innovation pursued (Green, Gavin, and Aiman-Smith 1995; Shenhar 2001).

What complicates the matter further is that neither success nor failure can be explained by a single factor, although scholarship has been seeking this elusive panacea for decades (Balachandra and Friar 1997). Indeed, Maidique and Zirger, who conducted the *Stanford Innovation Project,* argued that a range of factors, pertinent to both the firm and the project, tend to shape success, and therefore the quest for a magic bullet is not only unrealistic but illogical (1984). The project management literature of today faces a different dilemma—that of how to put some order into the vast number of factors that

have been suggested to explain the outcomes of technologically innovative projects. These include variables associated with the market, technology, the environment, the availability and utilization of financial resources, and the characteristics of the organization itself (Balachandra and Friar 1997; Brown and Eisenhardt 1995; Cooper 1979; Cooper and Kleinschmidt 1987; Griffin and Page 1996; Pinto and Slevin 1988; Rothwell et al. 1974; Shenhar 2001). A related problem is that studies have also tended to produce conflicting results. For instance, in a review of more than sixty articles on new product development (NPD) and R&D project success, Balachandra and Friar (1997, 1999) concluded that not only do the majority of the studies report results that do not build a uniform understanding of the fundamental forces behind success, but some of the findings conflict with one another.

Upon further investigation, the authors conducted a detailed analysis of nineteen empirical studies on R&D projects and NPD that reported no less than seventy-two success and failure factors. These they grouped into four main categories: market, technology, environment, and organization. Furthermore, half of these seventy-two factors were idiosyncratic to specific studies, and about three-quarters of the remaining half were only reported in one or two articles. As each article suggested between three and twelve factors to be most significant, Balachandra and Friar found few common elements in these studies. Ultimately they concluded that R&D and NPD success and failure are contextual, and they suggested that some consistency in the findings might be achieved by investigating projects against the background of three major axes: the nature of the innovation (radical or incremental), the nature of the market (existing or new), and the nature of the technology (familiar or experimental).

In a more recent review of the literature, Van der Panne, van Beers, and Kleinknecht (2003) examined forty-three articles published in peer-reviewed journals that report on the factors that have been found to explain the success and failure of innovative projects. The studies represent an amalgam of qualitative and quantitative research conducted between 1972 (when the notable SAPPHO project by Freeman and his colleagues took place [Freeman, Robertson, Achilladelis, and Jervis 1972]) and 1999. Van der Panne and his collaborators classified the factors into four major groups: those related to the firm,

to the project, to the product, and to the market. In nine of the forty-three papers they identified a large number of causes for success or failure. They also rank-ordered them. A closer analysis of the rankings in this subset led to the conclusion that there was a significant degree of similarity so far as the top ten factors were concerned, but very little agreement on the factors that ranked lower. Moreover, the remaining twenty-four studies reported findings that were either inconsistent or inconclusive. Some of the main explanatory variables in this category were support from top management; the type of organizational structure (functional, organic, matrix, or venture team); the degree to which a project is innovative; and the effect of the strength of competition.

They found a consensus of findings regarding the positive effect of the firm's culture, an organization's prior experience with bringing innovations to market, the diversity of the R&D team in terms of the balance between technical and marketing skills, management style, and the extent to which a project's demands for resources and the company's ability to match them were complementary. In sum, though, "[w]hile some studies claim a certain group of factors being crucial, other studies ignore the very same factors and claim very different factors to be decisive" (Van der Panne, van Beers, and Kleinknecht 2003: 310). As a result of such an abundance of explanatory factors, and the realization that the search for finding a single, all-important cause was naïve, the emphasis of empirical investigations in the project management literature in the late 1980s and early 1990s shifted to the discovery of sets of explanatory variables.

Despite systematically casting such a wide net to capture the factors that could explain success or failure, a puzzling but obvious omission from the project management literature on innovation in the past four decades has been the examination of the effect of social networks on group dynamics and outcomes. This lack of attention to social networks is even more surprising when considering that one of the most persuasive arguments about R&D project success has been based on the information-processing approach (Allen 1977, 1984). According to this line of reasoning, R&D "project effectiveness would be a function of matching communication patterns to the information processing demands of the project's work" (Tushman 1978: 640). An entire stream of research has been dedicated to studying both the sources

and modes of dissemination of internal and external communication in R&D organizations (Allen 1977; Ancona and Caldwell 1992; Katz and Allen 1985; Katz and Tushman 1981; Tushman 1977; Tushman and Scanlan 1981). The results from these studies established that "[t]he communication patterns on the high performing projects were systematically different than the communication patterns of the low performing projects" (Tushman 1978: 642). Ancona and Caldwell (1992) have shown that sharing knowledge outside of the group is positively related to performance. As the specialization of knowledge continues to grow, though, it is becoming increasingly clear that the transfer of knowledge, both within and outside groups, plays a fundamental role in an organization's ability to succeed at innovation (Argote, Ingram, Levine, and Moreland 2000; Argote, McEvily, and Reagans 2003). To this end, including social networks in the study of the sets of factors conducive to success on technical projects into the literature on project management carries great potential for generating powerful insights into the mechanisms that groups develop for sharing and transferring knowledge.

Teams and Small-Group Studies

Yet another branch of scholarship that has been very influential on the study of group dynamics is that focused on teams and small groups.[2] Over the past few decades, it has produced compelling evidence concerning the predictive value of individual, environmental, and group processes to team and group effectiveness. Historically, the main variables of interest to the researchers from this tradition have been size, leadership, group cohesiveness, goals, and motivation (Guzzo and Dickson 1996). Currently at its central focus are the issues surrounding team composition, and especially the role of diversity in it.

A large number of studies from this tradition have concentrated on the features of team design. Stewart (2006) conducted a comprehensive meta-analysis of ninety-three articles published in peer-review journals that looked at the relationship between aspects of design and a team's performance. His analysis covered research published over thirty years, up to 2003, and included both quantitative and qualitative studies. The great majority of these authors approached their investigations from the widely adopted "input-process-output" framework for teams (McGrath 1984). Such studies focused on four broad de-

sign categories: group composition (members' characteristics, heterogeneity); task design (mechanisms for differentiation and integration); the meaningfulness of tasks and the degree of team authority; and the organizational context (leadership and perceptions of leadership support). Stewart reached the conclusion that the correlation of these design categories to team performance was different for production, project, and management teams.

In a study of 626 individuals in forty-five production teams, Stewart and Barrick (2000) found a strong relationship between team structure and team performance. More specifically, on the basis of prior research as well as their own findings, the two investigators concluded that "structural characteristics related to the allocation of tasks, responsibilities, and authority do indeed influence team performance" (2000: 144). Interestingly enough, though, at the center of this literature is a focus on the formal structural characteristics, with the gross omission of the informal structures. Even when team processes are discussed, the analysis fails to incorporate the specific ways in which human agents get involved in social interactions. In fact, one cannot help noticing that in the same manner in which the scholarship on social networks has neglected teams, social networks have been neglected by the literature on teams and small groups. Furthermore, in a review of the literature on teams in organizations, Ilgen and his colleagues (2005) have also observed that it has been only recently that a few studies have employed social networks to better understand the patterns of interactions between, and within, teams.

For instance, the study of innovative teams has reached a consensus that in addition to the importance of having vision, clear task specifications, and support for innovation from other members of the group, the fourth critical group of variables has a lot to do with what West (1990) terms "participative safety." He argues that "the more people participate in decision making through having influence, interaction, and sharing information, the more likely they are to invest in the outcomes of those decisions and to offer ideas for new and improved ways of working" (Burningham and West 1995: 107). Given that a high level of participation in small groups has been strongly linked to trust, and that the latter was shown to emanate from social networks, the failure of this literature to incorporate the examination of the informal relations is indeed difficult to understand. Consequently, one of the contributions that my book

offers to the literature on teams and small groups is that it discusses the *specific* ways in which different social relations affect team performance, while integrating both formal and social network structural properties into the analysis of the allocation of tasks and authority.

Taken as a whole, the focus of the team and small-group literature has been on five groups of factors: environmental factors, processes and incentive systems, the characteristics of the team members, the identification of the innovators, and the composition of the teams in terms of heterogeneity, as well as the type of organizational culture that would enhance innovation. The assumption in this literature seems to be that once the right team and individual attributes from these groups are identified and put together, successful outcomes are more likely to follow. Accordingly, as far as team composition is concerned, the emphasis has been on mixing and matching attributes. However, the specific relations that individuals enter into and develop in small groups, during the process of knowledge creation and sharing, is absent from this tradition. My study differs from this approach by specifically investigating the different types of social relations people develop during the process of innovation and the ways in which these relations contribute to the shaping of the outcomes of projects and teams.

Furthermore, three distinct and exciting recent developments have taken place in this fertile body of scholarship that, without a doubt, are going to inform and shape profoundly the direction of the future research. One such development has been the recognition that small groups and teams have been generally investigated in a static manner divorced from their immediate context (McGrath, Arrow, and Berdahl 2000; West, Hirst, Richter, and Shipton 2004). The overwhelming majority of the existing models that have been built to explain team performance, as I suggested earlier, are based on McGrath's (1984) "input-process-output perspective" (Stewart and Barrick 2000; Ilgen, Hollenbeck, Johnson, and Jundt 2005). The model rests on the assumption that structural characteristics (inputs) exert an effect on the team's processing abilities and, consequently, shape the outputs. Inputs constitute the "knowledge, skills and abilities of group members; the composition of the team; and aspects of the organizational context such as the task and the associated objectives, reward systems, information systems, and training resources. Process

refers to the interactions among group members, information exchange, and patterns of participation in decision-making, leadership, social support, and sanctions for group related behaviour. Outputs include the products of the group's performance. . . ." (West, Hirst, Richter, and Shipton 2004: 273). An impressive amount of research has been conducted within this tradition, and extensive knowledge has been generated about groups, including several classic studies, such as those undertaken by McGrath (1984) and Hackman (1987). More recently, though, the model has been seen as an inadequate framework from which to understand the changing nature of teams, their fluid boundaries, and the intensity of interaction within them. A new way of thinking has emerged that calls for a reorientation toward the study of small groups and projects. The need for such a shift is based on the realization that the "input-process-output" model is a static one and implies a linear progression from inputs to process and ultimately to outputs (McGrath, Arrow, and Berdahl 2000; West, Hirst, Richter, and Shipton 2004; Ilgen, Hollenbeck, Johnson, and Jundt 2005). Indeed, one of the major criticisms against using it to understand and explain team behavior has been precisely that it does not incorporate a feedback mechanism (West, Hirst, Richter, and Shipton 2004).

A second distinct change in the focus and framework in this tradition involves a preference for multilevel theoretical and empirical research. The obsession with the outcomes of team performance, so characteristic of this stream of research up to the late 1990s, has now shifted to a heightened attention toward processes that mediate the relationship between inputs and performance. Moreover, the emphasis has changed to answering the question of *why* they have this effect. Yet a third clearly marked trend that has developed over the past ten years is expressed in the appeal to consider groups as complex, adaptive, and dynamic systems. It promotes the empirical investigation of groups and group processes as they develop out of the interaction with other levels of analysis and within a particular context (McGrath, Arrow, and Berdahl 2000: 95).

It is important to acknowledge, therefore, that groups and projects are not a mechanical collection of individuals with the appropriate technical skills, as viewed by many organizational experts, but are actually much more than this. They are entities in their own right, and they possess unique dynamics. Otherwise all groups and projects who share structural properties, and are in

possession of the relevant human capital, would be more or less equal performers. Thus, examining the effects of both the formal and the social network structures on the creation of these dynamics seems to be a good place to start. As I have shown earlier, the social network perspective has been applied to the study of innovation at the inter- and intraorganizational levels, but hardly at all to study projects. It is unrealistic, however, to expect that the interactions at these higher levels and the dynamics that they generate will be mirrored in small groups and projects. The intensity of the social interaction is much higher in them, and so it is plausible to expect that social networks and their properties will create somewhat different effects on group dynamics and, consequently, on performance. These relationships, in turn, are also affected by dynamics at the level of the organization that are created as a result of their peculiar structural properties, both of a formal and informal nature, and informed by systems of shared meanings.

In conclusion, the examination of the current scholarship on project management, teams, and small groups has raised several important observations. Our understanding of how to account for success and failure on technologically innovative projects will greatly benefit from approaching projects as small, complex systems with dynamics of their own. These dynamics are to a large degree context-specific and process-based, and not only result from interactions prescribed through formal channels but are also motivated by the specific patterns of social relations that team members establish. To this end, an investigation of the sets of factors associated with the processing of knowledge within innovative organizations is paramount. So, too, is achieving a better understanding of the dynamics conducive to the success of R&D projects by simultaneously exploring positive outcomes from both vantage points—the formal and the social networks' structures. Such research should incorporate multiple levels and be sensitive to the specific context within which the work is undertaken.

My own research strategy shares this holistic approach. Although structural factors at the project level are my main focus, I also pay close attention to organizational processes and cultural variables, which in combination with the structure played a critical role in shaping the outcomes of six technical projects in an R&D organization.