EXTREME TEAMING

Lessons in Complex, Cross-Sector Leadership

To all leaders of extreme teaming, especially those who led Projects Anna, Bianca, Fiona, Sofia, and Willa, and inspired us to write this book.

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Lessons in Complex, Cross-Sector Leadership

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FOREWORD

I had the privilege to teach at Harvard Business School with Amy Edmondson in the Technology and Operations Management (TOM) group 20 years ago. Amy was polishing off her research on psychological safety, examining a critical, but heretofore overlooked, factor that influenced the performance of work teams. That work would later establish her as a global management thought leader. Meanwhile I was down the hall performing the field research on companies like Xerox, IBM, Intel, Lucent, Procter & Gamble, and Genzyme that would culminate later in Open Innovation. At that time, we didn't seem to have much to say to each other, and so were friendly but distant colleagues. After all, it seemed that we were working on quite different problems, and investigating quite disparate phenomena.

I moved on to Berkeley from Harvard in 2003, and had the pleasure of watching my book *Open Innovation* (Chesbrough, 2003) develop into an important contribution to the study of innovation. But apart from saying hello to Amy at occasional academic conferences, things remained distant between us. Something happened fairly recently to change this state of affairs. Jean-François Harvey came to Berkeley a few short years ago as a visiting scholar. He was bright, well-trained, and full of ideas. While I learned a lot from him, he got infected with the Open Innovation virus during his time with me, and he is now pushing the open innovation concept forward in new and important ways. It is his insights, his energy, and his passion that have brought the work of two previously distant colleagues much closer together. One example of this comes from a very recent case study he conducted with Amy (Edmondson & Harvey, 2016a), and the other comes from this new book.

Now that I see Amy and JF's latest work in this new book, it is now obvious to me that Open Innovation and the organization of teams have a lot of common interests. Amy's work on teaming as a process (not just as an entity), combined with her exploration of the ways in which people from different organizations come together to pursue a common project, has positioned her to make new contributions to my own field of innovation studies. For most of the innovating in Open Innovation is done not by single individuals, nor by entire organizations, but by groups of people working across organizational boundaries. If you want to move knowledge across boundaries, you need to organize, motivate, and coordinate people in groups. With this new book, innovation scholars will find a wealth of insights about the core innovation work activity that takes place in collaborative innovation initiatives across those boundaries.

With my colleague Marcel Bogers, I have recently modified my definition of Open Innovation as follows: "*…a distributed innovation process that involves purposively managed knowledge flows across organizational boundaries, using pecuniary and non-pecuniary mechanisms in line with the organization's business model*" (Chesbrough & Bogers, 2014). This definition goes beyond the well-known phenomenon of knowledge spillovers long studied in the economics of R&D to purposive, intentional flows of knowledge of interest to management scholars. These intentional flows involve both flows of knowledge from outside the organization, or outside-in knowledge flows, and also flows from inside the organization to the outside, or inside-out knowledge flows. What Amy and JF's book reminds us is that we must look at the work of groups of people, if we are to understand these flows of knowledge.

One type of outside-in open innovation – so-called *crowdsourcing* – seeks to engage the problem-solving abilities of individuals located around the world. Crowdsourcing can take the form of contests that post a perplexing problem on a website in the hopes of eliciting novel solutions from remote sources. NASA and Samsung come to mind: the first has established a partnership with a number of crowdsourcing platforms to reach outside-of-the-box ideas for some of its most pressing problems, while the second seeks innovative solutions for existing electronic products and technologies. Crowdsourcing can also be more playful and everyday, such as imagining a new burger for McDonald's or creating a new flavor for Lays potato chips.

Similarly, open-source software development allows individuals to write code remotely, offering modular elements that can be compiled and combined to create robust software programs. Contributors, motivated by everything from fame to fortune to altruism to learning, work autonomously to push the technical envelope. And this open approach is not limited to software. In the data center hardware industry, Facebook's Open Compute Project (OCP) has achieved some important breakthroughs and has mobilized knowledge from numerous external contributors. Indeed, by developing an initial proposal, contributing initial reference designs, and offering test deployments of OCP designs – all examples of inside-out open innovation – Facebook initiated and then subsequently orchestrated a lot of outside-in open innovation.

But what if a problem is inherently multidisciplinary and complex, a so-called wicked problem? If solutions require people to work interdependently across disciplines or locations, crowdsourcing is unlikely to work. And so, a new kind of open innovation is needed to bring together people from several organizations in projects targeting such challenges. This book looks at the behavior of humans in groups and teams at the core of these kinds of strategic, complex innovation projects.

Edmondson and Harvey bring a new perspective to the field of open innovation with this book. Using their research into a handful of open innovation projects, they begin to identify what project leaders can do to overcome the major hurdles that lie ahead.

In many ways, open innovation has a lot to do with team development and leadership. Connecting these streams of research appears important to develop knowledge that will help support the increasingly important cross-boundary collaborations organizations must engage in today. Team-based configurations have become so fluid that some have argued for the vanishing of corporations, with software that can now combine the gig economy model with artificial intelligence to assemble "flash teams."[1] Yet, these flash teams have their limits, and I doubt they can be successful without good leadership. We need to understand what leaders can do to make the most of the new forms of collaboration that attempt to create value and innovate rapidly in our increasingly complex world.

This book is timely. It is also incomplete: it opens up a new field of inquiry. It should resonate with both researchers and practitioners. Researchers can find a rigorous approach to qualitative research enabling both theoretically robust constructs and convincing empirical findings. Practitioners from diverse fields can find actionable insights that promise to improve the management of complex innovation projects across the permeable organizational boundaries that arise in this increasingly Open Innovation landscape.

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NOTE

1. Readers of a certain age might recognize an echo of an earlier trend, of the so-called virtual organization of the 1990s. David Teece and I sought to understand but also qualify the limits of what virtual organizations can do with our 1996 Harvard Business Review article, “When is Virtual Virtuous?” There we reminded readers that real organizations had an ability to orchestrate complex, systemic technologies in ways that virtual organizations could not. I suspect that these “flash teams” will follow a similar pattern to the virtual organization. They will perform important work, but will not supplant all the other types of teams, due to their likely inability to orchestrate the actions of disparate actors in complex, interdependent situations.

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INTRODUCTION

Research on team effectiveness in the social sciences – notably, in psychology, sociology, and economics – is extensive and enduring. Teams fascinate scholars and practitioners alike because of their potential to achieve far more than the sum of what individual team members can do alone. Potential is not inevitability, however, and what it takes to achieve the desired synergy in teams remains a topic of considerable research. Achieving synergy requires integrating and leveraging diverse expertise and perspectives. Yet, the presence of diverse expertise and perspectives poses a barrier to doing so; people may not adequately understand each other's thoughts and ideas, and they lack the shared norms, values, or timeframes that facilitate interaction. Herein lies both the promise and the challenge of extreme teaming – project teams that cross disciplinary, organizational, and industry boundaries to innovate.

The late Harvard psychologist Richard Hackman, a preeminent scholar of team effectiveness, conducted numerous quantitative studies to pinpoint features that influence team performance, and this work provided foundational insights (e.g., Hackman, 1983, 1990; Hackman & Morris, 1975). The basic theoretical framework employed is an input-process-output model, in which a set of inputs such as task design or organizational support give rise to certain behavioral and interactional processes, which lead to various performance outputs. Decision-making, conflict-resolution, and information-management are some of the important processes Hackman and his colleagues studied. Factors that shape these processes (inputs) included variables at the individual, group, and organizational levels. For example, individual factors include members' skills, group factors include the size of the team, the team task, and the clarity of the team's goal, and organizational factors are such variables as access to resources and a supportive environment. Inputs and team processes both give rise to team outputs. The most obvious of these is team task performance, but Hackman (1990) conceptualized team effectiveness as more than task performance, identifying three vital dimensions of effectiveness. The first, the extent to which a team's work satisfies the needs of its customers, is what most managers would expect to matter, and is fundamentally about performance. The other two are a team's ability to work well together in the future (a kind of team-level learning outcome) and individual team members' satisfaction with the team experience (an individual level job satisfaction variable). The essence of the theory is that well-designed teams will be more likely to have desired processes and outcomes. In short, well-designed teams perform well.

Hackman identified three essential defining features of a team. First, teams have clear boundaries that distinguish members from non-members. Second, members are interdependent in working toward a common goal, such that they are collectively responsible for what they produce together. Third, teams are relatively stable entities, giving members the opportunity to learn how to work well together (Wageman, Hackman, & Lehman, 2005). Although teamwork and collaboration are needed in settings other than within formal teams, it is helpful to distinguish between these phenomena and actual team structures, as well as between groups and teams. Organizations encompass many kinds of groups, but Hackman proposed reserving the term "team" for groups that meet these three criteria. Others have proposed that teams be defined by the sense of identity that derives from being part of a group: a self-conception that is shared by members and gives rise to a self-inclusive category that causes them to identify with the group (Tajfel, 1978; Tajfel & Turner, 1986). Unclear social identity, or multiple social identities, can be detrimental to team performance (Brewer, 1996). We concur with this perspective, but see shared identity as an emergent state, rather than a defining criterion and structural input.

Most research on teams and teamwork focuses on the design of teams, including studies of structural inputs like team size, composition, and task. Although some team research is conducted in laboratories, much of it examines real teams in real organizations. Some perspectives emphasize processes, and process interventions related to coaching and facilitation, such as training individuals to operate in complex team environments (Cannon-Bowers & Salas, 1998), or focus on team norms and climate, including psychological safety (Edmondson, 1999).

One important area of study is team leadership, which has gained considerable attention over the past two decades as a vital force in helping teams achieve their potential. Most of the this literature examines how leaders influence the performance of groups that are reasonably stable performance units with clearly defined boundaries, that is, teams that meet Hackman's team-defining criteria. The kinds of teams studied in the field range from home improvement store teams (Chen et al., 2007), to financial services teams (Schaubroeck et al., 2007), customer services teams (Wageman, 2001), and more. The advantages of stable teams with clear boundaries and consistent membership have been well documented; members of such teams can leverage long-lasting relationships and contextual knowledge to communicate and execute effectively (Griffith & Neale, 2001; Lewis, 2004). Nonetheless, fewer teams in today's dynamic workplaces are stable or clearly bounded (Mortensen, 2014; O'Leary, Mortensen, & Woolley, 2011). Many teams change fast and members have little time to establish shared understanding about tasks, context, or each other (Wageman, Gardner, & Mortensen, 2012).

Recent work, therefore, has shifted to include a different perspective on teamwork in organizations, one that includes the interpersonal interactions taking place in shifting groups of people working collaboratively toward shared goals. This perspective calls attention to *teaming* as a process – rather than teams as entities (Edmondson, 2012) – and requires research to understand what leaders can do to support teamwork in shifting configurations and contexts, including teamwork that brings people from different organizations together on a novel project.

FROM TEAMS TO TEAMING

Recognizing that a great deal of collaborative work in organizations occurs outside of formal teams, recent work has employed a "teaming" perspective on managing interdependent work, which emphasizes the processes of teamwork rather than the structures (Edmondson, 2012). Teaming takes various forms. To begin with, stable intact teams are often tasked with carrying out interdependent work that requires back-and-forth ("reciprocal") coordination to do it well (Thompson, 1967), and one can reasonably call that highly interdependent coordination a form of teaming. This form is the one that has received most of the attention in prior literature, and our understanding of how such teamwork is reasonably well established.

Second, in addition to coordination that occurs within stable teams, teaming in today's workplaces occurs in fluid configurations as well. In some cases, people serve on multiple teams at once and thus confront the need to manage the various relationships they encounter in these different groups (Mortensen, 2014). In other cases, people work in hyper-fluid or extremely temporary team-like arrangements, such as in a hospital emergency department, where each patient is treated by a newly formed small team of professionals, involving various hand offs, where the teams convene and disband constantly (Valentine & Edmondson, 2015). A small but rapidly growing literature is examining such teams.

A third form of teaming, which we believe is also on the rise, involves people coming together from diverse backgrounds and organizations to address a complex and usually novel problem (Edmondson & Harvey, 2017). Such situations bring people together who are not only diverse in expertise but also are employed by different organizations. This book is focused on understanding both the challenges and the opportunities presented by such cross-sector teaming arrangements, which present an extreme form of teaming. For instance, in the economic development context, experts in agriculture, economic development, finance, marketing, supply chain management and project management from Coca-Cola, the United States Agency for International Development, the Inter-American Development Bank, and the nonprofit organization TechnoServe teamed up on an ambitious project to improve 25,000 Haitian mango farmers' business practices and double their income (Edmondson & Harvey, 2016b). This third form of teaming often stems from necessity to tackle complex, multifaceted problems. The success of these projects depends on learning – that is, on the ability to adapt rapidly and efficiently to new knowledge. In the absence of past experience and knowledge, such projects must make recourse to learning to shape their responses to threats and opportunities. Each project participant lacks not only a body of project-specific knowledge but also contextual knowledge about viable paths to success. As a result, such projects shift rapidly in ways that are difficult, or even impossible, to predict.

In these types of projects, people work together temporarily, spanning boundaries that include expertise, function, organization, and sometimes industry. The newly formed teams must develop *in situ* – that is, in a specific context where leadership plays an important role. Many such teams face highly novel challenges and therefore must learn quickly and effectively to succeed. Through field research studying several such extreme cases of teaming, we hope to provide insights and new directions to further this stream of research to contribute both to theory and practice.

EXTREME TEAMING FOR INNOVATION

Edmondson (2012) emphasized the importance of understanding and enabling teaming processes to complement the extensive research on team structures. We build on this prior work to elaborate the phenomena and leadership functions associated with effective teaming on innovation projects that span occupations, organizations, and industries. We refer to this type of cross-boundary collaboration as *extreme teaming*. Considerable research has investigated cross-functional teams, especially in the context of new product development and other innovation work (e.g., see Edmondson & Nembhard, 2009 for an exploration of the challenges and opportunities such teams face). Other work has examined the challenge of teaming across boundaries between hierarchical levels (e.g., Nembhard & Edmondson, 2006). Both kinds of cross-boundary teamwork are challenging, but extreme teaming takes these challenges to a new level.

Innovation is essential for staying relevant in today's challenging, fast paced environment. Few industries remain untouched by dynamism, uncertainty, and turbulence. The list of once-successful organizations that are no longer in business today – outpaced by more innovative rivals – is long and growing. In almost every industry, the demand for innovation is thus intensifying (Teece, 2012). Increasingly, companies must tap into ideas that are generated outside their organizational boundaries and find themselves collaborating to develop new products or services (Chesbrough, 2003) and even in exploiting them through open business models (Chesbrough, 2006a). The goal of extreme teaming is usually related to this impetus. By assembling groups of people with various backgrounds, those driving extreme teaming hope to set the stage for complex problem solving and innovation that affects more than one organization. How to do this well, especially facing ambitious goals and timelines, is a question of importance for both research and practice. This book thus builds on prior research to improve understanding of a particular type of teaming and to suggest new ideas for future research and practice. Our primary goal is to shed light on the leadership practices that help a group of individuals with very different backgrounds (notably, occupation, organization, and industry) develop into a high performing, albeit temporary, team. In short, we hope to explain how extreme teaming can be nurtured, despite its inherent challenges.

As business ecosystems evolve in ways that force organizations to become more fluid and flexible (Tucci, Chesbrough, Piller, & West, 2016), people working on innovation often move across contracts, projects, departments, and organizations (e.g., Hargadon & Bechky, 2006; O'Mahony & Bechky, 2008). A rise in project-based organizing has been noted across the public and private sectors alike (Hobday, 2000; Wheelright & Clark, 1992). When projects are the primary unit for execution and exploration of innovation work, fluidity of roles and tasks often follows (Bechky, 2006). Some projects are long in duration, going on for years, as in certain new product development projects and most construction projects. Others are very short, as in most patient-care teams, some task forces, event planning groups, and more. As more and more people work in multiple teams, projects, departments, or organizations, often simultaneously, it is important to understand the processes and practices that enable teaming across not just departmental but also organizational and industry boundaries.

A growing portion of the innovation landscape requires organizations to work beyond their usual disciplinary or organizational boundaries, including a growing number of projects that bring people together from multiple organizations to work together

(Ferraro, Etzion, & Gehman, 2015; Senge et al., 2008). Because leadership plays out in social or organizational settings (Pettigrew, 1992), and its effectiveness depends on fit with the situation or context (Fiedler, 1967), we need to know more about leadership in such contexts to better deal with its associated technological uncertainty (Fleming, 2001), coordination costs (Cummings & Kiesler, 2005), and logistical challenges (Lingo & O'Mahony, 2010).

The central message in this book is that extreme teaming is as challenging as it is necessary and, therefore, that leadership is vital to doing it well. We present qualitative research on a handful of cases of extreme teaming (complex cross-industry innovation projects) as a starting point for understanding the leadership functions that enable success in such challenging endeavors. This research does not allow us to draw firm conclusions about cause and effect, but rather to open a new area of study by observing some common practices shared by a diverse set of projects in extreme contexts. This research will also help in developing precise contextualized recommendations for leading extreme teaming. Most of the past research on team leadership has been in the context of leading stable, bounded teams rather than the more complex work arrangements created by extreme teaming. Leadership theory on how leaders tackle the challenges of teaming in newly formed, temporary work groups that span diverse skill sets and organizations is limited. Our work in this book takes a small step toward developing this theory; we hope that the leadership functions we describe will help those in the trenches to lead successful extreme teaming in innovation efforts around the world.

OVERVIEW OF THIS BOOK

Crossing the conceptual and physical boundaries between organizations heightens the already well-recognized challenges of cross-disciplinary work. Understanding the interpersonal and technical dynamics of extreme teaming is thus an important new area for research and practice. How do diverse groups of people come together to accomplish challenging innovation goals, requiring them to master new content, build new relationships, and integrate their ideas and expertise to produce high-value output? This book explores these questions in three parts to offer new directions for scholarly research and practical application.

Part I elaborates the need for extreme teaming, describing how business environments are evolving to make teaming across boundaries an important new activity for success. It also describes what makes this so difficult to do, and what insights can be drawn from prior work on leadership theory in the context of teams and teaming. Chapter 1 opens with a powerful illustration of extreme teaming to motivate our explanation of why organizations increasingly face the need for cross-boundary teaming. The chapter reflects the shift underway from a focus on business industries to a focus on innovation systems. We also explain why teams are the performance unit *par excellence* for innovation. Chapter 2 considers the main leadership theories that have been developed over the past few decades. One stream of research emphasizes leadership functions (rather than traits or other attributes), and we explain why this is the most appropriate approach to inform the activities of those leading cross-boundary teaming projects. We stress the need for a taxonomy centered on the extreme teaming context. Chapter 3 synthesizes team development and team diversity research to reveal the essential challenges to extreme teaming from both an interpersonal and a technical perspective. We explain why gaining additional insight into these dynamics is essential for managers who lead extreme teaming efforts. These three opening chapters thus set the stage for our study of extreme teaming in a variety of complex, cross-sector innovation projects.

Part II presents the findings from our multiyear study of extreme teaming in a set of remarkably varied industries. Our case-study approach used qualitative analyses of a series of unusual experiences of extreme teaming to develop a set of four interdependent leadership functions fostering extreme teaming and innovation results. These leadership functions are presented in Chapter 4: Build an Engaging Vision; Chapter 5: Cultivate Psychological Safety; Chapter 6: Develop Shared Mental Models, and Chapter 7: Empower Agile Execution. Each of these chapters opens with a brief story from one of our case studies to illustrate the leadership function elaborated in the chapter and to offer an in-depth account of the practices it entails.

In Part III, we discuss and extend the implications of our findings. Chapter 8 pulls the four leadership functions together to explain the overarching framework and rationale for their use as a system of leadership practices. We also explain how this framework contributes to leadership theory and practice. To foster extreme teaming, leadership can – and must – motivate people to extend themselves in these challenging tasks. Leaders also must enable this work by removing the natural, very real, barriers to collaborating across boundaries. At the same time, leaders must help teams overcome both the interpersonal and technical challenges of extreme teaming. These dual challenges give rise to a 2x2 matrix outlining the four leadership functions we described in Part II. Chapter 9 concludes with suggestions for future research stemming from our findings, and how team-diversity and team-leadership scholars may develop studies that inform the practice of managers involved in extreme teaming efforts.

CHAPTER TAKEAWAYS

- An input-process-output view of team performance has dominated the literature on teams and team effectiveness. The theory posits that teams will perform well if they are well designed.

- Well-designed means a clear boundary, a shared goal, an interdependent task, some stability, appropriate composition for the task, and adequate resources. Correspondingly, the research on team effectiveness has tended to study teams as reasonably stable performance units with clearly defined boundaries.
- More and more teams today do not qualify as "well-designed" according to traditional definitions – because of the shifting nature of the work, not because managers have failed to do their jobs.
- Business ecosystems change rapidly and people from different occupations and organizations increasingly move from project to project, and collaborate in temporary, team-based arrangements with fluid membership.
- This new reality calls for additional emphasis on teaming as a process rather than teams as entities.
- Teaming is a dynamic activity; teams are bounded entities. Teaming is largely determined by the mindset and practices of teamwork, not by the design and structures of effective teams.
- Extreme teaming refers to cross-sector collaboration. Increasingly, companies tap into ideas and skills outside their organizational boundaries. By assembling groups of people with various backgrounds, extreme teaming sets the stage for complex problem solving and innovation that affect more than one organization.
- The goal of this book is to shed light on the leadership practices that help a group of individuals with very different backgrounds (notably, occupation, organization, and industry) develop into a high performing, albeit temporary, team.

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PART I

TRENDS GIVING RISE TO EXTREME TEAMING

1

WHY EXTREME TEAMING MATTERS

The accelerated pace of knowledge development, well documented by scholars in management, sociology, history of science and other fields, gives rise to complexity and uncertainty in today's business and scientific environments (Powell & Snellman, 2004). In most fields of expertise, the rate of new knowledge development requires people to invest considerable time just to stay current. In technical fields, the explosion of new knowledge leads inexorably to greater specialization. Specialized jargon proliferates and experts struggle to keep up with developments in even closely related fields.

On the one hand, the so-called *knowledge explosion* leads to narrower and deeper areas of specialization (Edmondson & Nembhard, 2009). Fields thus spawn subfields. For instance, as new medical discoveries proliferate, the number of subspecialties grew from about 40 in 1985 to 100 in 2000 (Donini-Lenhoff & Hedrick, 2000), with the promise of more to come. Internal medicine divides into subspecialties like cardiology, endocrinology, gastroenterology, hematology, infectious diseases, nephrology, oncology, pulmonary diseases, rheumatology, and so on. Radiology today encompasses angiography and intervention radiology, body imaging, diagnostic radiology, diagnostic roentgenology, diagnostic ultrasonography, neuroradiology, radiation oncology, radiation therapy, vascular-interventional radiology, nuclear radiology, and pediatric radiology. Each of these subfields faces continued change. Technologies that were barely used 10 years ago (e.g., virtual reality) are having a major impact in various medical subfields today (e.g., cybertherapy). The minimum number of years of study required to graduate in those fields and subfields has slowly but steadily increased, and beyond formal training, experts must invest ongoing effort in remaining current. The promise of specialization lies in the depth of understanding experts can offer.

On the other hand, concurrent with the rise of narrow and deep expertise, the problems facing organizations and society have not, of course, narrowed accordingly. Instead, they are increasingly complex and multifaceted. Addressing them requires multidisciplinary approaches. Consider what it takes to design, build, or maintain high-tech infrastructure projects, intelligent buildings, avionics systems, mobile telephone networks, or banking communication systems. Even products such as shoes that appear simple can become tremendously complex: for example, 50 biomechanical engineers, industrial designers, and electromechanical experts teamed up to make asymmetrical spikes for Olympic gold medalist Jeremy Wariner (Hochman, 2008). In healthcare, organizations such as Hacking Health show that varied professionals' perspectives must be considered, in addition to the patients' perspectives, to produce successful innovation (Dionne & Carlile, 2016). In short, dealing with today's complex products and systems requires solving dozens, sometimes-even hundreds, of interconnected problems (Davies & Hobday, 2005).

Thus, to solve complex problems and innovate in ways that reflect the increasing rate of change, today's organizations must take advantage of deep specialized knowledge and manage knowledge integration across these domains of expertise at the same time. These two opposing challenges create the need for organizations to master extreme teaming. This chapter thus builds a case for the importance of extreme teaming for a new and increasingly important type of initiative – one that brings together diverse areas of expertise to solve a particularly challenging societal or business problem.

In the pages that follow, we set the stage with a particularly compelling case study to illustrate the power of extreme teaming at its best. We then shift to discuss recent work on business ecosystems, to emphasize the utility of a new perspective on how organizations thrive and innovate as a result of their interactions with other organizations in highly interdependent systems. We finish the chapter by proposing essential features of innovation efforts employing an extreme teaming approach.

EXTREME TEAMING THAT SAVED 33 LIVES

The success of the now legendary mining rescue in Chile in 2010, while widely covered in the news and immortalized in a major Hollywood film, is not widely understood. We offer the rescue as an extraordinary example of extreme teaming, to illustrate the enormous potential of diverse experts coming together to innovate to overcome a nearly impossible challenge. The case illustrates the centrality of diverse perspectives in producing innovation, as well as the importance of leadership in making it happen.

An Unprecedented Challenge

Although mining accidents often present immense hurdles that make rescue unlikely, the situation at Chile's San Jose copper mine that began on August 5, 2010 was unprecedented on several dimensions. The most daunting of these was the extraordinary depth – 700 meters below ground – at which the miners were trapped in the aftermath of an explosion that left half a million tons of rock blocking the mine's entrance of the mine. The number of miners trapped (33), the hardness of the rock, the instability of the land, and the complete inadequacy of provisions for the trapped men (enough food for two men for 10 days) combined to make the possibility of rescue appear all but impossible to consulted experts. A mining rescue in the United States just a few years earlier, in which nine men were trapped 240 feet below ground, had been considered at the time a remarkable feat (Robbins, 2007). In Chile, early estimates of the possibility of finding anyone alive – put at 10% – diminished sharply two days later when rescue workers narrowly escaped the secondary collapse of a ventilation shaft, taking away the initial best option for extracting the miners. At that point, no expert considered rescue of the 33 men a reasonable possibility. Nonetheless, within 70 days all of them would be alive and reunited with their families.

This outcome was the result of an extraordinary cross-industry teaming effort by hundreds of individuals spanning physical, organizational, cultural, geographic, and professional boundaries. Engineers, geologists, drilling specialists, and more came together from different organizations, sectors, and nations to work on the immensely challenging technical problem of locating, reaching, and extracting the trapped miners. Senior leaders in the Chilean government provided resources to support the on-site efforts.

How Senior Leadership Triggered Extreme Teaming

In Santiago, Chile's capital city, President Piñera and Laurence Golborne, the Minister of Mining, met on the morning of August 6, 2010. Piñera then sent Golborne to the mine with a mandate to do whatever possible to bring the miners home, sparing no expense. Golborne and Piñera quickly reached out to their networks of colleagues around the world. As the president put it, "We were humble enough to ask for help" (Robbins, 2007). Michael Duncan, a deputy chief medical officer with the U.S. National Aeronautics and Space Administration (NASA), reported that the Chilean officials said, "Let's try to identify who the experts are in the field – let's get some consultants in here that can give us the best information possible." Duncan brought experience with long space flights to help solve concerns related to the miners' physical and psychological survival in their small quarters. NASA engineers played a crucial role in the design of the escape capsule that would be used in the final stage of the rescue to extract the miners from the refuge.

The Chilean *Carabineros* Special Operations Group – an elite Chilean police unit for rescue operations – had arrived a few hours after the first collapse. Yet their initial attempt at rescue had triggered that devastating secondary shaft collapse. As news of a mine cave-in spread, family members, emergency response teams, rescue workers, and reporters poured into the vicinity. Meanwhile, the Chilean mining community dispatched experts, drilling machines, and bulldozers. At the request of President Pinera, Codelco, the state-owned company, sent a senior mining engineer to lead the effort; Andre Sougarret, known for his engineering prowess, calm composure and ease with people, brought extraordinary technical and leadership competence to the project.

Parallel Teaming Efforts

Sougarret formed three teams to oversee different aspects of the operation. One searched for the men, poking drill holes deep into the earth in the hopes of hearing sounds to indicate that the men were alive. Another worked on how to keep them alive if found, and a third brainstormed solutions for how to extract them from the refuge. The first team came up with four possible rescue strategies. The most obvious through the ventilation shaft, was quickly rendered impossible. The second strategy, drilling a new mine ramp, also soon proved impossible as the instability of the rock was discovered. The third, tunneling from an adjacent mine a mile away, would have taken 8 months and was thus soon excluded.

The only hope left was the last strategy – drilling a series of holes at various angles to try to locate the refuge.

The extreme depth of the refuge, along with its small size, made the problem of location staggeringly difficult. With the drills' limited precision, the odds of hitting the refuge with each laborious drilling trial were about one in eighty. Even that was optimistic, because the location of the refuge was imprecisely known. Maps of the tunnels had not been updated in years. Additional technical challenges disallowed drilling straight down from the top of the mine, further exacerbating the drilling accuracy problem.

Rescuers soon divided into subteams to experiment with different strategies for drilling holes. More often than not, these teams failed to achieve their desired goals in any individual drilling attempt, but they soon learned to celebrate the valuable information each attempt provided, such as revealing features of the rock, to inform future action. For instance, the drillers and geologists discovered that fallen rock had trapped water and sedimentary rocks, increasing drill deviations and further exacerbating the odds of reaching the refuge in time. This was the kind of technical detail that engineers had to quickly incorporate into their plans, which shifted rapidly with each passing day. One dramatic change to procedure was the discovery and use of frequent, short action-assessment cycles. In normal drilling operations, precision was measured after a hole was completely drilled. Here, in contrast, drillers realized that to hit the refuge, they would have to make measurements every few hours and promptly abandon holes that deviated too much, discouraging as that might be. As they learned more about the search challenge, the odds of success diminished further, with one driller putting it at less than 1%.

In this extreme story, different clusters of experts came up with remarkably complementary pieces of an ultimately viable complex solution. Of course this didn't happen by accident, but rather was enabled by a particular type of leadership. For example, a Chilean geologist named Felipe Matthews brought a unique technology for measuring drilling with high precision that he had recently developed. Matthews came to the site, and, working with several other strangers, discovered that his measurements were inconsistent with those of other groups; a rapidly improvised set of experiments showed that his equipment was most accurate. Matthews was then put in charge of measuring drilling efforts going forward. In this way, roles emerged and shifted as the teaming went on.

Leaders of different subgroupings met routinely every morning and called for additional quick meetings on an as-needed basis. They developed a protocol for transitioning between day and night drill shifts and for routine maintenance of machinery; "We structured, structured, structured all aspects of execution." As drill attempts continued to fail, one after another, Sougarret communicated gracefully with the families. Despite these failures, Sougarret and his new colleagues persevered.

A NASA engineer who went to Chile in late August teamed up with engineers in the Chilean navy to design the rescue capsule, after first going back to the United States to pull together a group of 20 NASA engineers. The engineers developed a twelve-page list of requirements, used by the Chilean navy in the final design for the capsule, called the Fenix. The Fenix interior, just large enough to hold a person, was equipped with a microphone, oxygen, and spring-loaded wheels to roll smoothly against the rock walls.

On October 13, 2010, the Fenix started its life-saving runs to bring miners one by one through the 15-minute journey to safety. Over the next two days, miners were hauled up one by one in the 28-inch-wide escape capsule painted with the red, white, and blue of the Chilean flag. After a few minutes to hug relatives, each was taken for medical evaluation. The resulting fervor of the national – and even global – celebration cannot be underestimated.

How Leadership Enables Extreme Teaming

The Chilean rescue presents a superb example of teaming at its best. Reflecting on the situation, one readily comprehends that a top-down, command-and-control approach would have failed to achieve this stunning outcome. No one person, or even one leadership team, or one organization or agency, could have successfully innovated to solve this problem. It's also clear that simply encouraging everyone to try anything they wanted could have led to chaos or harm. It required extreme teaming. Facing the unprecedented nature of the disaster, multiple temporary, constantly shifting groups of people working separately on different types of problems, and coordinating across groups, as needed, was the only viable approach. These separate efforts – managerial and technical – were intensely focused.

This approach necessitated progressive experimentation, a kind of rapid-cycle learning. Diverse technical experts worked collaboratively to design, test, modify, and abandon options, over and over again, until they got it right. They organized quickly to design and experiment with various solutions, and just as quickly admitted when these had failed. They willingly changed course based on feedback – some obvious (the collapse of the ventilation shaft), some subtle (being told that their measurements were inaccurate by Matthews intruding mid-process with a new technology). Perhaps most important, the engineers did not take repeated failure as evidence that a successful rescue was impossible. Unfortunately, extreme teaming involves risk. And risk necessarily brings both success and failure. Fortunately, there is nearly always much to be learned from the failures to inform next steps.

Finally, the support of senior leadership – not just the technical leadership on the front lines of innovation – was a critical input to the success of this extreme teaming process. Leadership's commitment to the initiative gave others motivation and the protection they needed to take technical and interpersonal risks that are integral to extreme teaming. This turns out to be important in many business organizations where extreme teaming is employed by diverse technical experts to innovate.

As this example demonstrates, extreme teaming can produce awe-inspiring results. The problem is that its success can be too easily thwarted by communication failures at the boundaries between professions, organizations, and industries. As individuals bring diverse expertise, skills, perspectives, and goals together in unique configurations to accomplish challenging goals, they must overcome subtle and not-so-subtle challenges of communicating across boundaries. Some boundaries are obvious — being in different countries with different time zones, for example. Others are subtle, such as when two engineers working for the same company in different facilities unknowingly bring different taken-for-granted assumptions about how to carry out this or that technical procedure to collaboration. To understand the challenge, it's helpful to review how industries operate in business ecosystems.

FROM INDUSTRIES TO ECOSYSTEMS

A new perspective on modern industries as interconnected networks of organizations, technologies, consumers, and products has led to a conceptualization of the activities and relationships taking place within industries as ecosystems (Iansiti & Levien, 2004). The computing industry is perhaps the most dramatic and well-documented example of this interconnectedness, exhibiting an astonishing degree of interaction between organizations bringing modular products and services together to produce value for consumers and business customers. Modularity allows interchangeability so long as relationships between parts are standardized and codified. The essential insight in this work is that the success of many companies is interdependent with (rather than at odds with) that of other firms in an ecosystem. In this way, organizations cannot thrive without a thriving ecosystem of suppliers, customers, and even competitors who spur learning and innovation. A company may thus experience a dramatic and unexpected loss due to failures occurring in suppliers or customers – rather than in their own operations. If the industrial economy was driven by economies of scale, the knowledge economy is increasingly driven by the economics of networks and platforms.

Historically, the way organizations structure activities to promote efficiency tended to encourage specialization. In a review of the historical development of the American legal profession, for example, Abbott (1988) showed that division of labor in large law firms came with a high degree of specialization and led to a dramatic increase in productivity. More generally, specialization occurs through an industrial organization approach that builds on the development of sophisticated contractual arrangements and provides organizations with external economies, that is a decrease in the average costs of doing business (Robertson & Langlois, 1995). Business and industrial activities become subject to more in-depth division and dispersion and organizations are thus prone to identify, cultivate, and exploit the core competencies that make their growth possible (Prahalad & Hamel, 1990). Organizations set out to be leaders in their field, focus on their strong points, and fine-tune them.

However, efficiency gains are not enough to undergird sustainable competitive advantage (Teece, 2014), and pressure is mounting for organizations to develop ways to deal with the increasingly complex problems that come with the constant demands for innovation. This is challenging. So much that executives from powerful multinational companies like GE claim that today's problems are too big for them to solve alone and that to do so they need to collaborate like they never have before (Nagji & Walters, 2012). Successful organizations have become fast, timely expertise integrators for fragmented, scattered, and thinly spread knowledge to be available to the right people in the right place at the right time (David & Foray, 2002).

Thanks to advances in evolutionary economics (e.g., Nelson & Rosenberg, 1993; Nelson & Wright, 1992), our understanding of the economic activity has evolved alongside the phenomena described above. It is gradually moving from a view that focuses on industries and markets to study enterprise performance to one that considers organizations as part of innovation systems, which support the development of knowledge between several actors (e.g., for-profit and nonprofit organizations, governments, universities, research centers, and consumers). These actors are seen as diverse and the relationships between them as well as the institutions influencing them form innovation systems.

From this perspective, research on learning and innovation emphasizes the dynamics of learning by interacting and its co-regulation (e.g., Freeman, 1987; Lundvall, 1988). For instance, Lundvall and his colleagues (e.g., Jensen, Johnson, Lorenz, & Lundvall, 2007; Lundvall, 1992; Lundvall & Johnson, 1994; Lundvall, Johnson, Andersen, & Dalum, 2002) posit that innovation should be regarded as an interactive process where organizations do not learn and innovate in isolation, but in interaction with other actors. Such viewpoint goes beyond the contributions of Arrow's analysis of learning by doing (1962) and of Rosenberg's learning by using (1982) by taking account of several parties interacting together as they seek solutions to complex problems. As reflected in abundant scholarly works that call for more cross-sector interactions (Googins & Rochlin, 2000; Selsky & Parker, 2005; Senge, Smith, Kruschwitz, Laur, & Schley, 2008), three-time Pulitzer-Prize Winner Thomas L. Friedman noted the enormous potential of today's innovation systems:

> *It is now possible for more people than ever to collaborate and compete in real time with more other people on more different kinds of work from more different corners of the planet and on more equal footing than at any previous time in the history of the world. (Friedman, 2006, p. 8)*

The premises of learning by interacting within innovation systems are threefold: (1) organizations are not self-sufficient; (2) they cannot generate all the necessary resources internally, and (3) they must mobilize resources from other entities in their environment if they are to survive (Meeus, Oerlemans, & Hage, 2001). Firms, governments, universities, consumers, etc. can all contribute in a different and interactive way to the innovation process through the cross-fertilization of knowledge around complex problems and approaches to solve them. More or higher interactive learning capabilities enable organizations to reach higher degree of novelty in their ways to solve complex problems and innovate. Organizations therefore need to master complex learning processes that allow them to proactively integrate dispersed knowledge for skills to be continually developed, refined, and updated (Amin & Cohendet, 2004).

This need to go outside organizational boundaries to innovate is now general knowledge among managers, thanks to the pioneering work on *open innovation* (Chesbrough, 2003). Organizations have been exploring and continue to explore the full potential of "purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation" (Chesbrough, 2006b: 1). However, while this literature has developed rapidly in recent years, it has remained mostly focused on contracts and other strategic mechanisms through which organizations may accelerate the generation and commercialization of innovation (e.g., licensing out and licensing in, joint ventures, spin-offs and spin-ins, and acquisitions). Organizational challenges associated with open innovation have been studied extensively but there is a dearth of research at the individual- and team-level of analysis (Vanhaverbeke, Chesbrough, & West, 2014; West, Vanhaverbeke, & Chesbrough, 2006). Understanding factors associated with effective extreme teaming, the topic of this book, expands the possibilities for open innovation, and leverages research on teams and leadership to do so.

By gaining a better understanding of how interorganizational collaboration works at the group-level, we hope to provide much needed support to managers. These activities, for the most part, are extremely challenging (Majchrzak, Jarvenpaa, & Bagherzadeh, 2014). Most managers remain ill equipped to effectively lead extreme teaming endeavors because these collaborations pose different challenges than those that managers typically face when leading teams inside their organization. We argue that gaining a better understanding of team-level activities and leadership is key for organizations to take advantage of the innovation systems in which they find themselves.

INNOVATION IN CROSS-BOUNDARY TEAMS

Cross-boundary teams allow organizations to leverage the potential of innovation systems. While a great variety of knowledge is accessible to organizations, it is the integration of knowledge that fuels innovative capabilities (Grant, 1996), just as happened in the Chilean mining rescue, and research shows that it is integration at the group-level that provides the most benefits (Van Den Bosch, Volberda, & De Boer, 1999). Teams have been described as "the basic building block of any intelligent organization" (Pinchot & Pinchot, 1993, p. 66), "the norm in a learning organization" (Senge, 1994, p. 355), and the unit of organizational learning (Edmondson, 2002). More recent work shows that teams are becoming increasingly common in the production of innovation (Jones, 2009; Wuchty, Jones, & Uzzi, 2007), and that teams are more likely than individuals to develop more innovative solutions (Singh & Fleming, 2010; Uzzi, Mukherjee, Stringer, & Jones, 2013). In a world where organizations are hard pressed to continuously produce innovation to maintain sustainable competitive advantage, the trend toward more dynamic and complex forms of teamwork will continue.

Recombining dispersed heterogeneous bits of knowledge is at the source of radical innovation. John Stuart Mill, two centuries ago, highlighted the creative friction that takes place at the interstices of knowledge domains when individuals interact together:

> *It is hardly possible to overrate the value… of placing human beings in contact with persons dissimilar to themselves, and with modes of thought and action unlike those with which they are familiar… Such communication has always been, and is peculiarly in the present age, one of the primary sources of progress. (Swedberg, 1990, p. 3)*

This quote highlights what takes place at the interstices of knowledge domains. Burt (1992, 2000, 2002) calls these spaces "structural holes" – gap between two discrete groups with nonredundant knowledge. Structural holes act like insulators in an electric circuit: knowledge within each group is buffered and develops within a distinct logic. Innovation emerges from selection and synthesis across the structural holes between groups (Burt, 2004). As a result, the knowledge recombination perspective has become a significant stream of research both in economics (e.g., Boschma, 2005; Cohendet & Llerena, 1997; Nooteboom, 2000) and management (e.g., Fleming, Mingo, & Chen, 2007; Gruber, Harhoff, & Hoisl, 2013; Nerkar, 2003; Nerkar & Paruchuri, 2005).

Newly formed, temporary teams that assemble members from various backgrounds often set the stage for knowledge recombination and innovation. While research has shown benefits of team member familiarity (Edmondson, Bohmer, & Pisano, 2001; Huckman, Staats, & Upton, 2009), studies that focus on creativity and innovation show that when people have worked together many times previously, their projects exhibit less innovation than those with unfamiliar team members (Skilton & Dooley, 2010). Social network theory suggests that highly diverse teams can obtain valuable knowledge from interpersonal relations outside the team. For example, among others (e.g., Guimera, Uzzi, Spiro, & Amara, 2005; Reagans & Zuckerman, 2001), a study of over 2000 artists who worked on 474 creative teams developing new material for Broadway from 1945 to 1989 by Uzzi and Spiro (2005) showed that teams with highly familiar members were less effective than teams with less familiar members, in both artistic and financial terms. Other research shows that when teams have spent a long time working together, their members become cut off from new sources of information, and their thinking starts to converge (Katz, 1982). This blinds them to alternative perspectives that could improve performance (Janis, 1971). Moreover, the longer team members work together, the more likely it is that they will get "stuck in a rut" of habit or routine, and end up exhausting the idea permutations available (Gersick & Hackman, 1990). While routines have value in terms of boosting efficiency and reducing uncertainty over team working approaches, they ultimately impede innovative performance because they limit teams' ability to generate new ideas to solve complex problems (Hirst, Van Knippenberg, Chen, & Sacramento, 2011).

From an interactionist perspective, it is the complex interaction between individuals and their work situations that drives creativity and innovation (Woodman, Sawyer, & Griffin, 1993). "By interacting and sharing tacit and explicit knowledge with others, the individual enhances the capacity to define a situation or problem, and apply his or her knowledge so as to act and specifically solve problems" (Nonaka, Von Krogh, & Voelpel, 2006, p. 1182). For instance, Hargadon and Sutton (1997) showed how designers managed to team across fields (mechanical, industrial, electrical, software engineering, as well as human factors and ergonomics experts) and made original connections between the old solutions of one industry and the new problems of another. As a group of people from eclectic backgrounds, such designers innovated by spanning boundaries and moving knowledge from one place to another – from energy to medical products, to financial services, to the public sector, and more.

In their study of open-ended problem solving, Hargadon and Bechky (2006) showed that management and design consultants relied on moments when people's perspectives and experiences were brought together in work groups to bear on problems rather than relying on the cognitive skills of participating individuals. Kurtzberg and Amabile (2001) also moved away from individuals' creative potential, emphasizing instead how creative minds interact in groups. Many other contributions in the creativity and innovation literature emphasize the benefits of social dynamics that occur during extreme teaming (e.g., Harvey, 2014; Paulus & Yang, 2000). Radical innovation thus occurs when cross-boundary teams make connections between heterogeneous knowledge.

Stories that portray the combinatorial nature of innovation in extreme teaming endeavors increasingly populate the news world. For example, to figure out how electronic devices can be adapted to the needs of people with mobility issues, Samsung brought together a team of people that was able to span a large variety of subfields of human-computer interaction and electrical engineering. That team has so far been able to develop a demo tablet that is controlled by a human brain (Young Rojahn, 2013). Spanning knowledge boundaries and successfully making connections between heterogeneous materials is also at the core of the work of teams in the healthcare and medical sectors: 3-D printing is now used to print teeth-straightening braces and expert knowledge in artificial intelligence and mobile technology is at the foundation of an application that serves as a diagnostic tool (Kotler, 2013).

Extreme teaming efforts are examples of what Nonaka and Konno (1998) termed "ba." Meaning "space" in Japanese, the concept of *ba* denotes a context in which people enter a space of shared emotions that encourages interaction to create new knowledge (Nonaka, Toyama, & Konno, 2000; Von Krogh, Nonaka, & Rechsteiner, 2012). Consistent with a recent stream of literature that has identified the importance of collective forms in the process of invention and innovation (e.g., Drazin, Glynn, & Kazanjian, 1999), a *ba* gives the opportunity to individuals to become active participants in knowledge creation activities, and engage in what Tsoukas has termed "productive dialogue" (2009). Extreme teaming leverages the opportunity for active boundary-crossing dialogue and inquiry that allow people to adjust and reframe their own knowledge, to examine their own perceptions in a different light and reflect on experience to generate ideas and produce innovation (Edmondson, Dillon, & Roloff, 2007). In accordance with our efforts with this book, Nonaka et al. (2006) also posit that research needs to help identify ways in which leaders can develop *Bas* to foster knowledge processes in teams.

CHAPTER TAKEAWAYS

- The so-called knowledge explosion has given rise to narrower and deeper areas of specialization. In this way, fields spawn subfields, and domain knowledge can quickly become obsolete, such that expertise is difficult to develop and to keep current.
- Problems, in turn, do not narrow along with expertise; instead many problems, especially so-called "wicked problems" are multifaceted and complex. Complex problems require tackling many interconnected issues.
- Integrating knowledge across domains is required for solving today's most pressing and complex problems.
- The 2010 Chilean mine rescue is an example of the power of collaboration across knowledge domains. Leadership played an important role in enabling the rescue against overwhelming odds.

- The business world has become more complex, and the need for innovation ever greater. Organizations can rarely focus on a single industry to capture value, and instead must continually collaborate beyond their boundaries. Ecosystems have replaced industries, and organizations must learn to develop knowledge "in the open," acquiring ideas and spinning others out in order to maintain and undergird their competitive advantage.
- Innovation takes place in new extreme teams where heterogeneous knowledge inputs are integrated to produce new and useful products, services, processes or business models. Unfamiliar connections between entities with different perspectives fuel creativity and innovation.