Creativity and Constraint: Exploring the Role of Constraint in the Creative Processes of New Product and Technology Development Teams

by

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A dissertation submitted in partial fulfillment
of the requirements for the degree of
Doctor of Philosophy
(Psychology and Business Administration)
in The University of Michigan
2011

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Put the data you have uncovered
to beneficial use.

To my family.

ACKNOWLEDGEMENTS

This dissertation would not have been possible without the guidance, support, collaboration, and encouragement of an incredible group of mentors, colleagues, collaborators, family, and friends.

I was fortunate to have had the opportunity to work with and learn from the best dissertation committee in the world. I will forever be grateful for the selfless mentorship of Lance Sandelands and Gretchen Spreitzer. Lance and Gretchen, you have been trusted advisors, vocal advocates, patient motivators, and genuine friends from the beginning to the end of my doctoral studies. As the two people most responsible for my opportunity to pursue a joint Ph.D. in Organizational Psychology and Management & Organizations, it is especially fitting that you co-piloted this journey. I asked you to be my co-chairs because of your different ways of seeing, and you exceeded my expectations! You were occasionally paradoxical, but always complementary; truly interdependent parts of a whole. Lance, thank you for helping me think bigger and more abstractly about the possibilities of these ideas, their patterns, and their meanings. Gretchen, thank you for helping me ground my ideas in a way that brought clarity, coherence, simplicity, and truth to the findings. I am so grateful for your unique perspectives and the ways in which you both challenged and inspired me to stretch beyond what I thought was possible. Thank you for consistently offering freedom, constraints, support, and guidance exactly when I needed them. And thank you for all of the time, commitment, and energy you have poured into the development of this work. I believe it is as much yours as it is mine.

I am also deeply indebted to Lynn Wooten and Oscar Ybarra for their insightful and enthusiastic contributions to this research. Lynn, thank you for helping me navigate the occasionally murky waters of qualitative data analysis. You put me at ease about diving headlong into hundreds of pages of transcripts and notes, and your thoughtful questions, practical guidance, and effortless command of methods gave me the tools to endure a long iterative process of analysis, and the confidence to trust the data. Oscar, thank you for helping me build a psychological understanding of creativity that was also genuinely social. You strengthened my understanding of the group creativity I observed by asking insightful questions, challenging me to wrestle with alternate explanations, and helping me identify and embrace my unique contributions. Lynn and Oscar, your perspectives, expertise, and encouragement were so valuable to my research, and you made the process great fun.

This research would not have been possible without the generosity and genuine curiosity of the members of "Gigantech" who provided me with a very rare opportunity to come into the organization and study their world-class innovation first-hand. I am truly grateful to the participants of this study, who opened up their teams and organization to a stranger (and a psychologist, nonetheless) who knew little to nothing about chemistry, physics, engineering, software, or nanotechnology. You brought life to this research through your words and your awe-inspiring innovations, and I am so thankful for your willingness to share your insights and experiences with me. Thank you especially to Larry, Suresh, Terry, Colleen, Terry, Jim, Dan, Dave, Serge, and Jeanette, who provided me with access to an amazing set of product and technology development projects and provided tremendous institutional and administrative support for the study. I know how

rare of an opportunity it was to learn from you, and I don't take it for granted. I will carry the learnings from my time there with me for the rest of my life, and I hope they will benefit many others as well, including your organization.

This research also would not have been possible without the contributions of the world-class creativity leaders who generously shared their expertise with me during the pilot phase of the study. To Jeff DeGraff, Marc de Jong, Joe Fleming, Mikael Hagstroem, Mike Hess, Steve Kritzler, Rich Nazarian, Maurie Stang, Michael Tschirhart, and Steve Webster, thank you for inspiring my passion for this topic through your vibrant stories, and for laying the groundwork for an understanding of how constraints affect creativity.

I have also benefitted greatly from the academic communities of which I have been a part at the University of Michigan and beyond. So many faculty and colleagues have helped and mentored me so generously over the last several years. I am particularly grateful for the meaningful collaborations I have had with Amy Wresniewski, Anne Harrington, Jeff Ericksen, Adam Grant, Jane Dutton, Scott DeRue, and Brad Bushman. I have learned so much from each of you and am so thankful to have had the opportunity to work with you.

I have also leaned heavily on the exceptional administrative staff in the departments of Psychology and Management & Organizations. Thank you to Jo Anne Cullip, Janet Nightingale, Nichola Hutchison, Laurie Brannan, and Shelly Whitmer, who kept me on track and provided steadfast support (and reminders) throughout my time at Michigan.

This research has benefited as well from conversations, feedback, and guidance from an exceptional group of creativity scholars, including Teresa Amabile, Arne

Carlson, Elizabeth Long-Lingo, Matt Karlesky, David Obstfeld, Siobhan O'Mahony, and Christina Shalley. Thank you also to Carla Moverman, who provided vital research assistance and generative dialogue in the early stages of the development of this project.

I am especially grateful to the special community of fellow doctoral students at the University of Michigan who have sustained me through our collaborations, conversations, and friendships. Kathryn Dekas, you have been a true "pardner" and confidant from the very beginning, always inspiring me to "think LaRue." I could not have dreamed of a better cohort-mate and friend. We did it – we got 'er dun! JP Stephens, you have been a positive presence in my doctoral career since I applied to Org Psych. Thank you for your unwavering friendship and your ability to see and share the good in every situation. Dan Gruber, thank you for all of the laughs, advice, and friendship throughout the program. You are a true gentleman scholar, and it was an honor to study under the tutelage of the master. Michelle Barton, I am so grateful for your warm friendship, perspective, and support over the years. I feel lucky to have had the opportunity to collaborate with you. And to Marlys Christianson, Emily Heaphy, Adam Cobb, Natalie Cotton, Maria Farkas, Flannery Garnett, Jeff Bednar, Chak Fu Lam, Ned Wellman, Samir Nurmohamed, Laura Rees, Matt Karlesky, Suntae Kim, Kristina Workman, Johan Chu, Chris Myers, M'Lis Bartlett, Kiran Pandey, Georges Potworowski, and Derek Robinson, you have inspired and helped me in so many ways, and I will miss being co-located with such a brilliant and wonderful group of people.

I am also indebted to the people and the lineage of the Organizational Psychology department at the University of Michigan. I am especially grateful to Mike Pratt, Amy Wrzesniewski, Adam Grant, Jacoba Lilius, and Monica Worline, among many other

former students, who have been tireless advocates of the Org Psych program and of me, the "LOPSY" (Last of the Org Psychers). The program will live on through its extraordinary faculty and graduates, a legacy I am so honored to be a part of. I left the lights on, just in case.

Finally, I am eternally grateful for the love, support, and inspiration of my family. Mom and Dad, thank you for encouraging me to wholeheartedly follow my passions, nurture my talents, and seek work in service to God and others. You provided the model of integrity, generosity, hard work, dedication, and impact that I have aspired to follow for as long as I can remember, and it is an honor to be the next Dr. Rosso. Dad, our conversations about your experiences championing breakthrough innovations ignited the spark that became this research. Thanks for your regular calls to check in and ask how you could help. Mom, you have supported me constantly, offering enthusiastic encouragement, flying from all corners of the earth to take on "cutie duty," and sharing valuable stories of grad school experiences best not replicated. Thank you both for always lifting us up and nurturing our creativity. Amy, you have been an endless source of laughter and grace through some challenging times the last several years. Thank you for being there so constantly, and so often in person, for me, Rebekah, and Penelope, despite living on the opposite side of the globe. It has meant the world to us. Todd and Leah, thank you so much for all of your encouragement and love. To the entire VanWieren family, thank you for your enthusiastic support, prayers, love, and homes away from home. You have provided an example of diligent faithfulness, kindness, and Hope that has inspired me to achieve great things. I am so grateful to be a part of your family, a legacy rich with doctors of many kinds. This dissertation is also in memoriam to

Faye Rosso, Andrew Nyboer, Marion Nyboer, and Wilma VanWieren, our beloved grandparents who passed away during the course of our graduate studies. All were models of steadfast faith and love to whom we owe so much gratitude.

Most importantly, to the love of my life, Rebekah. This experience has been such a partnership, and it simply would not have been possible without you. Thank you for your unending love, support, widsom, patience, optimism, kindness, and all of the sacrifices you have made for the sake of our family and the completion of this dissertation. 9 years ago today we were married, 6 years ago today we moved to Michigan, and I'm certain that a completed Ph.D. today will be the best anniversary gift I could give you. You and Pippi have been my inspiration, giving me the purpose and strength to persevere. It has been my life's greatest joy to create with you.

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ABSTRACT

Research on creativity in organizations has revealed a variety of important paradoxes; paradoxes that some have argued are fundamental to the nature of creativity itself. One such paradox is the tension between freedom and constraint in the creative process. Whereas theorists have described the ideal creative process as unstructured, open-ended, and free of external limitations, others have found that creative individuals and teams can benefit from constraints. The purpose of this dissertation is to make sense of this tension in the literature by investigating the ways in which constraint both inhibits and enhances work team creativity. Conducting inductive field research with four product and technology development teams in a multinational corporation known for innovation, I develop a typology of constraints affecting creative teams and address the research questions "When (under what circumstances) do constraints affect team creativity?" and "How (through what processes) do constraints affect team creativity?" This research uncovers a variety of salient constraints that can be organized into two broad categories – process constraints and product constraints – suggesting that these types of constraints play markedly different roles in the team creative process. This study also reveals that under different circumstances, these constraints affect team creativity differently. Specifically, enduring patterns of team social dynamics, characterized as enabling dynamics and disabling dynamics, were shown to play a vital role in how teams interpret and respond to constraint, and therefore whether constraints were likely to inhibit or enhance team creativity. Teams experiencing the right kinds of constraints in the right

environments, and which saw opportunity in constraint, benefitted creatively from them. The study makes explicit the underlying social psychological mechanisms by which constraints inhibit or enhance team creativity. The results of this research challenge the assumption that constraints kill creativity, demonstrating instead that for teams able to accept and embrace them, there is freedom in constraint.

This dissertation contributes to the creativity literature by examining an understudied tension, articulating a theoretical perspective that makes sense of disparate findings on the topic, heeding calls for more creativity research at the team level, and developing creativity theory grounded specifically in the organizational context.

CHAPTER 1

INTRODUCTION

"Man built most nobly when limitations were at their greatest."

-Frank Lloyd Wright

Modern organizations face a variety of constraints that on the surface seem to seriously threaten their ability to innovate. Limitations of time, money, human and natural resources, along with fierce competition and heavy customer and regulatory demands, all constrain the way new products and technologies are designed and developed. At the same time, organizations need to be able to successfully develop innovative products and technologies in order to capture market share in today's dynamically changing environments (Kanter, 1988; Nonaka, 1991). Researchers and practitioners alike have wondered how, given the many constraints on their work and work processes, new product development teams are able to design the creative new products that drive innovation for their organizations. And yet, with the right conditions in place, creative professionals seem to thrive under constraints, and even invite them into their work processes (Dadich, 2008; Mayer, 2006; Stokes, 2006). This dissertation investigates the conditions under which constraints affect team creativity, and the underlying social-psychological processes through which they do so.

Creativity is defined as the production of ideas or solutions that are novel and useful (Amabile, 1988, 1996). In order for ideas or solutions to be considered creative in an organizational setting, they must be both new and potentially valuable to the

organization (George, 2008). Creativity is a key precursor to organizational innovation, which is the successful implementation of creative ideas (Amabile, 1996; Kurtzberg, 2005). Creativity thus provides a critical source of competitive advantage and lasting stakeholder value vital to the success of organizations relying on innovative products and technologies (George, 2008).

To date, most of the organizational creativity research has focused on the creativity of individuals, and associated personal or environmental determinants, with limited theory or research devoted to creativity in groups or teams (Shalley, Zhou, & Oldham, 2004). This research tends to emphasize the internal cognitive processes of individuals over group-level processes (George, 2008), and has primarily been conducted in laboratory settings rather than in field studies of real organizations (Shalley et al., 2004). This is most likely a function of the roots of creativity research in the psychological literature (Amabile, 1988, 1996), and the fact that this is still a relatively young domain of study (George, 2008). However, theory and research at the individual level, and particularly that which is developed without the organizational context in mind, does not necessarily capture the realities and complexities of creativity in organizations. Organizations frequently turn to work teams to generate and develop the creative solutions that provide them with competitive advantage (Kurtzberg, 2005), as teams offer more diverse ideas, skills, and expertise that have proven beneficial for creativity (Drazin, Glynn, & Kazanjian, 1999; Gilson & Shalley, 2004; Pearsall, Ellis, & Evans, 2008). Although the creativity of individual members surely plays a role in team creativity (Shalley et al., 2004), the mechanisms underlying the production of creative team outcomes are likely to differ in significant ways from the processes underlying

individual creativity (Hargadon & Bechky, 2006; Kurtzberg & Amabile, 2001; Paulus & Nijstad, 2003). Although numerous calls have been made for more research on creativity at the group level (e.g., Amabile, 1988, 1996; George, 2008; Shalley et al., 2004; Zhou & Shalley, 2003), there remains a dearth of scholarship in this area.

The literature on creativity in organizations has been heavily influenced by Amabile's (1988) componential model of creativity (often referred to as the "intrinsic motivation perspective"), which suggests, among other things, that intrinsic motivation – the drive to engage in an activity because it is inherently interesting or involving – is essential to creative output (Amabile, 1988, 1996). A key conclusion from this theory is that an ideal creative process is unstructured, open-ended, and free from external limitations, providing creators with ample time and space to explore and play with ideas (Shalley et al., 2004). In other words, creativity is maximized by freedom and inhibited by external constraint (defined as factors introduced by the social environment that are intended to control an individual's engagement in a task (Amabile, 1988, 1996)). Proponents of this perspective argue that when external constraints are placed on the creative process, creators fall back on routines and surface-level thinking, which kill creativity (Amabile, Hadley, & Kramer, 2002; Andrews & Smith, 1996).

As influential as this perspective has been, and as intuitive as it is, it is somewhat limited in the sense that it was developed through the study of individual creative exemplars and children (Amabile, 1988, 1996). It is also limited in its narrow definition of constraint as intentionally controlling external factors. Indeed, empirical research has thus far offered only mixed support for the theoretical mechanisms and assumptions underlying the intrinsic motivation perspective (Shalley et al., 2004; Zhou & Shalley,

2003). In fact, recent studies have directly challenged the presumption that constraints typically inhibit creativity, revealing that creative performance, for individuals as well as teams, can actually benefit from constraints. For example, Baer & Oldham (2006) found a curvilinear relationship between time pressure and individual creativity, where moderate levels of time pressure had positive effects on creativity. Similar results in recent research on group-level creativity suggest that constraints such as standardized processes and routines can positively impact team creative outcomes, given appropriate environmental conditions (e.g., Hargadon & Sutton, 1996; Gilson, Mathieu, Shalley, & Ruddy, 2005). For example, Gilson, Mathieu, Shalley, and Ruddy (2005) found that teams with standardized routines and practices in place, in addition to being empowered by their organization to be creative, were more creative than teams who were empowered to be creative but lacked standardization. This finding is consistent with past research demonstrating that clearly specified structures, rules, and boundaries can help promote group creativity in organizational settings (Sutton & Hargadon, 1996). Indeed, creative teams have even been shown to *actively* place constraints on themselves as a way of enhancing their creativity (e.g., Hargadon & Sutton, 1996; Stokes, 2006).

These recent findings alluding to the potential benefits of constraints for creativity are not surprising in light of the experiences of product and technology development teams and other creative professionals. Creative professionals have noted the value and importance of constraint for enhancing the creativity of individuals and teams (e.g., Mayer, 2006; Stokes, 2006; Tharp, 2003). For example, psychologist Patricia Stokes (2006) describes constraints as "barriers that lead to breakthroughs" in a variety of creative professions, from product design and architecture to visual art and music.

Marissa Mayer, Vice President for Search Products and User Experience at Google, has also challenged the assumption that unbridled freedom is best for creativity in product and technology development, arguing that with the right people and conditions in place, “creativity thrives best when constrained” (Mayer, 2006). And at 3M Company, an organization long recognized for superior innovation, leaders are paying attention to the importance of managing the tension between constraint and creativity in a way that promotes breakthrough invention amidst challenging external environments (Hindo, 2007). Indeed, not only can constraint be helpful in creative product development, but it is considered to be an inherent part of the product and technology development process (Leonard-Barton, 1992).

This evidence suggests that, depending on how it is managed and the environment in which it occurs, constraint can help enhance creativity in teams. However, it remains unclear under what specific circumstances constraints are likely to have a positive or negative impact on team creativity, as well as the particular social-psychological mechanisms underlying these effects. In my dissertation, I aim to fill these gaps by answering two broad questions: (a) When do constraints affect team creativity?, and (b) How do constraints affect team creativity?

Prior conceptualizations of "constraint" have focused on singular, externally imposed constraints – namely, time constraints, resource constraints, and standardized routines and processes. And as mentioned earlier, constraints in the creativity literature have primarily been conceptualized as “external constraints” to date: factors introduced by the social environment that are intended to control (or are perceived as controlling) an individual’s engagement in a task (Amabile, 1988, 1996). This definition of constraint

emphasizes a controlling aspect of constraint, where constraint is something dictated externally, with little control given to the actor upon whom the constraint is imposed. However, given that prior research and anecdotal evidence have suggested that constraints can benefit creativity, I conceptualize constraint more broadly and neutrally, as "a state of being restricted, limited, or confined within prescribed bounds." This conceptualization allows for consideration of a wider set of possible constraints, enabling me to examine similarities and differences in the ways constraints affect team creativity. By attending to the commonalities among a broad range of constraints, I aim to develop fundamental insights about the role constraints play in the creative processes of work teams. It also allows me to remain agnostic about the nature and consequences of constraint with respect to creativity, and therefore open to consider how constraint may inhibit as well as enhance team creativity. In so doing, I take a constraints-oriented perspective on creativity, allowing for the possibility that constraint is a natural part of the team creative process.

Although a majority of the research on creativity in organizations has employed laboratory or survey methods, a thorough investigation of the role of constraint in the creative processes of work teams requires a richer and more dynamic data collection strategy. This is particularly important since so little theory and research exists on the topic. I therefore conducted exploratory field research with real product and technology development teams at a multinational corporation working on creative projects under a variety of constraints. Data collection was inductive, drawn from interviews, observations, and archival data from creative teams and their leaders. These richly

descriptive sources of data allowed me to build a deeper understanding of the role constraint plays in team creativity than would more static survey or experimental data.

The expected contributions of this research are fourfold: First, I aim to make sense of seemingly paradoxical research findings by developing theory about the role constraint plays in the creativity of teams. Second, I aim to uncover the mechanisms through which constraints affect team creativity, focusing particularly on group-level social-psychological processes. Third, by examining creativity at the team-level, I answer calls for more theory and research on creativity in groups (rather than individuals) (Amabile, 1996; Gilson & Shalley, 2004; Kurtzberg & Amabile, 2001; Shalley et al., 2004). And fourth, I examine creativity specifically in the organizational context; a context that has been surprisingly vacant from creativity theory to date (Drazin et al., 1999; George, 2008; Sutton & Hargadon, 1996). I expect that the insights gained from this project will not only extend the boundaries of theory about creativity in teams, but will produce practical insight for the practice and management of team creative work in organizations as well.

In Chapter 2, I review the extant literature related to the impact of constraint on creativity. In Chapter 3, I provide an overview of the research design and methods for my dissertation. In Chapter 4, I present and analyze the findings of this research. I conclude in Chapter 5 by discussing the implications and contributions of these findings, and the additional questions and directions they raise for future research. Finally, I finish with a brief conclusion in Chapter 6.

CHAPTER 2

LITERATURE REVIEW

Research on creativity in organizations is vast and diverse, although still relatively young. Built upon the foundation of psychological theory and research, the literature on creativity in organizations has favored a focus on individual-level creativity and the various personal and contextual factors that influence individuals' creativity (George, 2008). Much of the early psychological theory was borne from the study of "creative geniuses," both artistic and scientific, and their methods and approaches to creative problem-solving or design (Runco, 2004). Illustrative of this orientation, in J. P. Guilford's influential address to the American Psychological association in 1950, considered to be the inception of the psychological study of creativity, he defined "creativity" as a constellation of abilities and traits that make up a creative personality (Guilford, 1950). For many years, the psychological research on creativity followed in this person-centered tradition (Amabile, 1988). Correspondingly, the early organizational scholarship on creativity, which emerged in the late 1980's and 1990's, also dominantly emphasized the role of individual differences such as personality, cognitive style, work style, domain expertise, and other individual-level traits and behaviors in the production of creative ideas (Kurtzberg & Amabile, 2000).

Amabile's "Social Psychology of Creativity" (1983) ushered in a new era of creativity theory and research that highlighted the crucial role of the social context in the

promotion or inhibition of creativity. Amabile argued that social-environmental factors such as the nature or design of the task, rewards and reinforcement, presence of others, type of goals, family environment, social or cultural climate, and level of competition, are at least as important in determining creative performance as are the attributes of creators themselves. This treatise on the important influence of environmental factors on creative performance led to the development of the componential theory of creativity, otherwise known as the "intrinsic motivation hypothesis," which suggests that the primary mechanism through which the social environment affects individual creativity is through its influence on the creator's motivational state (Amabile, 1988, 1996). More specifically, Amabile proposed that social-environmental conditions promoting creators' *intrinsic motivation*, or the drive to engage in an activity because it is interesting or involving, are essential for eliciting or maintaining high levels of creativity (Amabile, 1988, 1996). This model has been extremely influential in the creativity literature; so much so that most creativity research conducted in the last two decades, at the individual level and otherwise, has focused on identifying and testing various contextual antecedents of creative performance (Shalley et al., 2004; George, 2008).

The growing emphasis on the impact of social-environmental factors on creativity concurrently gave rise to the entrance of creativity research into the domain of organizational scholarship. Research on creativity in organizations has largely mirrored the trajectory of the broader psychological research, focusing particularly on contextual antecedents of creativity, and in some cases, their interaction with personal characteristics. This research has highlighted the importance of contextual antecedents like freedom and autonomy (Amabile & Gryskiewicz, 1987, 1989), challenging or

complex work (Oldham & Cummings, 1996; Shalley & Gilson, 2004), clear and challenging goals (Carson & Carson, 1993; Shalley, 1991; 1995), organizational and supervisory support for creativity (Amabile, Conti, Coon, Lazenby, & Herron, 1996), adequate feedback (Zhou, 1998; Zhou & George, 2001), positive coworker relationships (Amabile et al., 1996; Perry-Smith & Shalley, 2003; Tierney, Farmer, & Graen, 1999), and psychological safety (George & Zhou, 2007; Isaksen, Laurer, Ekvall, & Britz, 2001). Others have continued focusing on personal characteristics like personality traits (e.g., George & Zhou, 2001; Oldham & Cummings, 1996), cognitive style (e.g., Eyesenck, 1999), and domain-specific knowledge (Amabile, 1996; Shalley & Gilson, 2004). More recently, scholars have begun to pay attention not just to contextual characteristics or personal characteristics, but to the interaction between the two (George, 2008; Runco, 2004; Shalley et al., 2004).

Creativity in Teams

Acknowledging the shift to team-based work structures and the importance of team-based work in organizational innovation and the development of new products (Sundstrom, 1999), organizational creativity researchers are increasingly turning their attention to the study of creativity in work teams (Zhou & Shalley, 2003). As with the research on individual-level creativity, research on creativity in teams has generally focused on the antecedents and environmental conditions likely to foster or hinder creative team output, and to some extent on the group processes associated with creativity (George, 2008).

One conclusion from the limited amount of research on creativity in teams is that diversity benefits team creativity by offering a wider array of knowledge, skills, and

perspectives (Ancona & Caldwell, 1992; Nemeth, 1986; Pelled, Eisenhardt, & Xin, 1999). More specifically, diverse viewpoints in a group increase the number of possible new ideas and thereby enhance the group's ability to link these disparate ideas together to produce novel solutions and approaches (Amabile, 1988, 1996; DeDreu & West, 2001; Kurtzberg, 2005; Miliken, Bartel, & Kurtzberg, 2003). Mannix and Neale (2005) suggest that the benefits of diversity for group creativity are most related to diversity in perspectives, knowledge, expertise, and personalities (and less to demographic diversity). To reap the creativity benefits from diversity, the group process must also be carefully controlled in a way that promotes participative decision-making and the inclusion of minority or dissenting opinions (DeDreu & West, 2001; Mannix & Neale, 2005). Researchers have also found that the introduction of newcomers in groups, or other changes in team composition, can have a positive impact on team creativity by introducing more diverse knowledge and viewpoints (Choi & Thompson, 2005; Levine & Choi, 2004; Staw, 1980) and by encouraging more dynamic group processes (Nemeth, 1992; Nemeth & Owens, 1996).

A related area of study has examined the role of group conflict on group creativity. According to this research, groups experiencing conflict related to the task at hand tend to produce more novel and divergent solutions (Nemeth, 1986; Van Dyne & Saavedra, 1996). As with group diversity, group task conflict seems productive for creativity because it promotes the consideration and discussion of multiple viewpoints (DeDreu & Weingart, 2003; Kurtzberg & Amabile, 2001). However, the impact of conflict on group creativity depends heavily on the type of conflict experienced. In particular, while moderate levels of task conflict can be beneficial to group creative

performance, relationship conflict and process conflict are likely to have detrimental effects on creativity and other forms of group performance (Jehn, 1995, 1997; Kurtzberg & Amabile, 2001). One takeaway from this research is the conclusion that constructive dialogue on difficult issues is important for team creativity (Leenders, van Engelen, & Kratzer, 2003).

While some research has demonstrated the value of diversity and task conflict for creativity in teams, other studies have suggested that some level of homogeneity in the group is important for teams to be able to collectively generate creative ideas. Specifically, similar group members are more likely to possess or develop shared mental models about group tasks and processes, which enable the group to more effectively identify and assess the potential value of the ideas generated (Shalley & Gilson, 2004). Such shared mental models may be particularly important at the idea generation and idea evaluation stages of the creative process (Shalley & Gilson, 2004).

Related to the earlier discussion about the detrimental effects of relationship conflict on group creativity, another strong conclusion from the literature is that positive and cohesive relationships among group members is an important determinant of team creativity (Amabile et al., 1996). Researchers have found that positive team member relationships promote feelings of team psychological safety, which help members feel more comfortable taking risks and raising novel or unusual ideas with each other (Gilson & Shalley, 2004; Sutton & Hargadon, 1996; Zhou & George, 2001). Of course, when team members feel more comfortable raising "out of the box" ideas, more creative solutions are possible. In addition, teams who spend more time socializing with each other, inside or outside of the workplace, have been found to be more creative (Gilson &

Shalley, 2004). In contrast, however, some research has demonstrated that competition among coworkers can actually stimulate creativity (e.g., Shalley & Oldham, 1997).

Affect has also been suggested to play a key role in creativity, with different research supporting the value of both positive and negative affect, respectively. Most of the research on affect and creativity has emphasized the importance of positive affect. This work has been influenced by the research of Isen (1999) and Fredrickson (1998), who proposed that the experience of positive moods or emotions stimulate broader and more inclusive cognition, which enables individuals to make more associations or connections between divergent materials or stimuli. In these broadened states resulting from positive mood or emotion, it is proposed that people are able to generate more creative ideas and solutions (Amabile, Barsade, Mueller, & Staw, 2005; Madjar, Oldham, & Pratt, 2002; Rhee, 2005; Zhou & George, 2003). On the other hand, studies have suggested that negative mood can contribute to employee creativity as well (e.g., George & Zhou, 2002; Kaufmann & Vosburg, 1997). For example, Zhou & George (2001) found that under the right conditions (e.g., high continuance commitment and useful feedback), job dissatisfaction can contribute to employee creativity by signaling that the status quo is no longer acceptable and therefore motivating employees to seek creative new ways of doing things. In sum, this research suggests that both positive and negative affect can be beneficial to creativity, depending on the context.

Although it has been suggested that individual- and group-level factors are likely to interact in the production of creative team outcomes, few studies have examined this directly. In one study that did, Taggar (2002) investigated the interactive effects of individual traits (e.g., cognitive ability, openness to experience, and conscientiousness)

and team-level processes (e.g., involving others, addressing conflict, and effective communication) on the creativity of teams in a laboratory setting. This study showed that teams were most creative when individual members were more creative and the team used creativity-relevant processes, and that conversely, a lack of creativity-relevant processes neutralized the effect of having highly creative members. Other studies have suggested that the personality composition of a team (e.g., extraversion, openness to experience, conscientiousness) has a significant impact on team creative performance (Barry & Stewart, 1997; McCrae, 1987).

Although most of the research on team creativity to date has focused on identifying various antecedents and contextual or environmental factors related to team creativity, researchers have recently begun to make some headway into examining the group-level *processes* through which team creative outcomes are generated. In a foundational study, Hargadon and Bechky (2006) conducted a qualitative examination of the group-level interactions that yield "collective creativity." They found four sets of interrelated behavior patterns that contribute to moments of collective creativity: help seeking, help giving, reflective reframing, and reinforcing. This research provided a rich investigation of dynamic group-level processes of creative teams in organizational contexts that provides a model and inspiration for future research to better understand the group processes underlying collective creativity.

Although researchers have begun to make forward progress in the study of creativity in groups and teams, the extant research in this area suffers from some notable limitations. First, this work has largely imported theories of creativity developed at the individual level to group- or team-level creativity. For example, much of the creativity

research at the team level has implicitly or explicitly applied Amabile's componential model of creativity, which was developed with individuals in mind. Many others have applied conclusions from research on antecedents of individual creativity to the team level (e.g., Gilson & Shalley, 2004; Kurtzberg & Amabile, 2001). While it may be that team-level creativity operates similarly to individual-level creativity, or is fostered by similar environmental conditions, there are likely to be important differences that have not been sufficiently accounted for in the current research (George, 2008; Paulus & Nijstad, 2003), such as the role of interpersonal processes. This lack of extant theory specifically on *team-level* creativity may be contributing to some of the seemingly paradoxical results found in the current literature to date. Second, with rare exceptions (e.g., Hargadon & Bechky, 2006; Sutton & Hargadon, 1996), research on team-level creativity has taken place in laboratory settings with temporary teams, as opposed to in organizational settings with real teams engaged in ongoing creative projects (George, 2008). Although laboratory studies are effective for isolating specific aspects of creativity, they lack external validity because they are unable to capture creators situated in their genuine work environments and behaving naturally (Zhou & Shalley, 2003). The study of team creativity in organizations is arguably best conducted in true organizational contexts, which are recognized as classic "strong situations" that fundamentally shape human behavior and experience in that particular context (Mischel, 1977). The contexts in which creative teams function must be taken into greater consideration because they are likely to influence team behavior in powerful ways that are unaccounted for by theories of creativity developed from observations of independent creators. Third, most studies of team creativity in organizations have employed quantitative research methods.

Creativity is a highly complex and dynamic phenomenon, and group-level creativity is an ever more complex phenomenon. Although survey and laboratory studies are efficient data collection methods that provide greater opportunities to examine causal relationships, we continue to know very little about the actual behaviors and processes in teams that contribute to creative team outcomes (George, 2008). In the present study, I aim to help fill these three critical gaps by conducting inductive field research with creative work teams in an organizational setting.

Constraint and Creativity

Constraint can be defined as a state of being restricted, limited, or confined within prescribed bounds. Although the impact of a variety of constraints on creativity have been considered theoretically, there exists limited empirical research in this area. As discussed earlier, much of the extant literature on this topic employs Amabile's (1988, 1996) "intrinsic motivation perspective" to argue that constraints have detrimental effects on creativity because they inhibit creators' intrinsic motivation.[1] This proposal, related to the presumption that intrinsic motivation is key to creativity and that constraint inhibits intrinsic motivation, has been influential in theory about the impact of constraint on creativity. However, the research evidence to date has been mixed regarding whether constraint inhibits or enhances creative processes and outcomes in individuals and groups, yielding inconsistent and sometimes paradoxical findings (George, 2008; Shalley et al., 2004; Zhou & Shalley, 2003). This has proven true even where the effects of very restrictive or directive types of constraints, typically described as "external constraints,"

[1] Amabile (1988, 1996) has suggested that creators benefit from maximal freedom in the creative process, and conversely, that they suffer from external constraint imposed on the creative process. Specifically, Amabile proposes that when external constraints are placed on the creative process, creators lose intrinsic motivation to create and therefore tend to rely on surface-level cognition, which inhibits their creativity.

have been studied in relation to creativity. In reaction to these inconsistencies in the research evidence, Amabile and colleagues have recently added greater nuance to their original theoretical assumptions, proposing that a suggested negative linear effect of constraints on creativity is an oversimplification (Hennessey & Amabile, 2010).

In the following section, I review the empirical research on the impact of constraints on creativity, highlighting evidence that suggests negative as well as positive effects. I then discuss the gaps in this literature and describe how my dissertation research seeks to redress these gaps.

Time constraints. Of the limited amount of empirical research examining the impact of constraint on creativity, most has focused on time constraints. The presence of time deadlines or production goals has typically been described as a negative influence on creativity because it discourages exploration and increases reliance on status quo ways of thinking and doing (Amabile, 1996). Researchers have argued that good creativity takes time (Gruber & Davis, 1988), and that creators need ample time and space to think creatively, suspend judgment, and play with ideas (Amabile & Gryskiewicz, 1987; Isaksen et al., 2000). Amabile, Hadley, and Kramer (2002) found some support for this premise in a longitudinal study of creative professionals, concluding that although creators may feel like they are more creative under time pressure from impending goals or deadlines, time constraints often "kill creativity" by inhibiting intrinsic motivation. Similarly, Andrews & Smith (1996) found a negative relationship between experienced time pressure and the creativity of marketing professionals' ideas. Kelly and McGrath (1985) also found that products generated by individuals working under a 10-minute time limit were less creative than those working under a 20-minute time limit. However, there

is also mounting evidence to the contrary, suggesting that time constraints can have a positive impact on creativity, at least in certain proportions. For example, Andrews and Farris (1972) found positive, significant relations between scientists' experienced time pressure and their creativity. More recently, researchers have found curvilinear effects of time constraint on creativity. For example, Baer & Oldham (2006) found a curvilinear relationship between time pressure and individual creativity, where moderate levels of time pressure had positive effects on creativity. This research applied activation theory to suggest that up until some optimal point, time pressure increases levels of activation, which allows for more cognitive resources to be devoted to creative idea generation (Baer & Oldham, 2006). After a certain point, however, the time pressure becomes too great and has debilitating effects on creativity. Indeed, Amabile, Hadley, and Kramer (2002) found similar effects in their longitudinal study, as did Ohly and colleagues (2006), who found a curvilinear relationship between time pressure and creativity after controlling for the effects of control variables and job characteristics. Hennessey and Amabile (2010) conclude that while the effects of time pressure on creativity is generally negative, creativity may be enhanced by time pressure if creators are protected from distractions and if they feel like they were on a mission. They contend, however, that these occasions are rare.

Resource constraints. A lack of material resources is another potential constraint that has received some research attention and mixed empirical findings. On one hand, ample material resources have been described as important for successful creativity (e.g., Katz & Allen, 1988). The work of Amabile and colleagues (e.g., Amabile, 1988, 1996; Amabile & Gryskiewicz, 1987; Amabile et al., 1996) has suggested that creators need to

feel comfortable and provided with sufficient material resources in order to be maximally creative. However, it has also been suggested that the availability or abundance of material resources might negatively impact creativity (Csikszentmihalyi, 1997). For example, while resources are needed to perform one's job, not having everything that is needed readily at hand may stretch employees to think of different ways of doing their work (Shalley & Gilson, 2004). In other words, a lack of resources may actually help foster creativity. Taking this a step further, Csikszentmihalyi (1997) suggests that resources can make people too comfortable, having a 'deadening' effect on creativity (p. 321).

Standardized routines and processes. Researchers have also investigated the impact of constraints of standardized routines and processes on creativity. While some studies have found that standardization and formalization hurt creative efforts (e.g., Mumford, Baughman, Maher, Costanza, & Supinsld, 1997; Soriano de Alencar & Bruno-Faria, 1997), recent research on group-level creativity suggests that standardized processes and routines, such as institutionalized problem-solving or brainstorming methods, can positively impact team creativity, given the presence of appropriate environmental conditions (e.g., Hargadon & Sutton, 1996; Gilson et al., 2005). For example, Gilson, Mathieu, Shalley, and Ruddy (2005) found that teams with standardized routines and practices in place, in addition to being empowered by their organization to be creative, were more creative than teams who were empowered to be creative but lacked standardization. This finding is consistent with past research demonstrating that clearly specified structures, rules, and boundaries can help promote group creativity if the organization demonstrates clear support for creativity and if members of the group are

familiar with and committed to those rules and structures (Sutton & Hargadon, 1996). For example, Sutton and Hargadon (1996), in their research with the famous design firm IDEO, found that the creativity of brainstorming groups in a product development context was enabled by the presence of explicit, visible, and well-enforced rules for brainstorming like "defer judgment," "build on the ideas of others," and "encourage wild ideas." Indeed, creative teams have even been shown to *actively* place constraints on themselves as a way of structuring or bounding their work in ways that enhance their creativity (e.g., Hargadon & Sutton, 1996; Stokes, 2006). Theorists have argued that constraints of standardized routines and processes are particularly beneficial to team creativity at the early stages of the creative process (i.e., idea generation and selection) because they provide common structures, expectations, and norms for the team creative process (DeRue & Rosso, 2009).

In sum, empirical research on the impact of constraint on creativity suggests that constraint does not necessarily impede creativity, and that indeed, depending on how it is managed and the environment in which it occurs, constraint may provide a beneficial stimulus and structure for creative efforts. However, although recent research has opened the door to new consideration of the potential benefits of constraint for creativity, it remains unclear under what conditions constraints are likely to enhance or inhibit team creativity, and what are the social-psychological mechanisms underlying these effects. My dissertation research therefore seeks to address the following questions: (a) When does constraint affect team creativity?, and (b) How does constraint affect team creativity?

As described earlier, constraint is defined as a state of being restricted, limited, or confined within prescribed bounds. Creativity is defined as the production of ideas or solutions that are novel and useful (Amabile, 1988). In asking "When do constraints affect team creativity?", I am interested in examining the specific circumstances under which constraints are likely to enhance or inhibit team creativity. The goal of this research question is to try to make sense of the paradoxical findings in the literature by investigating whether the relationship between constraint and creativity is dependent on other variables. Therefore, I observe and consider a range of contextual factors that may influence whether constraints are ultimately beneficial or detrimental to team creativity.

My second research question asks "How do constraints affect team creativity?" In asking this question, I seek to understand the underlying mechanisms through which constraint enhances and inhibits team creativity. *Mechanisms* can be defined as the how's and why's of observed relationships (Stinchcombe, 1991). More specifically, explanatory mechanisms are the underlying engine driving a relationship between two variables, capturing the theoretical processes through which one variable influences another (Hedstrom & Swedberg, 1998). In this research, I am particularly interested in understanding the social psychological processes through which constraints enhance and inhibit team creativity. By *social psychological processes,* I mean thoughts, feelings, motivations, behaviors, and group dynamics as influenced by the social environment and social interaction. Given that my unit of analysis is the team, I pay particular attention to team-level processes underlying the impact of constraints on creativity.

In the next chapter, I present the research design and methods that allow me to investigate these questions.

CHAPTER 3

RESEARCH DESIGN AND METHODS

As stated earlier, my two main research questions are (a) When do constraints affect team creativity?, and (b) How do constraints affect team creativity? Given the exploratory nature of these questions, and my goal of developing theory about the role constraint plays in the creative processes of work teams, it was appropriate to use an inductive, qualitative approach to data collection. More specifically, I chose to conduct field research in an organizational setting with real product and technology design teams engaged in ongoing creative projects. Product and technology design teams provide an ideal opportunity to study these questions because they face a variety of salient constraints and are relied upon by their organizations to generate creative solutions that will drive innovation. Therefore, creativity is not only essential to the success of new product and technology development teams, and an expected part of their work, but it is also essential to the long-term viability of their organizations. Inductive, qualitative strategies are particularly helpful for exploratory research of this kind, which aims to gather "thick, rich descriptions" (Geertz, 1973) for the purpose of building theory rather than testing it (Glaser & Strauss, 1967). In this chapter, I describe the design of the study, including the organizational context in which I conducted my research, my sampling strategy, and the methods I used to collect and analyze data.

Research Context

In order to build a strong understanding of when and how constraints affect team creativity, I chose an organization well-known for product and technology innovation, which I refer to as "Gigantech."[2] Gigantech is a multinational Fortune 500 corporation with a superior reputation and identity around innovation. Gigantech is headquartered in the United States, and employs approximately 75,000 people across more than 65 countries. The company produces over 55,000 products sold both to corporate clients and directly to consumers under recognizable brand names, driving $27 billion in global sales last year. Gigantech's products and technologies cover an extensive and diverse range of markets, including, for example, nanotechnology, healthcare, electronics, optics, and software. Gigantech's products therefore touch many aspects of modern life. The company was founded in the early 1900's and has become a world leader in imaginative product and technology development. Much of the success of the organization has been attributed to its ability to apply Gigantech technologies – often in combination – to customer and market needs. Although Gigantech pursues acquisition opportunities to extend its technological depth, it primarily seeks organic growth through the in-house development of breakthrough products and technologies. Creativity is therefore vital to the success of the organization.

Gigantech's commitment to continual innovation is underscored by its investment of more than $1 billion annually in research and development. Gigantech hires top scientists and engineers from diverse disciplinary backgrounds to help develop its products and technologies. Gigantech's research and development area employs over

[2] A pseudonym.

6,700 scientists and engineers, and is organized into (a) corporate research laboratories and (b) divisional product development laboratories. Gigantech has a clearly defined and deliberately maintained culture around innovation that permeates the way the company organizes its research and development activities and business units. The company has built a broad base of fundamental technologies, from which hundreds of new products are developed each year. Experts in these various technologies are encouraged and provided with frequent opportunities to interact and collaborate with each other in the development of new product and technology solutions. In addition, Gigantech has been a pioneer in providing R&D employees with personal time to explore new innovations and "skunkworks" projects during working hours. Finally, product and technology development is done in project teams at Gigantech, where R&D professionals are likely to be engaged in 2-3 key projects at a given time.

Given its tremendous history of groundbreaking product and technology innovation, its large scope as a Fortune 500 organization competing in a diverse range of markets, and the team-based structure to research and development, Gigantech provided an ideal setting in which to study the impact of constraints on team creativity. First, as a large firm working globally in a variety of highly regulated industries, under demands from a wide range of stakeholders (e.g., consumer sales as well as business-to-business sales), Gigantech faces a variety of salient constraints that affect the creative product and technology development process. This provided me with opportunities to examine a variety of constraints across a variety of different types of projects. Second, as an innovation exemplar, studying Gigantech teams provided exciting opportunities to build theory by observing "best in class" new product and technology development, following

the precedent of prior research on team creativity that has investigated exemplary creative organizations like IDEO and others (e.g., Sutton & Hargadon, 1996; Hargadon & Sutton, 1997). By studying an innovation exemplar, my aim is to be able to draw conclusions that may be beneficial to other organizations as well. Although Gigantech employs certain unique strategies and structures in the research and development process, the diversified nature of the organization is similar to other large multinationals seeking to champion innovation. Therefore, while the results of this study will necessarily be contextualized to the Gigantech setting, I believe that the theoretical insights gained will be applicable to other product and technology development settings as well.

In addition to the typical types of constraints faced by new product and technology development teams in a large organization (e.g., time pressures, regulatory and customer demands, standardized processes), like most organizations in the present economic climate, Gigantech as an organization is facing somewhat elevated resource constraints. However, given the vast range of products produced and sold by Gigantech, the organization has been somewhat less affected by the economic downturn, and has not undergone significant layoffs. In addition, mindful of the market opportunities that tend to follow economic recession, company leaders have actually aggressively invested in research and development with the aim of driving forward on cutting-edge innovations. As a result, even while global operations at Gigantech have suffered, the R&D area retains a sense of normalcy, albeit mindful of the fact that the normal state of affairs is that of considerable constraint.

Sample

I used a purposive sample for my examination of the role of constraint in team creativity, as consistent with guidelines for rigorous inductive field research aiming to build theory (Cresswell, 1994; Marshall & Rossman, 1999). My sample consisted of four product and technology development project teams from the corporate research laboratories, selected by the organization for variance in (a) the research laboratory of which they are a part, (b) the size of the team, and (c) the phase of the project. By studying four teams, I had the opportunity to collect richly descriptive data while increasing the probability of variation in contexts and team processes that serve to strengthen my theorizing. There are four distinct but related laboratories within corporate R&D, including "Materials," "Production," "Analytics," and "Software" laboratories[3]. The aim of the four corporate research laboratories is to create and develop cutting edge core technologies that can be later applied and combined to drive sustained product innovation for the organization. The orientation of the technologies coming from the corporate research laboratories are therefore long-term, targeted up to 10 years in the future. After their development in the corporate research laboratories, new technologies are employed later in the product development pipeline – in Gigantech's division product development laboratories – to create tangible products that meet customer and/or market needs. Therefore, the corporate research laboratories can be considered the creative heart of the organization. In essence, the rest of the organization depends on the corporate research labs for most of the groundbreaking core technologies and products that will feed product development – and therefore, sales and revenue – for the future.

[3] Pseudonyms.

Since the purpose of this study is exploratory in the sense that I seek to elaborate an under-theorized phenomenon, my sampling strategy is not designed with the intent of constructing a sample that is representative of the entire population. That said, following principles of purposive sampling, this sampling strategy was designed with the aim of maximizing representation across some likely sources of variation related to my research questions (Singleton & Straits, 2005). A key goal of this study is to uncover the circumstances under which constraints are likely to inhibit or enhance creativity. Based on initial insights from pilot interviews with creativity leaders, I suspected that the culture around creativity in a business unit, and the policies and practices of leaders within that unit, may affect how creative teams experience and respond to constraint. For example, creative teams working for leaders who encourage and reward divergent thinking may be more likely to benefit from constraint because they feel safe taking risks, knowing that the organization supports their behavior. By studying four teams, all with very different goals and different leaders, I am able to examine the role that the team or unit environment plays in how constraint shapes the team creative process. Second, team size may also affect a team's experience of and response to constraint, as smaller teams might be able to more quickly develop shared understandings of or approaches to the challenges at hand and therefore experience more positive benefits from constraint (or fewer negative consequences). Or perhaps larger creative teams, which have a greater need for coordination, would actually benefit more from the boundaries introduced by constraint. Although the four focal teams don't vary greatly in size, there is variation in this regard, with teams as small as six people and as large as thirty. Third, the impact of constraints on creative teams may depend on the phase of that team's project. Teams at the earliest

stages of the project, for example, may find constraint more productive in the sense that constraints provide helpful boundaries to their creative efforts. Teams further down the product development cycle, on the other hand, may respond less constructively to constraints that are externally imposed. And finally, the variation provided by my sampling strategy increased the breadth of constraints that I had the opportunity to observe. This allows me to consider whether different types of constraint affect the team creative process in fundamentally different ways. By studying teams comprised of members of a variety of different corporate research labs, and working with distinct products and technologies, I have a stronger ability to draw broader conclusions about when and how constraints affect team creativity.

Beyond the key differences outlined above, each of the four teams sampled in this study share important similarities. First, all of the teams were studied during the course of their engagement with ongoing product or technology development projects. Studying teams engaged in current projects provided the opportunity to examine team behaviors and experiences more dynamically. Secondly, although the four teams were spread across the four corporate research labs, they shared common values, policies, and missions oriented around corporate innovation. Third, given the orientation of the corporate research laboratories to early and groundbreaking innovation (as opposed to the shorter-term, more incremental innovations of the divisional product development businesses), all four teams were involved in projects requiring a great deal of creativity. In other words, the corporate laboratories are generally oriented toward the earlier stages of the creative process: the generation of core technologies (creation), as opposed to their implementation (innovation). Fourth, all project teams were comprised of 6-10 core

members, providing relative consistency from which I was able to make comparisons. And lastly, all four project teams were facing key constraints while working toward producing creative products and solutions. All of the commonalities listed here help me to draw meaningful cross-team conclusions about the impact of constraints on team creativity.

Product and technology development at Gigantech

Gigantech has an international reputation for superior innovation, driven fundamentally by product and technology development in the corporate research and development area. The company's ability to successfully innovate is bolstered both by strategic organization and by pervasive cultural norms at Gigantech. In this section, I will discuss some prominent attributes of these organizational forms and norms.

As described earlier, corporate research and development at Gigantech is organized into four laboratories: the Materials lab, Production lab, Analytics lab, and Software lab. These labs play distinct roles in the product and technology development process, and members from each lab bring unique expertise and training, and often different perspectives, to creative challenges. However, these labs are closely interrelated, as project teams are typically cross-functional. Successful projects therefore require collaboration across and integration of these diverse perspectives. In addition, corporate R&D projects are almost always conducted in collaboration with divisional product development groups specializing in target industries. Therefore, a broad-scale development project may include a variety of different stakeholders from various divisions in the company targeted to various industries. Given the size of the company

and the vast range of industries they serve, these efforts require considerable coordination and collaboration.

There are a variety of formal structures and informal practices in place to facilitate cross-pollination and the germination of new ideas between and among the research labs and the divisions. For example, all technical staff participate in an organizational technical forum, which brings together scientists and engineers from across the organization to communicate issues of importance on a regular basis. The technical forum also organizes a yearly internal "trade show," where technical staff show off their latest and greatest innovations, often at early stages of development, to each other and to the business units. There are many stories about famous innovations arising through connections made in this setting, where two or more scientists discovered that the technologies they were developing independently could be combined in inventive ways. These often lead to new projects (and new project teams).[4] Within the corporate labs and the broader organization, there also exist a variety of formal symposia and speaker series' where new innovations both internal and external to the organization are presented and discussed. Researchers from prominent universities are often invited to discuss their work with related ideas and technological breakthroughs. The physical co-location of the corporate labs on the campus of corporate headquarters is another key element to the development of these internal networks, putting technical staff in close proximity to each other and facilitating frequent interaction.

Although these formal structures and practices help to facilitate cross-functional interactions, much of it happens organically. Few formal boundaries exist between

[4] This raises the question of how much of the creativity of teams happens inside or outside of the group itself. Such a question is particularly relevant to Gigantech, where the boundaries of project teams are often quite fluid. I come back to this issue in the Discussion chapter of this dissertation.

groups, and technical staff seek help, trade ideas, and collaborate with a diverse range of colleagues. This contributes to broad networks among the technical staff, and considerable amounts of grassroots self-organizing. There is a generally strong culture of collaboration and knowledge-sharing in the organization, with staff often going out of their way to help each other and share their expertise. Technical staff are highly skilled scientists and engineers, trained at prestigious universities, many of whom chose to enter industry rather than pursue academic careers because they are motivated by the opportunity to create inventions that lead to tangible products. Gigantech seeks to hire people with strong creativity skills, and most technical staff thrive on the challenge of solving "unsolvable" problems. It is a culture of "tinkerers," who love playing with ideas, immersing themselves in interesting projects, and finding creative ways to solve difficult problems. Staff often collaborate on projects of mutual interest, and frequently contribute their expertise to projects that interest them or where called upon, even if they have no formal responsibility to the project. As a result, the size and membership of project teams can be hard to clearly define. Staff take great pride in their work and accomplishments, and during interviews would often show off samples from the exciting projects they were working on, usually in the backdrop of an office full of products, successful and not, from a career of innovations. Some jokingly referred to themselves and their colleagues as "a bunch of nerds," and across the corporate campus, signs boldly proclaimed an upcoming symposium called "Nerdapalooza."

Employees liken Gigantech R&D to a university-like environment, where ideas are the capital of greatest value. In this marketplace of ideas, only the best ideas with the greatest potential for success will be "green-lighted" by leaders. As a result, staff must

angle for visibility for their projects, and this promotes a healthy sense of competition alongside the norm of collaboration. Staff are rewarded and promoted for financially successful and groundbreaking innovations brought into the marketplace. In fact, unlike many organizations, where employees advance only by taking on roles of increasing managerial authority, Gigantech employs a "dual ladder" system, where technical staff may rise the ranks either through technical excellence (i.e., the technical ladder) or managerial excellence (i.e., the management ladder). This system of parallel promotional paths allows for equal compensation and esteem at equivalent stages of the seven-rung technical and managerial ladders. The dual ladder system creates a status hierarchy in the organization, where those at higher levels possess greater authority and respect in the organization. Those at the two highest levels of the technical ladder (approximately 20 at the top level, and 120 at the next level beneath) command a guru-like status in the organization, and many take active and visible roles in mentoring colleagues and shepherding and vetting projects, in addition to continuing to develop their own inventions. Perhaps more important to technical staff than promotion is recognition for excellence amongst the technical community. There is a system of awards given annually for superior technical excellence, including both individual and team awards, with emphases on cross-functional collaborations and boundary-spanning work. Some of these awards are nominated and selected by peers, and some by leaders. This kind of recognition within the technical community is a powerful motivator for members of the corporate labs.

R&D projects may begin formally or informally, but many evolve from the work of individuals or small groups of scientists or engineers in "skunkworks" mode. These

efforts are strongly endorsed by the organization, which provides time for employees to explore and develop "pet projects" that they are passionate about. The organization offers several levels of grants to fund these orphan projects, starting with small amounts of money to get the ideas off the ground. Leaders are supportive of these efforts, but typically stay out of these activities, offering employees considerable freedom. After approximately one year of support, scientists are asked to demonstrate the commercial viability of the project prior to receiving more funding. Projects can develop over the course of many years in this stage, prior to becoming an official project. Oftentimes, the product applications for these innovations are not immediately known. However, scientists ultimately must partner with an interested divisional product development group in order to move a project toward formalization. Formalized project teams are given a code name, and the boundaries of the team become more clearly defined. Often, teams are already cross-functional at this stage, but managers may pull in additional resources to round out the skills or expertise on the team as needed to meet key project goals. Once approved and formalized, managers' expectations for the project rise along with the increased funding, as does visibility and associated pressures. The time horizon for projects at this stage ranges from approximately 1-5 years, occasionally longer.

Method

To date, most research on creativity in both psychology and organizational studies has employed laboratory or survey methods, with data often collected cross-sectionally. However, given the nature of my research questions and my goal of constructing and elaborating theory, inductive field research is most appropriate (Lee, Mitchell, & Sablynski, 1999; Singleton & Straits, 2005). Field research with creative teams in an

organizational setting provides particularly compelling data on my research questions for three key reasons: First, my research question is exploratory in nature, with the aim of building new knowledge in an area in which little theory or research currently exists. Such lack of extant theory and research on a phenomenon provide optimal conditions for inductive qualitative research, which offers richer and more dynamic sources of data than do quantitative methodologies (Lee, 1999; Marshall & Rossman, 1989).

Second, given that I am studying creativity in work teams, the role of the organizational context has important theoretical significance in my study. Organizational creativity researchers have largely imported or adapted theory from the psychological literature, the foundation of which was developed from observations of independent artists or "creative geniuses" (Amabile, 1988, 1996). With respect to creativity in organizations, however, the role of context is very important, and calls have been made for creativity theory developed specifically with the organizational context in mind (George, 2008). Organizational contexts have particularly strong influence on employee behavior (Cappelli & Sherer, 1991; Johns, 2006; Rousseau & Fried, 2001), and creativity in an organizational context is likely to unfold differently than creativity in other contexts. More specifically, the organizational context contains unique social and structural factors (e.g., organizational mission, management practices, extrinsic rewards) and constraints (e.g., market, customer, or regulatory demands) that may not exist or may not be salient for creative endeavors in other contexts, like the arts. Scholars have argued for the need to "bring work back in" to organizational research (Barley & Kunda, 2001), and nowhere is this more true than in the "organizational" creativity literature, which has been dominated by laboratory research with undergraduates and largely focused on

individual-level creativity. Where team creativity has been studied, it has most often been conducted with temporarily-fabricated teams rather than with genuine project teams engaged in ongoing creative projects. Since it is difficult to generate meaningful conclusions about organizational phenomena unless the theory has been developed and tested specifically with the organizational context in mind (Weick, 1968), I believe that the richly descriptive data elicited by field research is best able to preserve "the natural order of things" (Singleton & Straits, 2005, p. 310) with respect to the relationship between constraint and creativity in work teams.

Similarly, team creativity researchers have demonstrated a tendency to import theory or research on individual-level creativity and apply it to the team level. However, there are important differences between the creative processes of individuals and teams, such as the need for teams to process several diverse perspectives and converge around solutions (Gilson & Shalley, 2004; Hargadon & Bechky, 2006). With few exceptions (e.g., Sutton & Hargadon, 1996; Hargadon & Bechky, 2006; Pearsall et al., 2008), researchers have not sufficiently accounted for these differences. My dissertation research focuses particularly on creative processes that occur at the team level. The use of qualitative research methods in this study provide me with the opportunity to construct theory about team creativity through the direct examination of creative teams.

Finally, researchers have tended to overlook the processes by which creative outcomes are produced. In this study, I seek to shed light on the specific team processes through which creativity unfolds. Field research provides the opportunity to examine more deeply the underlying social psychological mechanisms through which constraints affect team creativity.

Data collection. I collected two main types of data from which I draw conclusions about the role constraints play in the creative processes of new product and technology development teams: semi-structured interviews and direct observation.

Semi-structured interviews. My most prominent source of data in this study were semi-structured interviews with members of the new product and technology development teams. In total, I conducted 39 interviews with members and leaders of five different product and technology development teams over the course of three months, totaling 48.75 hours. Interviews lasted an average of 1.25 hours each. Before each interview began, respondents were given a brief overview of the nature of the research, the purpose of the interview, and their rights as a participant. Respondents were asked to sign an IRB-approved informed consent form indicating their agreement to participate in the research and to allow the interview to be audio recorded and transcribed for data analysis. Respondents were also be reminded that their responses would be anonymous and that they could request their comments remain "off the record" at any time during the course of the conversation.

The interview protocol (see Appendix C) was informed by pilot research with twelve senior leaders from eight different creative organizations (see Appendix B). Interview questions were designed to examine the two key research questions guiding the study, while remaining open-ended to allow for the exploration of compelling new and alternative insights that may emerge. This approach provided me with consistency for data analysis, as well as flexibility in drawing out unexpected or even competing perspectives that broadened and strengthened my findings. Overall, interview questions focused on team experiences and behaviors in the course of the creative project, with an

emphasis on (a) episodes in which constraints were having positive or negative consequences for the team's creative processes and performance, (b) the cognitive, affective, and behavioral experiences of the team underlying these episodes, and (c) the contexts in which these experiences were taking place. More specifically, questions focused on project goals related to creativity, constraints faced in the course of the project, how the team was dealing with (or dealt with) these constraints, impact on team processes and creative performance, team strategies and norms for managing the creative process, and ideal environments for or ingredients of successful team creativity. The aim of the interview questions, ultimately, was to elicit rich descriptions and understandings of the experiences, behaviors, and dynamics of new product and technology development teams under conditions of constraint.

To ensure the effectiveness of the interview protocol in yielding data appropriately targeted to my key research questions, I pilot tested the questions with four key informants prior to entering the field. I subsequently revised the protocol for brevity and a more conversational flow, resulting in the questionnaire seen in Appendix C.

Direct observation. The second main source of data came from direct observation of new product and technology development teams and their members (and their environments) as they went about their work. Given my role as an outsider in the organization, and my lack of technical expertise in these areas of technology, my observations were conducted as a non-participant observer (Lee, 1999). In particular, I had the opportunity to observe team meetings and interactions both in-person and over the telephone, including critical "gate reviews" where projects were reviewed, progress assessed, and goals allocated (and where constraints may be made most evident to

teams). I also had the opportunity to observe individual scientists and engineers at work in their labs, and routinely conducted my interviews in respondents' offices or labs. Throughout the course of the study, I maintained an office space in a central R&D building, which provided additional opportunities for casual observation and conversation with team members and technical, managerial, and administrative staff. All told, I conducted approximately 25 hours of "formal" observation, with many more hours of informal observation. During or following my observations of each relevant meeting, interaction, or conversation with project teams or individual members, I wrote field notes describing my observations and reactions (Lofland, 1971). These observations further flesh out the core interview data, and help me to build a more comprehensive understanding of how constraints affect team creativity in a variety of contexts.

Data Analysis. To analyze these sources of data, I used a grounded theory approach, in which I iteratively traveled back and forth between the data and my emerging theoretical understandings (Glaser & Strauss, 1967). I began by reading through all interview transcripts and observational memos, and free coded them line-by-line using the NVivo 8 software for patterns and themes that seemed meaningful, recurrent, fundamental, or interesting (Boyatzis, 1998). Guided by my research questions, I paid particular attention to examples of constraints either enabling or hindering the team creative process, and to the social psychological processes and team dynamics underlying these experiences. I then returned to the data, looking across the interviews to identify common patterns and themes, from which I distilled a higher-order set of categories for classifying the responses. I then analyzed these codes for emergent theoretical insights, continuing to travel back to the data for additional analysis and further coding based on

the new insights that were emerging. As suggested by Miles and Huberman (1984), I also sought outliers, rival cases and explanations, and other discrepant information.

I undertook this process several times, seeking to aggregate the codes into ever more fundamental categories, and refining and adjusting my theoretical framework in light of these new insights and interpretations, continuing until I reached theoretical saturation (Glaser & Strauss, 1967). This process allowed me to systematically develop theoretical and empirical insights that accurately reflect the data I have collected (Glaser & Strauss, 1967). I also regularly wrote analytical memos capturing my impressions, reactions, insights, and questions that emerged during the data analysis process, intended to help me make meaning of the data (Miles & Huberman, 1984).

Since one of the five original teams studied was a work group team rather than a project team, consisting of five members of a single corporate laboratory working on a number of simultaneous projects, I decided to exclude that team from the analyses. In addition, I was not able to code four interviews with members of the remaining four focal teams, due to software glitches in the audio recording device, and so I was unable to include these four interviews in the formal coding process. I did, however, draw on notes taken during these interviews to inform the broader analysis. Finally, since the main goal of this study was to understand the experiences of and responses to constraint within project teams, the data coding process did not include data from my interviews with five senior leaders, including the Vice President of Research and Development and the four Directors responsible for each corporate lab. Interview data analysis was thus drawn from the 25 codable interviews with members of the four teams.

Since the aim of this research was to produce rich descriptive insight about an under-theorized phenomenon, as opposed to producing widely generalizable results, issues of external validity and representativeness were of limited concern to this study (Singleton & Straits, 2005). However, the collection and analysis of qualitative data does present relevant concerns about issues of internal validity that required me to take certain steps to ensure empirical rigor (Lee, 1999). First, by triangulating my analysis from multiple sources of data related to my research question, including in-depth interviews and non-participant observation, I am able to more confidently draw theoretical and empirical conclusions (Zelditch, 1962). My interview and observational data provide distinct windows of evidence into when and how constraints affect team creativity. When these are convergent, they provide evidence of the validity of the study's findings (Zelditch, 1962). Second, by employing a semi-structured interview protocol and collecting the experiences of multiple teams composed of multiple respondents, I was able to maintain sufficient methodological consistency while basing conclusions on a diverse set of perspectives and experiences from a diverse array of product and technology development projects. Third, the practices of systematically coding data, repeatedly traveling back and forth between the data and my emergent model, and writing analytical memos helped to produce rigorous findings and mitigate researcher bias.

In the next chapter, I present the findings from my research, organized by research question. In my presentation of the findings, I elaborate more thoroughly on the specific analytical methods by which I arrived at my conclusions.

CHAPTER 4

FINDINGS

The two key research questions guiding this inquiry were (a) When do constraints affect team creativity?, and (b) How do constraints affect team creativity? Prior to answering these questions, it is important to understand the different types of constraints facing new product and technology development teams at Gigantech and how they impact team creativity. To set the stage for these inquiries, it is also important to provide context for each of the four focal project teams. I begin this chapter by providing in-depth descriptions of the four teams, focusing especially on explicating the key goals, constraints, and the notable social dynamics of each team. The goal of this step is to lay out the context that provides the ground for my investigation of when and how constraints affect team creativity.

After describing each team and project, I move to an examination of the various constraints facing the four focal teams. The goal of this inquiry was to uncover which constraints were most salient to new product and technology development teams in this creative context, and to understand what role different constraints play in the creative process. In this section of the findings, I develop a typology of constraints that fall into two main categories of constraint: process constraints and product constraints. I then discuss trends in the ways process and product constraints tend to affect team creativity.

After providing this background, I move away from a specific process/product constraint distinction to my more general research questions. My first research question is

when do constraints affect team creativity. The goal of this inquiry is to examine whether constraints affect team creativity differently in different contexts. These analyses reveal common sets of dynamics across the four teams, which I call disabling dynamics and enabling dynamics, that shape the interpretations teams make of constraint, and therefore the trajectory that constraints are likely to take in terms of team creativity (i.e., inhibiting or enhancing).

This leads me to my second and final key research question: how do constraints affect team creativity. The goal of this inquiry is to examine the underlying social psychological processes, or mechanisms, through which constraints inhibit or enhance team creativity. These analyses uncover three mechanisms through which constraints tend to inhibit creativity, and four mechanisms through which constraints tend to enhance creativity.

Project Team Description and Dynamics

As noted in Chapter 3's discussion of research methods, an asset to the design of this research is the variation between the project teams studied. All four of the teams were formal project teams based in the Corporate Research group, working toward the development of new products and technologies in collaboration with relevant divisions with specific product outcomes in mind. At the same time, the four teams also varied with respect to project goals, project stage, expected timelines, salient constraints, team size, team composition, the nature of creativity required, leadership approaches, and the task and interpersonal dynamics of the team. In this section, I describe each team and provide an overview of the project goals and history, key constraints faced by the team, and the notable social dynamics. This context sets the stage for the subsequent discussion

of when and how constraints affect team creativity. Table 4.1 summarizes the key attributes of each project and team.

Coatings Team

Overview. The Coatings team is a large project team, formally organized by senior leaders to complete a very high visibility project oriented around a groundbreaking new coating material with three specific unique properties. At the time of study, the team was in the early-to-mid stages of the project, although there was tremendous pressure to develop the technology quickly. The timeline for the project from start to finish was set at 6 months, which is unusually fast in product and technology development at Gigantech. A key driver behind this aggressive timeline was that the CEO and the Vice President of Corporate R&D wanted to see the expected outcome realized as quickly as possible, due to competitive pressures and market needs. If realized, the technology could be applied to a multitude of consumer and commercial product applications in a variety of industries, and generate millions and perhaps even billions of dollars in revenue.

Coatings was the largest of all project teams studied, in large part because the organization had allocated nearly unlimited financial resources to the project. As a result, in many respects, the team had the freedom to spend whatever was necessary in order to drive the project to completion. Symbolic of the significance of this expected technology solution, the Coatings project had been likened by the Vice President of R&D and other senior leaders to the "quest for the holy grail." This was a prominent metaphor throughout the course of the study, as team members and even employees unrelated to the project routinely used related language and imagery to describe the goals and ambitions of the project. Given the scope of the technological innovation and potential financial

windfall this technology represents, the organization is willing to do whatever it takes to bring it to fruition as quickly as possible, including acquiring companies working with similar technologies if needed.

The Coatings team was the largest of the four teams studied, and was considerably larger than a "typical" R&D team. Although there were 10 core team members – employees dedicated to the Coatings project either full time or half time – the stated size of the entire team varied considerably, with respondents estimating anywhere from 20-50 total members. I conducted interviews with eight of the 10 core team members. The uncertainty around the actual size of the entire team is in part indicative of the Gigantech culture and norms of contributing informally to interesting projects where one may not have formal responsibilities or accountabilities. It also illustrates the breadth of interest and involvement in this high visibility project across the organization. A number of technical staff have contributed in some way to the project, and core team members discussed collaborating with or seeking input from interested colleagues who were not "official" members of the team. The formal team was cross-functional and comprised of members mainly from the Materials lab and the Production lab. Among those, I interviewed six from the Materials lab, in which the core technology innovation was taking place, and two from the Production lab, which was focused on how to produce the technology on a large scale. The Coatings project, like most R&D projects at Gigantech, was borne from earlier exploratory work in the Materials lab, and deals with nano-chemical technology innovation. The Coatings team is organized into two subteams, each exploring different potential pathways to achieving the team's goals. I interviewed members from both subteams, including the formally assigned leaders of

both. I also interviewed the product owner who spearheaded the original development of the technology upon which the Coatings project was established.

Constraints. Time pressure was the single most salient constraint for Coatings team members (7 of 8 respondents mentioned), with the very aggressive six month timeline looming large. Competitive pressures were extremely strong, with a variety of other organizations presumably chasing after the same "holy grail." While the team felt that it was comfortably ahead of potential competitors, the imperative of completing the project as soon as possible was very palpable during interviews and observation. The tremendous visibility of the project from higher-ups and across the organization elevated these pressures for all involved.

While time was by far the most salient constraint for the Coatings team, respondents raised three other key constraints as well. First, respondents highlighted equipment limitations as a constraint (6 of 8 respondents), as new labs were being feverishly established to help the team complete its work. Respondents noted that not having adequate access to equipment was slowing the team's ability to run experiments and move the project forward. Respondents also identified the specific requirements of the product criteria – that the target coating should achieve three unique properties – as a constraint limiting or defining the expected solution (7 of 8 respondents). Finally, intellectual property issues were a salient constraint for members of the Coatings team (5 of 8 respondents), as this team was highly attuned to the need to work within the boundaries of existing patents and competitive forces on similar types of technologies. Aside from these constraints, the team was flush with monetary resources, and possessed considerable freedom in how it accomplished its tasks and goals.

Team Dynamics. Although the Coatings team was halfway into the proposed six month timeline at the time of the study, members described the team as if it was still coming together and cohering around common goals and assumptions. Formal team leaders shared some frustrations about getting team members aligned, getting labs set up, and coordinating among the two subteams. The team was spending considerable time benchmarking competitors' solutions, while concurrently developing their own, with an eye toward intellectual property issues and the possibility of acquiring a competitor in possession of helpful technology (a fairly unusual approach at Gigantech). Therefore, team members didn't feel like this was their most "creative" time in the project lifecycle. Already an unusually large team, the team was also frantically onboarding new staff from the labs and hiring new employees, which was leading to additional difficulties with coordination and alignment. These challenges were further exacerbated by the cross-functional nature of the team, coordinating members from all four corporate labs. Indeed, there was some tension between members of the Materials lab and the Production lab, due to different outlooks and lack of collaboration and interaction. The subteam structure, where both subteams were "competing" against each other for the best solution to the problem, also presented some turf issues. Finally, given the strong presence on the team of the dominant and highly esteemed product owner, the formally assigned team leaders felt they lacked genuine authority, which made their jobs of organizing and coordinating team members more difficult.

While those in formal or assigned leadership roles demonstrated stress about the aggressive project timeframe, there was a strong impression from other team members that the six month timeline was both flexible and fairly unrealistic (i.e., management

knew it was unlikely but wanted to aim for it anyway). Many team members interpreted the aggressive timeframe as symbolic of the importance of the project. Some seemed to see the timeline as irksome or disingenuous, while others experienced it as motivating.

As discussed earlier, the norm at Gigantech is for technical staff to participate in two or three main project teams at a time. With the Coatings project, however, a good number of team members were working exclusively on the Coatings project. This again demonstrates the magnitude and importance of the project, and its visibility with senior leaders in the organization.

Medical Team

Overview. Medical is a smaller project team, composed of six people, also working toward groundbreaking technology innovation at the nano-chemical level, albeit in a very different technology platform and application. The goal of the Medical team is to develop a new material with unique chemical and physical properties (e.g., extremely durable, while translucent and very lightweight) to be used in a healthcare application. The current Medical project was borne from one team member's work over the prior eight years, beginning as a personal pet project of the project owner. Therefore, the technology development is quite advanced at this stage. Since the formalization of the project team in the prior two years, the Medical team has explored a variety of product applications in very disparate industries, some larger and some smaller in scope, but is currently pursuing a more modest application in a consumer industry where Gigantech already has a foothold. Although Gigantech typically aims for innovations that have the potential to yield millions of dollars in corporate revenue with products in multiple industries, the strategy behind the Medical team's current approach is to test the waters

with one or two products before expanding the technology into other potential applications. At this somewhat advanced stage of the project, the key elements of the technology are in place, but the team is struggling with how to produce the material on a large scale in a cost-effective way while also maintaining consistent high quality (a typical challenge with in nanotechnology). The fundamental technology driving this project is very innovative, but it is less certain that it will have the profit potential of some other projects. That is why the organization wants to test applications of the technology in the marketplace prior to launching broader product initiatives.

Like the Coatings team, the Medical team is cross-functional, composed fairly evenly of members of the Materials lab and the Production lab. The team also involves members of the divisional R&D unit related to the target healthcare industry, and the entire team meets regularly. I interviewed all six core members of the team, including four Materials lab scientists (one of which was the product owner), one Production lab engineer, and a scientist from the divisional R&D unit who was also the formal team leader.

Constraints. The Medical team was facing several key constraints. First, team members described facing some challenging human resource limitations (4 of 6 members identified). Specifically, members felt the team did not have enough people, and that the team lacked the breadth of skills needed for the project. Second, the team was also experiencing constraints of time (4 of 6 members identified), with impending project goals on the horizon and limited amounts of time to complete key tasks, particularly given the lack of people. Money was also described as an important constraint by respondents (3 of 6 members identified), who noted that the team didn't always have the

money resources they would like to obtain resources relevant to the completion of the project. And finally, the team was feeling constrained by the business needs and demands of the project (3 of 6 members identified), particularly around the need for this project to be successful financially for the organization if the fundamental technology will be pursued for application in a broader array of products.

Team Dynamics. Among the four focal teams, Medical was perhaps the least cohesive group from a team dynamics standpoint. There were tensions in the team along many dimensions, including differences in functional background, personality, and experience. Divisional product development staff felt that the Corporate Research lab staff were focused on the development of the "perfect" material solution at the expense of finalizing a marketable solution (a classic tension). Conversely, Corporate lab staff felt that the Divisional product development staff didn't fully appreciate the need for an elegant solution. There were also Materials lab vs. Production lab tensions in the team, marked by differences in problem-solving approaches and the prioritization of job demands. One member has been perceived to be particularly problematic and is seen as inflexible, linear-thinking, and unable to cope with the stress created by the various constraints experienced by the team. These dynamics have led to some frustration and confrontation in the team, where members are having some difficulty seeing eye to eye.

Amidst these somewhat challenging interpersonal dynamics, the team was trying to hire and onboard a couple of new people to fill in expertise gaps and to help with workload. Team members seemed to think that the additional human resources would help free up the team to better accomplish their goals and allow senior members to focus more on "creative" tasks rather than on "routine" tasks.

Electronics Team

Overview. Electronics is a medium-sized team of eight core members at the middle stage of a project involving members from the Materials lab, Production lab, and Software lab. Although Gigantech technology development efforts are often intended for applicability in several product domains, this particular project is targeted to one product application at present: an electronics interface found in consumer electronics. While still groundbreaking, this innovation is slightly more iterative in the sense that it is an improvement – albeit a vast one, in terms of price and performance – to an already existing approach. The original core technology was licensed from researchers at a large university, and Electronics team scientists have extended and expanded upon it. At this stage of the Electronics project, the technology is mostly developed, and so the focus is more on developing a creative *production* solution (i.e., how can these intricate electronics be efficiently mass produced on a large scale with high reliability?). Unlike the Medical team, which aims to produce Gigantech consumer branded products from their technology solution, the technology being developed by the Electronics team is intended for sale to other businesses to be applied to those businesses' branded products.

I interviewed four of the eight core team members, including two scientists from the Materials lab and two engineers from the Production lab. This included the product owner, a scientist in the Materials lab who was also the formal team leader.

Constraints. As with all projects in this study, team members identified time constraints are a core constraint facing the team (3 of 4 respondents mentioned). The team was not experiencing particularly tight time constraints like some of the other teams, but members were keenly aware of the deadlines facing the team. Second, given

that they were developing a consumer-oriented interface, the Electronics team was also considerably constrained by user interface factors (i.e., how consumers will interact with the device) that determined the requirements of the product design (2 of 4 respondents identified). Specifically, the team needed to produce an electronics interface using novel technologies that mimicked the way previous technologies were used by consumers. And third, since the Electronics team was developing technological innovation for application in a highly competitive and fast-changing consumer electronics market, the team was constrained by the demands of their Business-to-Business customers and the needs of the market (2 of 4 respondents identified). In particular, in order to succeed in the market, the technology and product solution needed to be cheaper and perform better than competitors' solutions, otherwise customers will purchase from others.

Team Dynamics: Although the Electronics team is pretty evenly divided between members of the Materials lab and Production lab. There were conflicts of opinion and different perspectives about the project that fell across Materials lab vs. Production lab lines, typical tensions in product and technology development teams at Gigantech related to differences between scientists (Materials lab) and engineers (Production lab). That being said, team members worked fairly well together as a team, and were able to put differences of opinion aside in the best interests of team-oriented solutions. This was aided by the team leader's establishment of strong routines around regular and open communication, including regular full team meetings in which progress is discussed and ideas are shared. These norms have fostered a positive and productive team dynamic despite the differences of opinion amongst team members. In fact, team members

acknowledged value in the sometimes divergent perspectives on the team, and suggested that these "healthy tensions" promoted the team's creativity overall.

Software Team

Overview: Software is a medium-sized team of eight core members based primarily in the Software lab. This team has been organized around a consumer-interfacing software development project. This is an unusual type of project for the Software lab, as most Software lab projects are developed in service to internal customers from other labs or divisions of the company. The project was also highly visible both within the company and externally, as its launch was in partnership with a very prominent external partner who was developing an innovative technology platform on which the Software product would be an early pioneer. Within Gigantech, the Software lab is often described as unique or different from the other Corporate labs, particularly with respect to the nature of projects and approaches to team work. Indeed, the nature of the creative work in the Software project team was quite dynamic, high-touch teamwork, as compared to more segmented, individual laboratory-based work. The Software team used the "Agile" approach to software development, the goal of which is to establish considerable structure around roles, responsibilities, and processes within which the team creative process can unfold. The technology behind the Software project was originally developed to be used internally in Gigantech product research and development. It employs principles of physiological and psychological science to make predictions about how users will interact with products. Now, the Software team has developed a customer-interfacing online software service that can be used by anyone, including individual consumers as well as corporate clients.

The Software team was composed of scientists and software developers. There were three members with leadership roles: two scientists who were team technical co-leaders and acted as content experts, and one software developer in charge of administering and facilitating the group process. I interviewed seven of the eight team members, including three scientists and four software developers. This team differed from others in the study in that two of the software developers on the team were non-Gigantech contractors. These contractors, who frequently work with Gigantech teams, are hired on a project-by-project basis, depending on the needs of the particular project.

Constraints: The most salient constraint facing the Software team was time constraints (7 of 7 respondents identified). The team was working under a very aggressive timeframe to complete the project, more aggressive even than the typical timeframes for similar software development projects. This was in part driven by the desire to capture market share, as well as the need to align with the key external partner's timeframe for the launch of their new technology platform. Time was the only constraint on which members of the Software team had high levels of agreement. However, members of the team did also describe a variety of other constraints related to the need for the product to meet very specific user interface needs, customer and market needs, and internal business priorities. Specifically, the end product needed to be designed in such a way that it could be user friendly for consumers, meet the key needs of the market, including both business customers and individual consumers, and align with Gigantech's corporate identity and priorities. These constraints were therefore important limitations defining the design and development of the Software team's product.

Team Dynamics: The Software team, the project, and the space in which they meet (so-called "the war room") are dynamic, playful, and team-oriented. The team meets daily at 1:00 pm for a "scrum," in which members quickly and methodically take turns reporting their progress and identifying impediments to their work. There is a very clear, predetermined structure for these meetings and how they operate. Accordingly, the Software team was very efficient in these daily meetings, the goals of which seemed to be to both drive progress and open the channels of communication to strengthen the group dynamic. The "war room" was awash with sticky notes on the walls, organized into categories capturing key ideas and insights, impediments facing the team or individual members, questions left to be answered, team goals, and humorous quotes from prior team meetings and interactions. Many of these concepts were captured with vivid imagery and drawings. The "war room" itself was vibrant and colorful, and the tone of the meetings held there were energetic and playful as well as serious and focused. A series of inside jokes were shared by the team during their interactions, and these were reflected in memorabilia on the table and on the walls (e.g., toys, puzzles, hats, bobble heads, drawings).

Members of the Software team reported strong interpersonal cohesion, based around what they described as similar personalities, work styles, and senses of humor. Members lauded the team dynamic and the open environment, and recounted frequent opportunities taken for team-building and to interject "fun" into the project and reward hard work (e.g., team outings to baseball games).

In the next section, I begin to more thoroughly analyze the impact of constraints on team creativity, beginning with the development of a typology of constraints affecting

creative teams. These analyses reveal a diverse set of constraints that can be grouped into two broad categories – process constraints and product constraints – and suggest that these different types of constraints affect team creativity differently. These analyses therefore provide important context for the subsequent discussion of when and how constraints affect team creativity.

Types of Constraints

I began this study with a deliberately broad definition of constraint, as "a state of being restricted, limited, or confined within prescribed bounds." The goal of this open-ended approach was threefold. First, since the extant theory and research have focused on only a very limited set of constraints, I wanted to ensure that I didn't limit the theoretical scope of my research by focusing on any particular subset of constraints or entering the study with preconceived notions about which constraints would have the greatest impact on these teams. Second, by considering a broad set of possible constraints, I was able to observe the similarities and differences among constraints as they affect team creativity. This is vital from a theory-building perspective. And third, given my inductive research strategy, it was important for me to allow respondents to identify and discuss the "constraints" they perceived in their projects, rather than to predetermine constraints for them ahead of time. This proved to be a fruitful strategy, as a broad and diverse set of constraints were revealed to impact these product and technology development teams.

To begin to examine the role constraints played in the focal product and technology development teams' work processes and creativity, I asked respondents to describe episodes in which their team had responded to or introduced constraints into the project work process. I then asked respondents what constraints their team was facing in

the project at that time, and to discuss the impact of each of the constraints they identified on the team's processes and creative performance (see interview protocol in Appendix C). My criterion for categorizing a "constraint" was simply respondents' identification of something as a constraint. When respondents mentioned that something was a constraint, I "open coded" (Strauss & Corbin, 1992) that item as a constraint type, labeling it accordingly (e.g., "Constraint – time"). This open coding took place as part of the line-by-line coding of each interview transcript for meaningful and recurrent themes. After coding all transcripts, I distilled the constraint codes into higher order categories, defined by core similarities related to the nature of the constraint (i.e., what was the limiting factor of the constraint?) and how it affected the team. For example, the codes "Constraint – lack of people" and "Constraint – skill set" were distilled into the category "Human resources constraints" because they were both related to limitations of human resources. Similarly, the codes "Constraint – customer demands," "Constraint – customer needs," and "Constraint – market demands" were distilled into the category "Customer and market needs constraints" because they were all related to the demands of the competitive marketplace. I went through several iterations of this process, seeking to distill the constraints into ever more fundamental categories, until I could no longer aggregate these categories further. At that point, I concluded my coding, ending with 15 unique types of constraint. The categories of constraints that this process yielded can be seen in Table 4.2, along with the number of sources (respondents) that identified each constraint of the 25 total respondents, as well as the total number of references to each type of constraint across the 25 interviews. While most of these constraint types were identified by multiple respondents in multiple teams, some were mentioned only by a

couple of respondents total, scattered across teams. Since the unit of analysis for this research is the team, and interview questions were framed in terms of team experiences and behaviors, I wanted only to retain constraints that were shared by a "critical mass" of team members, showing that these were indeed core constraints affecting the whole team rather than constraints affecting individual members within the team. I therefore excluded any constraints that were not identified by half of at least one team's members, determining that there was not a shared perception that these were core or salient constraints facing the project team. This excluded seven types of constraints, which were identified by no more than three of the 25 respondents, and never by more than two respondents per team (five of these seven were mentioned by no more than one respondent per team). These exclusions yielded a remainder of eight core constraints, which are highlighted in Table 4.2.

A surprising variety of constraints emerged from this analysis, including a number of key constraints that I had not considered coming into the study. In the following paragraphs, I describe the eight core constraints raised by team members, presented in order of prominence from the most frequently mentioned to the least frequently mentioned. These include limitations or restrictions related to (a) time, (b) product requirements, (c) equipment, (d) customer and market needs, (e) business needs, (f) intellectual property, (g) human resources, and (h) money. I illustrate each of these constraints with quotations from members of the four focal product and technology development teams, who are identified by both team number (T1 (Coatings), T3 (Medical), T4 (Electronics), and T5 (Software)) and respondent number (e.g., R1, R2, R3, R4, etc.).

Time. By far the most common type of constraint mentioned by respondents was time. 21 of the 25 respondents, including members of every team, identified limitations of time as a key constraint facing their project team. Perceived time constraints were typically related to the project timeline or the allocated time for the completion of the project or a portion thereof. For many team members, time was the most significant and most pervasive constraint they faced in the new product and technology development process; so much so, in fact, that it was considered to be an inherent and inescapable part of the product development process. One member of the Software team said,

> "Another big constraint on these things is that [management] wants to have a release of a certain date. 'Cause time is always a constraint. So there's always been a lot of discussion on what we can do within the time that's available" (T5R4).

While time constraints tend to be imposed externally from managers and leaders, some respondents discussed their teams' efforts to deliberately place time constraints on their projects as a way to enhance their creativity. For example, another member of the Software team said,

> "We committed [to the client] to have our product production ready by November 17th, because we would have the benefit of joint press releases, et cetera. But that only gave us, I think it was like six weeks, something to that effect. So, there was a huge time constraint that we placed, I guess, on ourselves" (T5R6).

Indeed, given the reward structures at Gigantech, it benefits technical staff to develop their ideas and projects as quickly as possible. Said one senior member of the Coatings team,

> "When I look at people to work with, you know, I try to see something where these people are pressing to get something going...that if you do something, it's gonna go, you know. I want to work with a partner who's gonna provide me with some hope of getting a product out sometime in real time [laughter]" (T1R5).

Although the prominence of time constraints in product development was a consistent message across the teams, there was considerable variance in how different project teams seemed to interpret time constraints. For example, while the Medical and Software teams were both experiencing aggressive time constraints, members of the two teams described them quite differently. One member of the Medical team expressed the team's frustration with aggressive timelines, saying,

> "Management is always coming up with new deadlines, and very aggressive deadlines, which on the one hand I understand because everybody needs a deadline to get things accomplished, but sometimes these deadlines and the expectations are so unrealistic that it makes everyone more stressed out than they should be" (T3R3).

However, while the Software team was also experiencing very aggressive timelines, members seemed to take it more in stride, even seeing creative benefits in the limited time. For example, one Software team member said, "We got pretty creative, if you will, in solving some of those challenges because we had some tight deadlines we had to meet" (T5R2). In some instances, time constraints were interpreted differently by members of the same project team. One senior member of the Coatings team, with a high rank and tenure, captured this dynamic, saying,

> "The different reactions to [the aggressive time constraint] have been interesting. I mean, several people just stressed out like crazy, like, 'Oh my God, we can't – how can we ever do this?' And other old guys like me just said, 'We can't. That don't matter.'" (T1R6).

As this quote illustrates, these perceptions seem to be informed, in part, by team members' experience dealing with time constraints in creative projects in the past. Such interpretations are also shaped by how aggressive the time constraint is perceived to be, and therefore, how challenging the creative task seems in light of the time limitations.

Generally, the more aggressive the time constraints, the more difficult or damaging they were perceived to be for team creativity.

The felt presence of time constraint also seems to vary according to the stage of the project. For example, projects at the earliest stages at Gigantech are by design unencumbered by time constraints, as individuals or small teams develop projects independently on "skunkworks" time, beyond the accountability and daily purview of managers. Given the informal and nebulous nature of work at this stage, there are often few time constraints present. Gigantech leaders, as a matter of practice, try stay out of the development of these very early ideas. However, as projects become more formalized and teams are organized around them, time constraints begin to come more into play. Said one respondent,

> "I didn't feel during these years in the [early] phase that there was a particular time pressure. Now, since the business units got involved and they've ratcheted up some investment, they do have definite sales revenue realization expectations for the project…Timelines become more rigid, and they're always shorter than you're comfortable with" (T4R1).

Among the different types of constraints raised, time constraints provoked the most variance among respondents on whether or not the constraint was perceived as "real." Such perceptions also seemed to impact how teams interpreted and responded to the constraint. Specifically, it seems the time constraint must be perceived as genuine in order to impact team creativity either for better or for worse. If a time constraint is perceived to be real, then teams understand that it is likely not negotiable and that they will need to organize accordingly around it. However, if a time constraint is perceived to be fabricated – for example, as strictly a motivational tool – it is unlikely to play much of

a significant role. A member of the Coatings team reflected this sentiment about the aggressive six month time constraint they were under, saying,

> "I'm not sure that it's real, to be honest with you. I think it may be a way to create a sense of urgency on upper management's part, which I understand. So there's a constraint maybe for time, but [we] don't feel that yet" (T1R2).

In sum, although time constraints are a common and expected component of project team work at Gigantech, their impact on creative teams varied considerably.

Product requirements. The second most commonly identified type of constraints were limitations related to the requirements of the expected product. 13 of the 25 respondents identified product requirements as a key constraint facing their project teams. Although mentioned by members of every team, these constraints were particularly salient to the Coatings and Electronics teams. Although the product requirements obviously varied considerably across the different projects, they share in common that they are constraining factors because they define the properties of the expected product or technology outcome. For example, the Coatings project was expected to achieve a very difficult combination of three specific unique chemical properties – properties that have never before existed in combination. One team member described them as follows:

> "Well, there are product requirements. From those things, we can decide oh, okay, we have to meet the certain number of criteria, and so we work on trying to fulfill those criteria. And so we're kind of in the midst of that. And I would say it's been a constraint on creativity. The constraint was combining all three of these properties, until one solution emerged. So that was pretty well defined" (T1R6).

A member of the Medical team described the product requirement constraints of their project in a similar way:

> "It is reasonable cost, reasonable work flow, high strength, good aesthetic value, good chemical durability, no toxins that aren't suitable for the [medical] industry. So you start with that list, so there's already this one list of – I think it's fair to

> call them constraints – that are just the definition of the materials problem" (T3R4).

Product requirements like these are therefore a key component defining the goals of the project and the trajectory of the team. Such constraints are, of course, a normative part of the product and technology development process, because project teams need to have some sense for what the desired outcome is of their efforts. One respondent talked about the role of these constraints in developing what will be useful products for customers, beyond just novel or interesting solutions:

> "It's not just about [novel] material, because we don't sell chemicals. We sell finished products. So if you're gonna sell a finished product, you're gonna make a material, it has to go through some process usually to be put into a product that's useful" (T1R5).

Product requirement constraints are typically imposed externally by team leaders or managers with a view toward developing products that meet specific, well-defined needs for end-users. These requirements were often described as being "handed down" from superiors. As with time constraints, product requirements can be interpreted positively or negatively by creative teams. Overall, however, the data revealed that teams described constraints related to product requirements in overwhelmingly positive terms. This was particularly surprising given the remarkable specificity with which product requirements are typically defined, which I would have expected to be perceived as inhibiting creative possibilities. On the contrary, respondents found the definition and clarity resulting from product requirement constraints to be quite helpful, especially in the team context where greater ambiguity can exist around goals. One respondent noted that having a clear problem to be solved is "helpful, but it's because – I wanna say, maybe the problem isn't so well-defined as the desired solution is well-defined" (T1R7).

In other words, product requirement constraints provide a helpful target for the team to aim for and organize their creative efforts around. This sentiment was reflected by a member of another team, who said, "I don't know if that's a constraint as much as it is a target. You have to hit it or no one's going to care. But it doesn't feel so constraining, because I can think of many ways of hitting those targets" (T4R1). In fact, although product requirement constraints are typically determined for project teams by higher-ups, many of the project teams described introducing product requirement constraints on themselves. For example, a member of the Electronics team said that a large-scale product development project like his is

> "complicated because of the variety of different issues – the number of unknown elements become larger. So what we decided is that we're gonna constrain ourselves to a much simpler implementation. The reason we did it is because we wanted a limited number of challenges. You constrain yourself into a simpler version that has 15 challenges. And then you solve those 15, and you start enlarging it" (T4R5).

Others described product requirements as essential to creative product development outcomes. For example, a member of the Electronics team said,

> "Once you set up a goal, you're constrained. And development – good, creative development on a complicated project – cannot happen without technical constraint. Perhaps it can, but in my opinion, it has a lower chance of timely success" (T4R5).

Respondents did speak about the potential for product requirements to be detrimental to team creativity if for some reason the broader environment or task structure doesn't allow for flexible creative *processes*. For example, a member of the Electronics team noted that product requirement constraints, while typically helpful for project team creativity, would be detrimental if, for example, "we can think of ten ways of hitting the targets, but because of the organization we're in, we can't really do half of

those" (T4R1). This is a finding I will discuss in greater detail in the next section exploring when constraints affect team creativity (research question 1).

Equipment. Equipment limitations present another important constraint for creative teams. This constraint was mentioned by 9 of the 25 respondents, and was particularly salient to the Coatings team. In order to be able to innovate, product and technology development teams need to have access to adequate and appropriate resources. In the realm of cutting edge technical work like that being done in the corporate laboratories at Gigantech, team members rely on intricate and expensive scientific instruments and technical machinery to conduct experiments, produce samples, and test and analyze the results of their work. Lack of access to such equipment can therefore be a tremendous constraint to team performance and the creative process. While R&D teams at Gigantech typically have access to a wealth of equipment resources, there are times that the equipment at hand is insufficient or the organization does not possess the equipment needed. This was the case for two of the teams studied, which were struggling with a lack of resources. For example, the Coatings team was in the middle of a crucial testing and experimentation phase, but did not have access to all of the process equipment they needed to move forward and complete their work. This was due to a variety of factors, including sharing resources with other project teams in the firm who needed access to the same equipment, new labs and equipment in the process of being established, and outdated equipment in the company. This limitation was exacerbated by the very fast ramp-up of the project and its aggressive timeframe. One team member described the issue saying,

> "The other big constraint we have right now is we want to develop this testing center for all these coatings, and it was supposed to have been up on the second

> floor of this building…but nothing's really happened from a facilities management perspective. And it's sitting there – it'll probably be [two months] before it's done…It's getting to be a real headache, I'll put it that way" (T1R2).

Another team member expressed frustration with outdated resources, saying,

> "You might not be able to do some of the innovative processing that you want to do because that process equipment is not available within Gigantech. So if you want to do a particular type of chemistry or combine things in a certain way, well, then you've got to work within the constraints of some sort of kettles that they have set up maybe 40 years ago, you know. When you can't do certain things the simplest, best way, then that's a serious and negative constraint" (T1R5).

Team members described the negative impact these equipment constraints were having on the team's creativity and productivity:

> "We can't use that [equipment], you know, to experiment with because there's no place to do it. And because you can't do that and it's probably the best way to make a number of different materials, it's hard to innovate" (T1R5).

These constraints contributed to delays and inefficiencies in the project at a time when the team could not afford them. A similar story emerged from the Medical team, which did not have the access they wanted to key instruments and machines due to both limited capital equipment capacities in the organization and geographical restrictions. Thus, in the two main teams for which equipment constraints were a factor, team members highlighted the negative impact of these limitations on team's ability to create as they would like.

Customer and market needs. The fourth most frequently mentioned type of constraint facing new product and technology development teams were customer and market needs constraints. Such constraints were mentioned by 8 of the 25 respondents, including members of all teams, and were particularly salient to the Electronics team. Customer and market needs are common constraints affecting the product development process because new products and technologies must be designed to address customer

and market needs. While product requirement constraints are related to desired property outcomes as determined *internally* by members or leaders of the organization, customer and market need constraints are related to needs determined *externally* by the broader competitive landscape. In other words, the demands of the broader marketplace constrain which products and solutions creative teams pursue. This is a constraint unique to creative work in an organizational setting (as opposed to an artistic setting, for example), where product and technology development teams must produce creative solutions that will generate customer interest and sell well. This is particularly true at an organization like Gigantech, which markets and sells products and technologies to other businesses as well as directly to consumers. One member of the Coatings team described the customer and market need constraints facing her team, saying,

> "Usually, the people who are in the divisions trying to figure out what they can sell, you know, will go to the customer to get information about the products that the customer wants, or maybe unexpressed needs that they have. And from those things, we can decide oh, okay, we have to meet this certain number of criteria, and so we work on trying to fulfill those criteria" (T1R5).

A member of the Electronics team described these constraints similarly, saying,

> "So there were property targets demanded by the market in our application area that constrained the work a little bit. They didn't constrain our solutions or the range of solutions we might pursue, but they certainly forced us to pursue certain aspects of the work if we wanted to be successful" (T4R1).

And a member of the Medical team put it even more succinctly: "Who is really your customer and what is really important to them? The biggest constraint is the target market" (T3R4).

Although constraints posed by external customer and market needs would seem to have a negative perceived impact on team creativity, respondents suggested that they were often quite helpful, not just because they provided clarity and direction, but because

they provided the sense that the team was doing important work that was having practical impact in its application. One member of the Electronics team captured the importance of these constraints, saying "We had to hit these kinds of things for the market to care" (T4R1). Others described how without customer and market need constraints, a product development team could design extremely novel solutions that would have no utility for customers (and therefore, would be a failure, both from a design and a sales standpoint). A member of the Medical team elaborated on this challenge:

> "So you maximize all of the properties you're aiming for, you think those are all the important properties of the thing, but then who are you selling it to? The doctor – what does he care about? He doesn't know the difference [in the chemical make-up of the material]. He wants to know, does this take me a 30 minute appointment or a 15 minute appointment to put it in?" (T3R4).

This quote captures the distinction between product requirement constraints and customer and market needs constraints. Not only is usefulness an important criteria for the definition of a "creative" solution, as stated in the definition of creativity as "ideas or solutions that are both novel and useful," but technical staff also intrinsically want their product and technology solutions to be useful for customers. As noted earlier, that is why most have chosen to pursue a career in industry rather than academia.

While the data revealed that creative teams mostly looked favorably on customer and market need constraints, these types of constraints can introduce complexity and ambiguity into the creative process. As a member of the Software team noted, "There's no way that you're gonna be able to 100 percent satisfy 100 percent of your users, so you're constantly…you know, you constantly have to make trade-offs" (T5R4). By and large, however, team members found it creatively stimulating "trying to provide something for the customer that they want to use" (T5R7).

Business needs. The needs of the business also present important constraints for creative teams in organizational settings. For the teams I studied, these were among the most significant constraints they faced in the product and technology development process. 7 of the 25 respondents mentioned business need constraints as core constraints facing the project, including members of all teams, and this constraint was particularly salient to the Medical team. Similar to how teams are constrained by the external demands of customers and the market, they are heavily constrained by the needs, goals, and priorities of the organization itself. Simply put, the products and technologies developed by these teams need to make money, and lots of it. If they are unlikely to drive significant revenue, then these projects will not be pursued by managers. This is a central criterion for the funding and promotion of prospective projects. A leader of the Medical team put it bluntly, "The biggest constraint? They need us to make money for the company" (T1R1). These constraints are very real in a profit-seeking organization. Although there is room for variance, the benchmark that managers at Gigantech are aiming for is that each project has the potential to bring in at least tens of millions of dollars. Clearly, this constrains which products are developed, and how they are developed. Although the magnitude of these business need constraints was striking to me, by and large respondents did not allude to them being debilitating. Team members mostly described these constraints matter-of-factly, as an expected part of the job, even potentially helpful. Some did express frustration over such stringent financial criteria for projects, however. For example, some respondents contrasted product and technology development efforts at a large corporation like Gigantech to development at a small start-up, concluding that while smaller and younger organizations can afford to pursue smaller

and riskier projects that may or may not drive large profits, a company like Gigantech has more at stake in producing creative solutions that will have greater financial impact more quickly. This causes some very novel ideas to be shelved in favor of those that will have greater business utility. Illustrating this point, a member of the Medical team said,

> "The business stuff is all constraints that are dictated by an industrial, large-scale outfit like ours. What I mean by that is we're not a start-up company. Sometime in the past we were a start-up company, and there was a mentality, 'oh, let's just try it out and see how it goes in the business, and then if it grows, it grows; if it doesn't grow, it doesn't grow,' but it's no longer like that. [Now], it's much more, you know, well, we're only gonna get into this business if it's really in the tens of millions of dollars. You know, don't ever touch any project if it's not $20 million" (T3R1).

In contrast, others saw both practical and creative value in business need constraints:

> "You've got to coordinate with what is the business need and what do we need to sell this thing, 'cause if we can't sell it, we're not gonna be working on it. Some technical people lose focus on that fact. They just [think] technology is technology for technology's sake. You know, that's fine, but in the end it's gotta be useful for something and you have to be able to make some money on it" (T5R8).

Beyond the criteria of financial profitability for the organization, business need constraints also include criteria of fit with the strategic direction and technology platforms of the organization. For example, a product owner from the Coatings team said,

> "I look at the broad picture of the company, where the company is going, what are the strengths of the company, what does the company need? And you can create good technology, but if the technology does not fit the company, it is unlikely to succeed. You have to develop a technology which is suitable for the company, so then you need to know the history, you need to know the production line, and you need to know the management mindset…so it's very complicated" (T1R1).

Getting acclimated to product development in the context of such stark business needs was consistently described as an adjustment for many scientists fresh from graduate school or new to industry. However, although this constraint seems like it would present a difficult reality for scientists and engineers oriented toward groundbreaking

product and technology development, it was mostly interpreted as enabling and clarifying, even motivating. Said one member of the Electronics team,

> "People come out of grad school and R&D programs learning how to do research, learning how to do literature, learning how to organize their stuff, but they don't have the boundary conditions – so you can take a material and say, 'This material's interesting, it has interesting effects,' and you can kind of justify what you're doing by saying, 'It *could* be good for A, B, or C.' Now [you] come to Gigantech, and you're in an industrial lab – 'it could be good for' is not enough. It has to be the *best* solution or it has no value, because if it's the second best solution then whoever has the best solution wins in the market. So you have a completely different set of boundary conditions, and that forces people to be much more creative" (T3R4).

As was discussed earlier, the drive to be "the best" is a powerful motivator for creatives in product and technology development, and the reward system and hierarchy at Gigantech rewards such excellence.

Intellectual property. Intellectual property issues were another key category of constraints identified by respondents. These were raised by 7 of the 25 respondents, and primarily by the Coatings team. Intellectual property concerns influence every product and technology effort in any setting where the goal is to develop novel and useful solutions. New products and technologies must be differentiable from competitors, and designed in such a way as to not infringe on the intellectual property rights of others (unless the firm is licensing the patents of others). The criteria established by the U.S. Patent act are clear that inventions must be (a) novel, (b) useful, and (c) nonobvious to "one of ordinary skill in the art." Since the goal of most product and technology efforts is to develop patentable solutions that will drive long-term value and profitability for the organization, this is a clear constraint for new product and technology development teams. Organizations like Gigantech need to both protect their own intellectual property positions, as well as work within the constraints of others'. This is of course an important

and expected part of the development process. One member of the Medical team described the challenges that come from these constraints in the following way:

> "There's constraint after constraint. One is intellectual property. Is the approach you're taking protectable? Or could it be copied easily by a competitor? Are there right-to-practice issues? Are you moving in a direction with the group's concepts where you're gonna have to dodge a lot of patents that other people have protected this area? Is it new enough? Is it open enough? Can you protect it? Those are important constraints that people work under all the time in an environment like this" (T3R4).

Like a few of the other constraints already discussed, intellectual property constraints are "facts of life" in new product and technology development: they are always there. Perhaps for this reason, they were not raised as constraints by as many teams. However, like other constraints, intellectual property constraints can also vary in their severity, depending on how much competition exists in a space or how well-developed the particular industry is. Either way, they play an important role in shaping the new product and technology development process for creative teams, often helping to define what can even be considered "creative" in a given space.

Human resources. Another limitation that emerged as a key constraint in the team creative process were human resources constraints. Human resources constraints are limitations in staffing. Human resource constraints were mentioned by 5 respondents, and were only really salient to the Medical team, which felt constrained by a lack of manpower to help with the project workload, as well as by a lack of the right kind of team members on the team. The Medical team was recruiting and onboarding new members, but not at a fast enough pace. These human resources constraints were consistently described by team members as harmful to the team and their creativity, as they struggled to accomplish key project tasks with the people they had. One team

member described these challenges, saying, "So you're kind of constrained and one of the things that is constraining is that we don't…sometimes we don't have the help that we need just to do some of the tedious time consuming tasks" (T3R3). He went on to describe the additional constraints that come from hiring and onboarding new team members to fill these gaps:

> "The flip side to that is okay, they have just hired, in the program, two technicians. The problem with that now is that you have to get them up to speed. You have to train them to do things but when you're still in more of the research mode, it's very hard to just immediately get a technician onboard and say, 'Do this, and this, and this,' because you're still trying to develop and explore certain areas of the project. And so sometimes you want help, but then when you get full-time help, you're maybe not ready for it" (T3R3).

Beyond the challenges of manpower and training, the team felt constrained by the composition the team, specifically in terms of the types of background and expertise possessed by current team members. One team member said,

> "Another type of constraint is what are your skill sets with your people. A successful project often requires contributions of a lot of different types and yet there's usually a core of people who have certain strengths and certain sets of things that they just don't spend much time on. That could be the technical part, or it can be, more broadly, certain functions getting done and certain functions not getting done. And so then you look around and say, 'Oh God, our team, we need more help from the Production lab. We haven't done enough on large scale equipment and with statistical thinking.' So at various times, you can be constrained because the demographics aren't ideal for the priorities or needs [of the project]" (T3R4).

The fields in which these teams are working are highly specialized and typically require graduate-level training. As a result, leaders may have difficulty finding or hiring people with the right combination of specialized skills that is needed by the team. This can also constrain the team. Although these kinds of human resources constraints are relatively rare in R&D at Gigantech, given the organization's highly trained staff and heavy

emphasis and investment in innovation, they are real for many product and technology development teams.

Money. Monetary constraint was the final category of key constraints. Monetary constraints were mentioned by 5 of the 25 respondents, emphasized primarily by the Medical team. As evidenced by the billions of dollars spent on research and development at Gigantech and similar firms, new product and technology development is a costly endeavor, particularly at the level of the cutting edge technological innovation happening at Gigantech. The state of the art changes quickly as scientists and engineers make breakthroughs in nanotechnology and other innovative areas. These scientific innovations require costly technological resources, materials, people, and other forms of investment. Even at a large firm like Gigantech, financial resources are far from unlimited, and managers make difficult decisions about where and how to allocate financial resources in order to realize the greatest return on the investment. While all of the teams studied expressed gratitude for the generous way in which the firm was investing in R&D, monetary limitations were key constraints for some teams. For example, when asked about constraints, an engineer on the Medical team said,

> "Money. It's always money, right? You can never spend enough money [*laughter*]. I mean, I guess that's the obvious one. We could – if we had an unlimited budget, we would spend so much money it would be disturbing. [*laughs*] Because we can always think of something like, 'Oh, we want better – we want a better motor for this. We want a better drive for this so that we can get even better control. We want this kind of feedback. So you're always dancing around the budget" (T3R6).

However, where monetary constraints existed, they were not necessarily interpreted negatively. For example, one member of the Software team described the team setting financial constraints on themselves:

> "There was a significant cost constraint placed on our development team, because we were kind of in skunkworks mode. We were in kind of an ideation mode. We didn't have a lot of cap backs to spend on things like a big data center, system admins, a big development team. So there was definitely a monetary threshold that we had set for ourselves" (T5R6).

Monetary constraints certainly play a role in the product and technology development process at Gigantech, but by and large there seemed to be an understanding among team members that (a) they were working in an environment of relative largesse, particularly given the broader economic difficulties affecting the nation, and (b) where monetary constraints existed, as long as they weren't stifling, they were not necessarily having a negative impact on team creativity.

Process Constraints vs. Product Constraints

The constraints outlined above paint a fairly comprehensive picture of the key constraints affecting new product and technology development projects. All represent substantial constraints that these teams must manage in their creative work. However, as illustrated by the analyses above, it became clear that different constraints tended to affect team creativity in different ways. More specifically, teams tended to experience different types of constraints differently in terms of their impact on team creativity. Some constraints were experienced as quite negative, others as more positive, and sometimes, positive or negative depending on the level of constraint or the context surrounding the project. As this became clear, I set out to understand why this might be and whether there were commonalities among these constraints responsible for these different reactions. To examine this question, I looked across the constraint types to consider how they were similar and different in terms of how they constrained creative teams. More specifically, I sought to understand whether certain types of constraints operated similarly on team

creativity. To investigate this question, I analyzed the data on the eight types of constraint for common patterns in how they influenced the team creative process and what impact this seemed to have on team creativity. After several iterations of analysis, there emerged two broad categories within which the eight aforementioned constraints could be organized. I called these categories Process Constraints and Product Constraints. *Process Constraints* constrain how it is that the work is done (i.e., they limit possible approaches), whereas *Product Constraints* constrain the intended or expected outcomes of the work (i.e., they limit possible solutions). With these differences in mind, I then scrutinized the trends in the data regarding what impact – positive, negative, or both – these different categories of constraint tended to have on team creativity. I distinguish and expound on these two categories of constraint below, and the ways in which they impact team creativity. I also outline these categories, and their salience in each of the four teams, in Table 4.3.

Process Constraints. Constraints of *time, equipment, human resources*, and *money* can be described as Process Constraints. Process Constraints introduce limitations to the processes by which product and technology development teams approach creative projects. In other words, they constrain *how* work is done. Time constraints, equipment constraints, human resources constraints, and monetary constraints all play a role in limiting the resources project teams have at their disposal in the creative process. As a result, they shape how creative teams approach their work. For example, teams facing significant time constraints must make decisions about how to organize to accomplish their development goals under such time pressures. This may require trade-offs or compromises in the process of invention, such as either lowering expectations or

leveraging existing and proven platforms. Alternately, the time constraint may stimulate creative teams to action or inspire them to identify novel approaches to solve problems in unusual ways. Similarly, teams facing stringent monetary constraints will need to find places to streamline their efforts, or perhaps find new ways to make do with what resources they have or to use those resources in novel ways. Whatever the implication, process constraints shape how creative teams approach their work.

Product Constraints. Constraints from *product requirements*, *customer and market needs*, *business needs*, and *intellectual property* can be described as Product Constraints. Product constraints limit the realm of possible solutions that can be pursued by product and technology development teams. In other words, they constrain the *outcome* of the project. Product requirement constraints, customer and market need constraints, business need constraints, and intellectual property constraints all play a role in limiting alternatives for the creative solution. As a result, they narrow or define the intended or expected outcomes of the project. For example, teams presented with strict product requirement constraints are limited in terms of which solution they will/must arrive at. This narrowing of possibilities may help a diverse team clarify and coalesce around creative goals, or it could lead them to a solution that is less than optimal. Similarly, when faced with heavy customer or market demands, teams may be inspired to think outside of the box to meet the challenge, or they may discard some potentially interesting ideas. Either way, product constraints impact the solutions creative teams derive.

Considering process constraints and product constraints together. In sum, while process constraints are about constrained means, product constraints are about

constrained ends. In the interviews, these two categories of constraints were emphasized about equally, and received approximately the same number of mentions when respondents were asked to discuss the constraints affecting their projects (see Table 4.2). Both process and product constraints play important and necessary roles in the product and technology development process, and as the earlier examples illustrate, both possess the potential to inhibit or enhance team creativity. More specifically, it seems that process constraints tend to inhibit team creativity when they reduce experimentation and intrinsic motivation, and when they are perceived to restrict possibilities. On the other hand, process constraints may enhance team creativity when they provoke motivation, team cohesion, and novel approaches to difficult challenges. Likewise, product constraints tend to enhance team creativity when they provide focus, structure, and a common framework, and they tend to inhibit team creativity when they reduce perceived challenge or promote the status quo. These are mechanisms that I will return to later, when discussing the findings related to research question 2: how do constraints affect team creativity.

While these data reveal that both process constraints and product constraints have the potential to enhance or inhibit team creativity, as evidenced by the representative quotes shown earlier, the data suggest that overall, constraints on work processes (i.e., process constraints) seem to have more negative implications for team creativity than constraints on work outcomes (i.e., product constraints). In turn, product constraints seem to have greater potential to positively impact team creativity than do process constraints. To put it more simply, process constraints seem more likely to inhibit team creativity, while product constraints seem more likely to enhance team creativity. Why is this the case? It seems that process and product constraints differentially impact team creativity

both because they operate differently on team creativity and because they tend to be interpreted differently. Process Constraints constrain how the work is done, and therefore limit the set of possible approaches that can be taken by the team. This tends to inhibit the sense of empowerment team members feel in their work, as well as how much freedom they have in the way they enact the project. Previous research demonstrates that a lack of empowerment and autonomy reduces intrinsic motivation, which inhibits creativity (Amabile, 1996; Deci & Ryan, 2002). On the other hand, Product Constraints constrain the intended or expected outcomes of the project, and therefore limit the set of possible solutions to the problem. As long as those limitations are not too burdensome, it seems the team collectively benefits from the focusing effect of a well-defined creative challenge, while still retaining the freedom to create in whichever manner they choose.

The data do show exceptions to these rules, however. All four of the teams studied demonstrated a capacity for creativity overall, even when faced with difficult process constraints, and even where some team members perceived those constraints to be harmful. By the same token, there were instances where product constraints were harmful to team creativity. These conclusions beg the question of whether there are certain circumstances that influence the impact of process and product constraints on team creativity. In the next section, I examine this question by asking "When do constraints affect team creativity?" In so doing, I step back to a broader investigation of the role of the team context in shaping the impact of constraints on team creativity. Through these analyses, I conclude in the Discussion that although process constraints are more likely to negatively affect team creativity and product constraints are more

likely to positively affect team creativity, these relationships depend, importantly, on the social dynamic of the team facing the constraint, and on the perceived level of constraint.

When do constraints affect team creativity?

Much of the extant theory and research investigating the impact of constraint on creativity suggests that constraint is an unwelcome external condition that mostly has a negative effect on creativity. Contrary to these assumptions, my analyses suggest that constraint is a normal, often expected, and even integral part of the creative processes of work teams in organizational settings. Creative teams in organizations expect to do their work in the presence of constraint, and they are accustomed to doing so. After all, any task or activity, creative or not, done within the purview of an organization will be constrained by the boundaries, norms, expectations, and limitations of that organization and project. As illustrated in the previous section, these constraints may be helpful, or they may be harmful. So in some sense, the question, "When do constraints affect team creativity?," is an incomplete one. Constraints *always* affect team creativity; it's a matter of whether for better or worse. However, my analyses reveal that under different circumstances, constraints affect team creativity differently. In this section, I explore contextual factors that influence the impact these constraints have on team creativity.

In order to examine the circumstances under which constraints impact team creativity differently, I analyzed each of the four focal teams as independent cases and conducted cross-case analyses (Miles & Huberman, 1984). The goal of this process was to identify contextual similarities and differences across the four independent cases (Eisenhardt, 1989; Yin, 1994), paying particularly close attention to the ways in which each team talked about their team processes, contexts, and constraints, and what

relationship these had to team creativity. To examine these issues, the interview transcripts were open coded (Strauss & Corbin, 1992) using the NVivo 8 software for contextual factors, and group processes and dynamics in the team. I then iterated back through the interviews, distilling the open codes into ever more fundamental categories, until these categories could no longer be further aggregated conceptually. This process yielded a total of 10 contextual factors, all related to the broader Gigantech organizational context of which the teams were a part. These included categories such as "collaborative culture and environment," "culture of embracing challenge," "few boundaries," "freedom," and "open networks." As for the coding of group processes and dynamics, the 51 original open codes were reduced to 29 categories, which were organized into 5 broad dimensions of team dynamics: Collaboration, Communication, Task Structure, Leadership, and Social Environment. These dimensions, and the codes underlying them, can be seen in Table 4.4. The four teams were then compared on these dimensions, with an eye toward shared patterns of behaviors and interpretations. The data on contextual factors were all positive factors of the organizational context related to creativity. These data revealed no discernable differences across cases with respect to interpretations of organizational context. The data on group processes and dynamics, however, revealed important differences in how teams interacted with each other and organized to achieve their goals. These distinctions were particularly notable in comparison to respondents' descriptions of the surrounding organizational context: while interpretations of the organizational context were roundly positive, interpretations of the team context and dynamics were highly variant. However, the ways in which teams varied in their descriptions of the social dynamics of the team were surprisingly consistent. In particular,

across the four cases, there emerged two dominant and distinct patterns of social dynamics that were related to positive and negative/neutral trajectories for team creativity, respectively. I refer to these two patterns as *enabling dynamics* and *disabling dynamics*. Although the four teams varied in many ways, teams demonstrating enabling or disabling dynamics shared identifiable similarities that seemed to be indicative of fundamentally different dynamics in the team.

Disabling dynamics. Two of the teams, Coatings and Medical, demonstrated attributes of what I call disabling dynamics. Teams with disabling dynamics demonstrated difficulty organizing around shared goals. Team members tended to work independently or in small subgroups, as opposed to collectively and across laboratory boundaries. They exhibited cross-functional conflicts and difficulty integrating their diverse perspectives. Often, team members demonstrated distrust of others' motives, and this distrust was exacerbated by a lack of regular and open communication. These teams also seemed to exist in environments lacking in facilitative leadership exemplifying healthy group practices and norms. In some cases, a lack of authority of team leaders contributed to the dysfunction. In this dynamic, constraints were often seen as obstacles to creativity that limited the team and its ability to create in ways it was capable of. It also limited members' intrinsic motivation to be creative and break free of status quo approaches to problems.

Enabling pathways. The Electronics and Software teams, on the other hand, demonstrated attributes of teams with what I call enabling dynamics. Teams with enabling dynamics expressed clarity and cohesiveness around common goals. Team members reported a supportive environment for creativity in the team that encouraged

risk-taking in pursuit of innovation. Team leaders established clear routines for regular and open communication in the group, even where strong differences in perspective existed. These differences were often verbalized and processed, rather than segmented and ignored. Leaders also provided team members with considerable freedom in their work, trusting them to enact their own roles and responsibilities. Dynamics in these teams were playful yet focused, and members reported feelings of interpersonal connectedness. For teams in this state, constraints were more likely to be perceived as opportunities, excuses, or stimuli for creativity, providing empowering creative challenges that engaged team members' drive to solve challenging problems. Teams with enabling dynamics often strategically imposed constraints on themselves as a way to bolster their performance and creativity. However, even where unwelcomed constraints were experienced, team members were often able to see value in them. In this way, members of teams with enabling dynamics demonstrated cognitive flexibility, with a heightened awareness about the constraints they were facing and prescience about the impact of those constraints on the team.

As discussed above, there were a series of features that seemed to be common to teams demonstrating enabling dynamics and disabling dynamics. In the remainder of this section, I examine these features more closely and illustrate them with evidence from the four focal teams. I then make sense of these patterns in terms of their relationship to team creativity. A matrix of these five factors and their related themes (i.e., codes), analyzed by team, is presented in Table 4.4.

Contextual factors underlying enabling and disabling dynamics

Collaboration. The first differentiator between teams demonstrating enabling and disabling dynamics was the level of collaboration in the team. Teams with enabling dynamics demonstrated high levels of team-oriented collaboration, where members set aside individual or functional differences to pursue shared goals. Given the independent and strong-minded nature of technical staff, along with the individual nature of some rewards in the organization, such a strong team orientation was a powerful indicator of an enabling group dynamic. One member of the Software team described the way in which team members set egos aside for common goals:

> "It seems like it would be obvious, but sometimes I think when you've got a lot of motivated individuals, you create a scenario where you might have somebody where they try to establish an alpha type of role. We didn't have that at all. We naturally slid or fell into our respective roles. We all played very well together" (T5R6).

Another team member expressed the group dynamic similarly, saying, "You just realize we're working on this thing as a team…It's not like we've got these individual goals we're trying to accomplish. We just want to make this a good product" (T5R4). An orientation toward common goals in these teams brought team members together across functional boundaries, even where it was challenging for members. For example, although the Electronics team was dealing with significant differences in perspective cross-functionally, members from the Materials lab and Production lab worked together to overcome their differences and focus on higher-level group goals. A lead engineer in the Production lab described the steps they had taken to overcome this adversity and work together:

> "Well, I mean, I think the interaction (is) pretty good. They complain. They always complain. What would engineers do if they don't complain? [*Laughs*] We

> just have to – I think psychologically, you just have to [focus on team goals] because there is stress and demands from different groups and we need to come together…So you just have to convince yourself and you just do it" (T4R5).

Teams with disabling dynamics, on the other hand, demonstrated a lack of collaboration and a lack of willingness to find common ground, particularly across functional boundaries. These differences in perspective could be quite stark, and teams with disabling dynamics tended to either avoid them or push forward in subgroups focused on their own approaches. This made it difficult for the team to build synergy and leverage the collective expertise in the group. A member of the Coatings team described such a dynamic in their team, saying,

> "This team is kind of a mix. It has some where there's a bunch of people working together to try new ideas and collaborating very well, and then there are also some situations where people (have) already been doing things and they're just continuing with what they were doing. And that's fine, but I find that's harder to tap in and join in on some of those ideas and advance them forward because there's already ownership of the idea by somebody else. It's kinda like, 'This is my turf'" (T1R7).

Internal turf battles of this sort, and the lack of collaboration they often led to, inhibited the team's ability to build energy around a collective pursuit. Some teams rarely met together as an entire group, and when all-team meetings did occur, they were often characterized by acrimony. A leader of the Medical team expressed frustration over these dynamics: "I also have some individuals that show up to some meetings, not to others. They'll agree to meeting notes, and then totally derail meetings. And hopefully, you'll be privy to one of those meetings, 'cause they're very frustrating" (T3R5).

Communication. A second dimension on which teams with enabling and disabling dynamics differed was the quality and frequency of communication within the team. Teams with enabling dynamics demonstrated an environment of open, respectful,

and consistent communication in which members were encouraged to share divergent perspectives. This created an environment in which team members felt comfortable expressing their viewpoints, and felt that those viewpoints were taken seriously by those in positions of authority: "And we're - you know, everything's out in the open so we don't hide anything. We say, okay, here is the stuff we need to deal with and make choices about" (T5R4). For these teams, their open environment and the opportunity to express ideas without fear of repercussion was a matter of great pride that enhanced the team's ability to forge more creative solutions. One member of the Software team described the creative impact of an open environment of communication, saying,

> "And you're gonna add onto it or try to modify ideas and go back and forth. And to have an openness about that helps…and accept other people's critiques. So you know if people are comfortable working with each other, that works pretty smoothly. And people will come up with more ideas if they know they [won't] get shut down" (T5R4).

For the Software team, such communication practices were built into the project methodology, which brought all team members together in the "war room" at 1:00 pm every day to systematically and verbally report out on goals, progress, obstacles, and needs. Said one team member,

> "Everything is okay to put on the board, basically. You write things on post-it notes and stick it up [on the wall] and describe it. Or it could be venting, you know. It's good. But you also put up what worked well and it's a way for team members to compliment other team members. You say, 'Graphic design went really, really well the last two weeks. We really made progress there.' And that was somebody else's work that you're complimenting so that works well too. So that openness you know having fun, making jokes, stuff like that. Letting people throw out all kinds of ideas" (T5R4).

These practices established broader norms of open communication that was a tremendous asset to the team's creative process. Although less systematic, the Electronics team had

also developed norms for open communication, and a comfortable environment in which to do so. One team member described this climate, saying,

> "That's honestly one of the things I like about this project a lot is…we have a very good team as far as being very good at bouncing ideas off of each other, and we all get along well enough where we're comfortable doing that. And you actually want feedback from someone" (T4R3).

In contrast, teams with disabling dynamics struggled with communication, particularly across functional boundaries. Members of subgroups tended to communicate within their own areas, but not frequently or effectively with those from other disciplines. This inhibited the ability of the members of the team to understand and integrate diverse perspectives and ideas. For example, in the Coatings team, which was built from two previously separate subteams, leaders were having difficulty fostering communication beyond the original silos. One team member said, "One of the main objectives, early on, was to get better communication. And so one of the big reasons for this team was to say we can't be working in silos here" (T1R7). The team continued to struggle with establishing open communication between the groups, as noted by one of the team leaders:

> "The other one is just developing the team dynamics, you know, and how we communicate and do we communicate well enough, which we don't, by the way. But that's one of the types of things that will drive me nuts. I mean, we aren't doing bad; we just aren't really up to speed yet" (T1R2).

In addition, teams with disabling dynamics did not have norms or formalized practices for regular communication. Oftentimes, communication was limited to regular business meetings where the main purpose was reporting on individual or small group results, rather than fostering group ideation processes. A leader from the Coatings team described the struggle with facilitating communication in the team, meeting only once a week:

> "Yeah, we don't really do the work that's – it's almost sort of like a reporting of the results. And I'd rather have a meeting where it's kind of a working meeting, but I don't think people are comfortable yet. I mean, they say what they've done, you know. [But] I'd almost rather have a working meeting where you're – I haven't figured out how to get this yet, by the way. And I'm not saying have a meeting every day. What I'm saying is I think to improve the communication and things like that it would help the team to have more organization" (T1R2).

Beyond cross-functional communication difficulties and few norms or practices supporting regular communication, teams with disabling dynamics demonstrated unhealthy communication dynamics in general, where certain vocal members tended to dominate or derail conversations. For example, the Medical team recounted how one team member, experiencing great stress from the constraints of the project, lashed out at other members during meetings. These dynamics created for frustrating team environments in which members found it difficult to make forward progress.

Task structure. Teams with enabling and disabling dynamics also differed on how the project work was organized and managed. Teams with enabling dynamics exhibited clarity and structure around the goals of the project, but also considerable freedom and flexibility in their approach to it. This process freedom allowed team members to be creative in their strategies to address these difficult problems. One member of the Software team described how, despite working towards very clearly defined product outcomes, this freedom was creatively empowering for him and his colleagues: "There's still a lot of leeway for us to get our job done. I think we have been empowered to be creative and solve a lot of our own problems" (T5R6). A member of the Electronics team expressed a similar experience in his team, saying,

> "I mean, you have the overall goal at the end of making a perfect [product] day in and day out. [But] really, it's basically been put into our hands to do it. There's no one saying, 'You gotta do it this way, or do that.' There are certain goals that they

> want, but they're not necessarily tied down to how you do it. So it's actually – it's pretty flexible pretty much in every dimension as far as that goes" (T4R3).

Empowered to enact their work as they knew best, team members were more engaged in their work and took greater ownership of the team's results. Unsurprisingly, intrinsic motivation for the project seemed particularly high on these teams. A leader on the Electronics team talked about how deliberate this management approach was for him, restricting his own involvement in others' work to give them needed flexibility:

> "You can't interfere with the process of how people get there. It can get incredibly frustrating, because you can see how people – how somebody is just driving himself or herself into a corner. You can see it absolutely clear that it's a dead end, because of your experience or just because you're outside. [But] you can't interfere with that. Sometimes you have to let a person hit the wall, bounce back. And then if he needs help, provide that help, but only if he asks for it" (T4R5).

Teams with disabling dynamics, on the other hand, tended to lack clarity around the direction of the project and felt less empowered in their work. For example, although the overall product goals of the Coatings project were quite clearly defined, the subgroups in the team had somewhat contradictory approaches to those goals. This created confusion in the team as leaders struggled to integrate the formerly separate teams and establish a broad team structure to the project. Although the Coatings and Medical teams still retained a fair amount of freedom in their approach, given the lack of broader clarity this freedom was experienced as debilitating by some. In the Medical team, for example, leaders struggled to find the right balance of structure and freedom:

> "If you set [a goal] too close, that's micromanaging. If you set it way too far, it's not gonna work because then there is no leadership…I mean, you have to get enough room for people to start creating things. And it can't happen over a day. And I mean, it's a perception thing. Some people will say, 'He is micromanaging me.' Or other people might say, 'Well, no. I have enough freedom to do whatever I need to do, and he is just there asking questions and trying to help.' It's a complicated thing" (T3R3).

In the Coatings team, on the other hand, the extreme time constraints had created additional pressures that restricted the flexibility team members had in their approach. Without adequate time to play with new ideas, team members felt like they were mired in routine rather than creativity.

Leadership. Teams were also affected by the leadership dynamics of the team. All four teams could be considered to have shared leadership structures, managed by more than one central leader. Formal leadership was exercised by assigned project leaders, who were tasked with administering the group's progress toward project goals, and informally by technical leaders, who had founded or were otherwise responsible for the core technological invention. How those leaders managed their projects was, unsurprisingly, closely related to the dynamic of the team. In the teams demonstrating enabling dynamics, there was good clarity around the specific roles and responsibilities of each leader, and authority was enacted accordingly and respected by the team. For example, while the Software team had two leaders responsible for the technical aspects of the project and a third responsible for administration, these individuals led together as a collective unit, respecting each others' roles and boundaries. They also collaborated closely in building a strategic direction and defining organizing practices and routines for the team. This provided valuable clarity and structure for the team, as described by a member of the Software team:

> "One thing I'll say is that having a strong leader helps a lot. By strong I don't mean imposing, but somebody very skilled at organizing. It doesn't mean bossing them around, but providing structure and expectations and things like that. Because I think that makes the team more functional. It helps free them up to be more creative. So they're not gonna go down these wormholes and get lost and stuff. So there are some specific things that [members] know they need to accomplish and that they are expected to accomplish" (T5R4).

In an environment of considerable constraint and of strong personalities and diverse perspectives, enabling leadership also means insulating members of the team from outside distractions and interference. Another member of the Software team described how leaders intervened with one member to maintain a productive group dynamic and the team's ability to focus on their creative work:

> "There was a guy who wanted his fingers in every single little – in everybody's work – and I mean, that could be dangerous because it can slow [the team] down. And that…was recognized by team leadership, and like, 'Okay, cease and desist. Layoff, okay? Let the other people do their thing and focus on yours'" (T5R3).

Although granting process freedom to team members was crucial, as mentioned earlier, leaders of teams with enabling dynamics also kept a close eye on progress and held members accountable to results. A member of the Electronics team described how the team was held accountable to leaders both inside and outside of the team: "The nice thing is, I mean, it's not just like one random person here. I mean, we get held accountable by [the division] and other people that we work with as well" (T4R3). Team members respected the authority of these leaders as a result.

Teams with disabling dynamics, on the other hand, struggled for various reasons to establish patterns of authority in the team, which hindered the ability of leaders to bring the team together around project goals. For example, the Medical team, a small team in which the technical leader/product owner was not the project leader, struggled to find clarity around the direction pushed by the product owner and that of the project lead. This was due to the different orientations and priorities of the different functions to which these leaders belonged. While the project leader was under strong pressure from the division to finalize the product and take it to market, the technical leader and staff were

vying for more time to perfect the technical solution. One team member explained how the project leader was finding it difficult to manage these competing priorities amidst pressure from her superiors:

> "That comes from managers and her and [the division], and she gets stressed out about it. But yeah, she feels all that and she expresses it in our meeting. I think she gets irritated with us sometimes. We may come up with an idea and she's thinking it's a good idea, but there's no way that we can develop that nugget of the project in time for the launch date. But I think she's pulled in the deadline direction a little stronger than we are" (T3R3).

The Coatings project team leaders also struggled to establish and exercise authority in their team, built from two previously separate subteams. One leader described her frustrations with maintaining accountability for results in the group in an environment in which she lacked ultimate authority:

> "You know, if you say you're going to do this or somebody asks you to do it and it really is legitimate, it needs to be – somebody needs to follow through and make sure that it's done. And the issue with a team leader in my sense is we can't go out and say, 'You've got to do this.' You want it done and you need it done, but you don't have all of the authority you need to be able to make sure that it gets done. But I (still) have the responsibility. You know what I mean? (T1R6).

This difficulty was exacerbated by a strong-minded technical leader and other technical staff who had slightly different priorities for the technical solution, and less urgency around hitting management's very aggressive deadline. The other team leader expressed similar frustrations with building leadership credibility and authority alongside the technical lead:

> "He developed the foundations for the technology. So he has credibility because of his technical capability and what he's discovered, okay? And then there's a leader, like myself, where I'm trying to organize things…It's more – I don't think I have authority. That's one of my issues, actually. [*Laughs*] I just want to know when we go into meetings and we assign the action items that they're going to be carried through. I don't see any repercussions for people if people just blow it off" (T1R2).

Such dynamics made it difficult for these leaders to unify their teams around a shared vision and to facilitate the type of progress they sought.

Social environment. Finally, teams with enabling and disabling dynamics varied in the social environment amongst team members. Most notably, these teams evoked a different sense of connection to, comfort with, and enjoyment of each other; that is to say that the energy among teams on enabling and disabling pathways "felt" qualitatively different – such that it felt like something intangible or special was happening in the enabling teams. This sense was apparent not only to members of the team itself, but to those outside of the team as well. Members of such teams tended to convey feelings of deep alignment with other team members, and sincere appreciation for each other. This was especially true in the Software team. One member of the Software team described the connection he felt to fellow team members, saying,

> "To have everybody that's that similar in alignment, like I said, [is special]. Being balanced, having the same personality types, the same sense of humor, the same creative type of delineation, is very unique. I don't know if I've ever really seen a team that's really been that aligned before" (T5R6).

This sense of unique connectedness was in part rooted in members' perceptions that they had similar interests, personalities, and approaches to problem-solving: "One thing I've noticed throughout the entire team…is we've all got kind of the same – similar mentality" (T5R3). The Software team also exuded playfulness in their interactions with each other, which contributed to the creativity of the group. Said one member of the team,

> "We all played very well together, and I think fun, actually, was a contributing factor. We all had a lot of fun. There were opportunities to blow off steam and talk about things like music, reminiscing about whatever was on TV last Sunday or whatever was that made us chuckle. So I think fun is a big component. I think

> if you're not enjoying what you're doing, the likelihood of you being creative is going to be significantly less" (T5R6).

Team leaders went to great lengths to nurture and protect this playful dynamic. For example, describing some of the Software team's norms for chronicling successes and impediments in post-it notes on the wall, which often include inside jokes, one leader said: "It's like, I love it, [even though] it kinda hurts productivity. *[Laughter]* And that's, again, you know, one of the things that I told both [the other leaders], is for me team dynamics is huge" (T5R1). Leaders even went as far as to mandate fun group outings to bring members together in social settings outside of the workplace and celebrate successes, show appreciation for members' efforts, and just relax together: "There were periodic 'demands' that we actually go out and have lunch. [The leader] would say, 'You know what? You guys go out and have lunch. Somebody use your corporate card – it's on [me]'" (T5R6). One team member described the impact of this team dynamic on how the group responded to constraint:

> "This team worked really, really well. I mean, it's always been – I wanna say laid back, friendly, I guess. I've been on teams before even here where, I mean, it's – gosh, where the team was not respondent to that kind of pressure with the same approach, but I guess this team has always worked really well, really comfortable to work in" (T5R3).

Teams with disabling dynamics lacked the kind of interpersonal closeness and connectedness demonstrated by teams with enabling dynamics. As described earlier, some teams conveyed dynamics of disconnection, as evidenced by interpersonal frustration, conflict, and distrust. More often, however, teams with disabling dynamics simply put limited effort or focus on the relational dynamics of the team. In such teams, task-orientation superseded any relationship building. Accordingly, these teams missed opportunities to build a relational rapport, and work often felt solitary. Members rarely

interacted outside of regular meetings where results where accounted for. One member of the Coatings team described the task-oriented nature of the team dynamic, saying

> "Overall, I think people – there's a – a pleasant interaction socially when we meet but I also think then after the pleasantries, everybody just gets focused and has your meeting, so I think people are pretty focused in and trying to use their time wisely but I mean, socially, I – I think – I would say there's a good rapport among people when I see 'em, but I also think we don't spend too much time with that, it's just really very professional, in terms of the focus and the goals" (T1R7).

The feeling in observing these teams was that they lacked a sense of unity and alignment possessed by the other teams. In other words, they lacked the "groupiness" or cohesiveness of teams with enabling dynamics. They also lacked the sense of playfulness distinctive of these teams. This heavy seriousness and reclusiveness seemed to shape the energy of the group dynamic. One of the Coatings team leaders described this as a lack of inspiration:

> "I haven't seen – I think that's what bothers me, I haven't seen…anything inspiring yet out of this team. And I have been on teams where I've seen inspiration. When I was working on [another project], we were inspired. There was tension; we knew we had to get it done. But we were having a ton of fun. And I don't feel that yet [on this project]" (T1R2).

The role of enabling and disabling dynamics in team creativity

As described above, there were distinct patterns of social dynamics in the four focal teams that could be classified as enabling dynamics and disabling dynamics. Among the four teams, two were seen as demonstrating enabling dynamics and two demonstrating disabling dynamics. While all four of these teams were facing salient constraints in their projects, the data suggest that these social dynamics put teams on trajectories that shaped the way they interpreted the constraints they faced, which in turn affected the impact these constraints had on team creativity. Disabling dynamics were characterized by poor collaboration, communication, structure, and interpersonal

connection, while enabling dynamics were characterized by clarity, curiosity, openness, equity, partnership, and playfulness. A main conclusion from these data is that teams experiencing enabling group dynamics felt more empowered, purposeful, intrinsically motivated, and creative. They also felt more comfortable with the constraints they were facing, even relatively aggressive constraints.

How do these social dynamics affect the way teams interpret and respond to constraints? By limiting the set of possible process or product alternatives available, constraints introduce tension to the creative process. This tension is representative of a paradox for creative teams: On one hand, they don't like to feel limited or have freedoms taken away, but on the other hand, they need the boundaries these limitations provide because they structure the team creative process. Teams in the enabling environments described earlier seemed to demonstrate a heightened collective awareness and understanding of the positive and negative aspects of constraint. That is, they were accepting of the paradox of constraint; they understood that they needed both freedom and constraint to be successful. Take, for example, the following comment from a member of the Software team, describing the creative implications of the constraints the team was facing around common user interface "metaphors" (norms):

> "Well, in some ways it inhibits the creativity, because you're kind of constrained by preexisting metaphors. But I think it also helps us, especially when we're targeting an end user who doesn't necessarily operate in the same domain that we do as developers. It also helps us to see outside of our domain, which I think is beneficial; get a bird's eye view of what the rest of the landscape looks like, if you will…You may have an epiphany, or you may be disgruntled because you don't want to implement something that looks like a designer's. So yeah, it can definitely help, but also hinder" (T5R6).

This kind of mindful understanding and acceptance of paradox enabled the team to better manage and leverage the constraints they faced. This capacity was bolstered by

the sense of psychological safety and empowerment that was fostered by an enabling social dynamic in the team. In this enabling state, constraint was perceived as not an obstacle, but an opportunity. It was something that could be potentially helpful, rather than certainly harmful. Rather than killing intrinsic motivation, it provided a creative challenge that stimulated the inherent motivation of technical staff to solve unsolved problems. And it empowered them to do so by setting boundaries that clarified goals and established a platform around which the team could coalesce. Teams experiencing enabling dynamics demonstrated an enhanced sense of playfulness, not just in the team dynamic but in their approach to challenging problems. These teams projected the aura of a group playing a game. The game (product and technology development) had clear rules and boundaries (constraints) and was very serious in its high stakes, but was attractive in its challenges (significant innovation that drove considerable business revenue) and rewards (scientific achievement, status and recognition), and enjoyable in the process of playing it. In such a "game," freedom and constraint were not perceived as oppositional forces, but as vital dualities of the creative process. As a result, these teams were not only willing to accept the constraints they faced, but they actively imposed constraints on themselves because they found them to enhance their creativity. In other words, they found freedom in constraint.

This does not mean that teams experiencing enabling dynamics were always creative, however, or that teams with disabling dynamics were not or could not be creative. For example, although the Coatings team struggled with difficult team dynamics at the time of the study, and was experiencing somewhat of a creative drought, the team had made creative breakthroughs in the past. In general, the four teams demonstrated a

capacity for creativity. This was not particularly surprising given that Gigantech is known as an innovation exemplar. Leaders hire technical staff in part for their creativity skills, and the broader organizational culture is centered around innovation, with creativity-relevant practices and structures in place accordingly. Given my findings about the crucial impact of team social dynamics on team creativity, however, it is presumable that enabling or disabling team contexts would matter even more in other organizations (which may not have organizational cultures as facilitative of creativity). These findings therefore further underscore the importance of team-level factors in team creativity.

In addition, although the enabling and disabling dynamics in the four focal teams seemed stable over the short course of this study, they appear to be quite malleable over the broader project lifecycle. Many of the teams studied reported changes in the team dynamic over time. For example, members of the Software team described a series of challenging situations and disabling dynamics in an earlier stage of the project, revolving around certain members on the team at that time. This suggests that enabling and disabling dynamics are flexible states that can be changed for better or worse over time, and underscores the impact of these dynamics on team creativity.

Furthermore, the identification of these two basic patterns of social dynamics across the four teams studied is not intended to suggest that the dynamics of teams deemed to be demonstrating enabling dynamics were *all* enabling (positive), or that the dynamics of teams demonstrating disabling dynamics were *all* disabling (negative/ neutral). As mentioned earlier, all four teams demonstrated a capacity for creativity, and certainly all exist within a broader organizational context that was supportive and facilitative of creativity. Indeed, even though these patterns of social dynamics "hung

together" in the teams, there were exceptions. One example is that, as shown in Table 4.4, the Electronics team was experiencing some strong differences of opinion and even some conflict related to those differences. Alone, these could be considered disabling dynamics. However, team members described those divergent viewpoints as "healthy tensions," and the team came together regularly to work through their differences. Members described the team as better off creatively as a result of these discussions, and therefore the way in which team conflict and differences of opinion – which are inevitable, of course – were processed, were enabling. Therefore, the intent of the enabling dynamics and disabling dynamics distinction is not to suggest that some teams were "good" and others "bad," but that there were fundamental and enduring patterns of social dynamics in these groups that were facilitative and inhibitive of team creativity, respectively.[5]

The role of constraint severity

Earlier, I discussed the impact of constraint type on team creativity, with a key conclusion being that process constraints hold more potential to inhibit creativity while product constraints hold more potential to enhance creativity. Similarly, the perceived severity of the constraint seems to make an important difference in the way teams interpret and respond to the constraint. The analyses revealed that while a medium level of constraints were perceived to be helpful to team creativity, constraints that were

[5] Although these patterns seemed to endure over the course of this study, this study was just a snapshot of the life of these teams, and it is possible that teams can slip from enabling to disabling dynamics more easily than these findings suggest. In the Discussion, I discuss how future research may investigate this further.

In addition, although my analyses suggested that these patterns of collaboration, communication, task structure, leadership, and social environment "hung together" as distinctly enabling and disabling dynamics, an alternative way of thinking about these patterns is that these dynamics, or the factors thereof, are continuous rather than categorical variables (i.e., that these are independent dimensions on which teams can vary). In the Discussion, I consider how future research may test and expand these assumptions.

perceived as too heavy or aggressive were harmful to team creativity. This was true for process and product constraints alike. For example, although the Software team found motivation in the time constraints it was facing, one member described how too much time pressure can disable the team: "If there's too much time pressure, of course, then people aren't - they probably aren't gonna end up doing a good job on anything…creative or otherwise" (T5R4). He goes on to describe how the software development methodology the team was using was designed to ensure the constraints are kept to manageable levels: "And again, the 'Agile' process helps with regard to that, 'cause you're figuring out what is likely to get done in the next period of time and what's gonna be impossible to do" (T5R4). A member of the Electronics team described the negative impact of aggressive product constraints as well:

> "You can't constrain someone so much to send them down the path of enlightenment or – you can't say, 'Invent a light bulb,' and stand over their shoulder and make them do this. There needs to be a certain amount of freedom. Yeah. I don't know….You need the right environment where you're not too constrained. But some amount can be good. I mean, if there's no constraint then nothing ever gets done because no one ever has to make anything" (T4R3).

On the other hand, the data revealed that a lack of constraint can also be harmful. For example, a member of the Coatings team described how creative teams struggle without constraints:

> "I think if you have such broad, you know, possibilities it's harder to – I don't know, you can flounder for a while, 'cause eventually you've got to figure it out: what is it that I'm going for? And if you don't know that or if you can't get a team together – and here's another good example, is if you are given a broad purview, you know, say, 'Oh you can work on anything as long as it's flat plastic,' which is what my boss told me my second day of work here. *[Laughter]* How do you like that? Right out of grad school! That's too broad, you know" (T1R1).

These data suggest that there is a "sweet spot" in which constraints hold the potential to enhance team creativity, and that both an overabundance and a scarcity of

constraints are debilitating. These findings support prior research at the individual level suggesting a curvilinear effect of time constraint on creativity (e.g., Hennessey & Amabile, 2010; Amabile et al., 2002; Baer & Oldham, 2006; Ohly, Sonnentag, & Pluntke, 2006). Of course, finding the right balance can be difficult. A member of the Electronics team described the challenge of determining the right "amount" of constraint from a management perspective:

> "When leadership puts constraints in place, the leadership has to be certain that [they're] not putting [a] constraint that's gonna prevent the right solution. And it's always a risky business. The higher you go, there are fewer and fewer people around who would be capable of putting those constraints and not risking the whole project" (T4R5).

With respect to the present research question ("When do constraints affect team creativity?"), my data suggest that the team dynamic (whether enabling or disabling) plays an important role in shaping the team's interpretation of the severity of the constraint. Therefore, an enabling team dynamic may mitigate the potentially damaging impact of severe constraints. For example, the Software team was facing very aggressive time limitations. As was discussed earlier, process constraints were found to be more likely than product constraints to have a negative impact on team creativity. However, not only did the aggressive time constraint not seem to negatively affect the Software team, but it actually seemed to have a positive impact on the team as they were able to leverage it as a motivating creative challenge. This would have been unlikely in a disabling team context.

In this section, I examined how team social dynamics and constraint severity influence the impact of constraints on team creativity, answering the question "When do constraints affect team creativity?" In the next section, I explore the social-psychological

mechanisms underlying these different pathways, answering the question "*How* do constraints affect team creativity?"

How do constraints affect team creativity?

In recent years, researchers have begun to show greater interest in how constraints affect creativity. Earlier theory and research largely took for granted the assumptions that external constraints inhibit creativity by reducing intrinsic motivation. However, although recent work has taken important steps forward to demonstrate the potential for constraint to positively impact creativity, it has largely left unexplored the question of *how* exactly this happens[6]. In this section, I examine the social-psychological mechanisms through which constraints inhibit and enhance team creativity.

To investigate the question of how constraints affect team creativity, I coded the interview transcripts using the NVivo 8 software for team behavioral and psychological responses to constraints. This was done using the line-by-line open coding approach described earlier (Miles & Huberman, 1984), conducted at the same time the interviews were coded for other emergent and meaningful themes. This open coding yielded a number of team responses to constraint – 51 in total. The next steps were to return to the data to distill these codes into more fundamental categories, grouped by related social psychological mechanisms. I continued this iterative process, cycling between the data and theory, until I arrived at a set of seven discrete mechanisms. Eight of the original 51 open codes were discarded in this process because they did not emerge as central themes or because they didn't align with the fundamental pathways revealed by the emergent analyses. The remaining 43 open codes, however, were thematically grouped into the

[6] With the exception of Baer & Oldham (2006), who suggest activation theory as a theoretical mechanism to explain why moderate time pressure can positively influence individual creativity.

seven key mechanisms, which were deemed to be conceptually distinct social psychological processes through which constraints affect team creativity. For example, the open codes "stress," "paralysis," "distraction," "inhibition," and "limited communication" were all related to constraints de-motivating the team, and so these were grouped under the mechanism category "Paralyzing." It became evident through this process that some of these processes were distinctly creativity-inhibiting mechanisms, while others were distinctly creativity-enhancing mechanisms. They were therefore grouped as such, as seen in Table 4.5.

These analyses revealed seven social-psychologically distinct pathways through which constraints affect team creativity. Constraints were found to inhibit creativity by (a) paralyzing, (b) restricting possibilities, and (c) promoting the status-quo. Constraints were found to enhance creativity by (a) focusing and simplifying, (b) stimulating action, (c) structuring and framing, and (d) provoking new approaches. I unpack each of these team-level processes and illustrate them with examples from the four focal teams below. Representative quotes for each mechanism category can be seen in Table 4.6.

Creativity-Inhibiting Mechanisms

Paralyzing. As discussed earlier, Amabile's (1988; 1996) componential model of creativity (i.e., the intrinsic motivation perspective) suggests that external constraints (or "extrinsic constraints") hinder creativity, with the theorized mechanism being that constraint inhibits intrinsic motivation, thereby having a detrimental effect on creativity. The category of process constraints, uncovered by the present study, captures the type of external constraints highlighted by Amabile. Extending Amabile's perspective to the team level, my analyses revealed that constraints can indeed kill creativity by

demotivating creative teams, especially in the face of process constraints such as limitations of time and resources, and when those constraints are perceived as severe. Respondents described several examples of difficult process constraints paralyzing the team from action, and therefore, creativity. For example, one member of the Medical team described how the time constraints imposed by management were paralyzing the team from action:

> "Management…[is] always coming up with new deadlines and very aggressive deadlines, which on the one hand I understand, because you need – everybody needs a deadline to get things accomplished, but sometimes these deadlines and the expectations are so unrealistic that it makes everyone more stressed out than they should be. [We] should just be focusing on the work and not have to worry about, ugh, management's gonna kill this if we don't do this by this date" (T3R3).

Another member of the team expressed a similar impact:

> "What I've seen just recently is that it has totally paralyzed [the team's] ability to get things done. And that's bad – that's really bad. …And the response is, 'Okay, then I'm just going to do nothing.' And that's a really big risk for this project" (T3R5).

These demotivational processes may also have a contagion effect, beginning with certain individuals on the team and spreading to affect the group process. A member of the Software team described how a rigid time constraint had come to paralyze the group at any earlier stage of the project: "…Some people, they just, it just drives them nuts. They can't do it. They vibrate and, you know, it's just…it becomes debilitating. They focus so much on the fact that they only have so much time and they can't do it" (T5R8). These data suggest that aggressive process constraints can hinder team creativity by inhibiting the intrinsic motivation of team members.

Restricting possibilities. A second way in which constraints can inhibit team creativity is by restricting the set of alternatives available to the team. Constraints are by

definition limitations, and when these limitations are stringent, they can obstruct the emergence or pursuit of potential creative ideas and solutions. As a result, teams may have to settle for less novel approaches than they would prefer or than would be ideal. One member of the Medical team described how strong market and business constraints can lead to the development of less creative products:

> "The second scenario is that in the presence of that kind of constraint, a market or business constraint, you say, yeah, let me go try it in the lab, and I'll say, 'Oh, but, how much do you think this would be really worth?' And then say, 'Okay, well, which business of [Gigantech] can even do something like that? Let's say, well, transparent, let's see, watch case. Oh, you know, what do I know about [the] watch case market? What do I know about – you know, I know there's a lot of watches being made, right? Do we have anybody at Gigantech in the business units that could know something about it? Well, not really.' And I'm, obviously, giving you an example [of] something that may be going on in your brain of convincing you why you shouldn't be doing that experiment - and instead, you should be doing an experiment that [leads to]…a more mainstream, expected type of thing" (T3R1).

Here, the constraint of needing to produce something that could be sold by the company restricted the team's ability to develop something more groundbreaking. Respondents talked about how these kinds of considerations could lead to self-limiting cognition that leads the team toward less novel solutions:

> "You kind of catch yourself in this sort of continuous loop of self-analyzing potential impacts. You say, okay, I may be able to do this, and then, you know, immediate thought – no, you could say in the absence of any kind of market constraints you would say, oh, yeah, let me try doing it in the lab. I want to try this experiment. I don't care how it's gonna turn out. I'm gonna see if I can do it and see if it seems like a decent idea, why don't they try it?" (T3R1).

This psychological process may unfold in response to process constraints as well, such as time limitations. As a member of the Software team described how time constraints at an earlier stage of the project forced the group into a suboptimal solution – a solution that has in turn continued to constrain the group to this day:

> "In the beginning there wasn't a ton of time for us to sit around thinking, ideating over what might be the best approach for certain things. So time has definitely, I would argue, created a lot of technical debt for us in the beginning, because we cut a lot of corners and did certain suboptimal things to make sure that we had our product ready… Nobody was really happy with it, but it had to be done" (T5R4).

These examples illustrate how constraints can force creative teams to make unattractive creative compromises to the detriment of a broader or more novel range of solutions.

Promoting the status-quo. Finally, constraints can inhibit team creativity by promoting status quo solutions. Although the technical staff at Gigantech were highly motivated to push the boundaries of the state-of-the-art, time is an important factor in any product and technology development environment, and it shapes decisions creative teams must make about where and how to allocate their efforts. Where time and other process constraints are heavy, teams are likely to fall back on tried-and-true approaches and solutions that have worked effectively in the past. This can lead to status quo outcomes that are less novel than otherwise possible. One member of the Coatings team described how aggressive time constraints, such as those her team was facing, can lead to simpler and easier solutions that may be less creative:

> "Well, you tend to not have this outside-the-boxing thinking, you – you tend to do either what someone else has tried or what's already easiest to do, because there's a method there. You can't take the difficult path because you don't have time – you know what I mean, it's like if somebody's doing something this way, you'll just go ahead and do it, because to think of a different way to do it that might, in the long run, work better is gonna take more time and I don't think you allow yourself that freedom because they're wanting results tomorrow or the next week you're presenting a group meeting, you know, so it definitely just makes – I think it makes you choose a simpler path, which might not be the most creative path" (T1R7).

Similarly, a member of the Software team described how the strict time constraints his team faced earlier in the project led to a more prescriptive, status-quo technical solution:

> "The biggest impact that ten-week duration had on our creative ability, if you will, was that we ended up dropping features from the application that we just didn't have time to implement. And that's pretty typical in the software development world, where, in that case, the schedule ruled. And, you know, in the software world, we think of a triangle of time, resources, and functionality. And you can always move, you know, two of those legs of the triangle, but one of them has to be pretty constant, and we kept the "time" leg of the triangle constant at the cost of functionality" (T5R2).

In other words, creative teams must rely on the tools they have readily available to them when they don't have the process freedom they desire, and these may be more routine solutions.

Creativity-Enhancing Mechanisms

Focusing and simplifying. There are also several ways in which constraints were revealed to enhance team creativity. The first is by focusing and simplifying the problem that needs to be solved. Creative teams need and like to have ample process freedom in their work. However, too much freedom and ambiguity, particularly around the desired product outcome, can be paralyzing to creative teams because it leaves them without a clear goal around which to organize. In other words, it can be difficult for teams to be creative if they are uncertain about what it is they are trying to create together. This would be true at the individual level as well, but is amplified at the team level where the need for coordination and convergence is essential to success. Product constraints help structure the path to creative solutions by limiting the problem space and turning ill-defined problems into well-defined problems (Stokes, 2006). Respondents suggested that the presence of constraint helps to narrow creative teams' collective attention to clearer problems, and thereby directing the creative process around clearer, shared goals. This enhanced goal clarity allows the team to focus on the *creative* process rather than on the problem identification process. One member of the Medical team described how product

constraints aided the team's creative process by more clearly defining the creative challenge:

> "The thing that I think helps creativity [the most] is identifying a well defined problem. You understand that we've got a very complex process from raw materials to the end. So each step along the way – if we could find well defined descriptions of everything that we wanted in each step – that would make it very easy, because then we could focus all our efforts on being creative in solving that particular problem rather than suggesting solutions that we think might solve our perceived image of the problem" (T3R6).

Therefore, directing their efforts toward a better specified problem helped the focus their creative efforts in the areas of greatest opportunity. A member of the Coatings team also discussed the creative benefits of a constrained target, emphasizing how product constraints help to increase the potential for a useful *and* novel solution:

> "Well, I think it's a lot easier to innovate as to do something useful and apply it if you know what the heck you're trying to get to. You know, having a clear goal [of] things that you have to achieve is a good thing. It doesn't mean those things are easy to achieve. And sometimes those things are not compatible with each other, you know. So in the past, a lot of work used to be done and say, 'Oh, I can think of doing this new chemistry, and then let's go find a home for it.' And I've not seen that be successful in terms of translating some sort of new thing into a product. I mean, you get a lot of patents and generate technology, but its application is less than sure" (T1R5).

Although product constraints may limit the scope of the problem space, creatively speaking, sometimes the simpler solution is the more elegant solution.

Stimulating action. Constraints can also enhance team creativity by stimulating creative action. As discussed earlier, creativity is often enhanced when there are challenges to overcome (Amabile et al., 1996; Shalley & Gilson, 2004). My data revealed that constraints stimulate creativity in teams by posing such challenges, providing a spark that mobilizes the team around creative goals. Without constraint, status quo approaches and solutions may be perceived as acceptable and there is less incentive to take action.

Solutions generated may also be less creative as a result. Constraint may indicate that the status quo is no longer acceptable, motivating teams to find new ways of doing things, thus enhancing creativity. George and Zhou's (2007) mood-as-information theory suggests a similar process: negative moods provide information that current efforts are insufficient, leading to lower confidence in the progress being made, motivating creators to exert more effort to come up with creative ideas. Respondents from all four of the teams described times in which constraints ignited a creative spark in the team. A technical leader of the Coatings team described how this process played out in his team, in response to some very challenging product requirement constraints:

> "And in a way sometimes you would say that's a negative factor, 'Oh, this is a constraint, this is bad,' but turn it around and you get people excited about your coating, people see the usefulness of the coating, and people will work with you and embrace this constraint and say, 'Look, we can overcome this constraint'…You see, you can use this way to challenge your coworkers to develop the most desired technology. So this is what we're seeing, yeah, because people need to be challenged sometimes…You [say], 'Look, this is a problem, [let's] solve it.' There is a constraint, but in the meantime you provoke people to develop this desire…You see, here [at Gigantech] people need to be challenged…they are self-driven people, they want to show their abilities and they want to prove [themselves]" (T1R1).

A member of the Coatings team echoed this sentiment, noting that it is a pervasive drive of technical staff at Gigantech:

> "Yeah, I mean I think people have generally responded to the challenge in a positive manner to say, 'Let's go, let's take it on,' I mean, that's pretty typical of I think the Gigantech culture: people who work here, most of us tend to like a challenge *[Laughter]"* (T1R7).

There is a great sense of pride for technical staff in being able to solve difficult problems, as well as to leave a lasting legacy through their product development work (at the organization and especially in the consumer market). Teams are therefore drawn in and motivated by an alluring challenge or seemingly unsolvable puzzle. This pattern also held

true for some teams in response to process constraints, such as time limitations, as noted by a member of the Electronics team:

> "I think a lot of times, especially [in] engineering, and especially [in] the research lab, where [often] you have a lot of time, you can sit there and kind of stare at it for a while and not [act]…And I think having a, 'We need it at this point,' kinda thing is actually really beneficial because it makes you do something rather than just think about it or talk about it" (T4R3).

Therefore, although process constraints such as time and resource limitations tend to have a negative impact on team creativity overall, in the right environment they can be powerful motivators for creativity.

Structuring and framing. A third way in which constraints can enhance team creativity is by providing a common framework from which or within which to build. As limitations, product constraints help to clarify the boundaries around the expected product outcomes. By doing so, they help to establish a common set of expectations about the domain in which the team is working and assumptions about what would be considered "creative" or innovative in that particular space. This provides a scaffolding around which the team is better able to create something together collectively. By bounding the space for the creative endeavor, it also helps teams reference and leverage past experience and expertise in that domain. This helps to structure the team creative process in a way that makes the production of novel and useful solutions more probable. For example, a member of the Medical team described the creative security and helpful structure fostered by product constraints:

> "I think it actually enhances because I've found that within boundaries – for an average creative person, if you have defined boundaries, you know what's expected, what you have to absolutely do – creativity actually blossoms. I liken it to the study that was done on a school playground, where they removed the fence because they felt it was just so inhumane to fence in these children. And what they found was that instead of using the entire playground, as the kids had done

> before, they all huddled in the middle because they didn't know where the boundaries were. So, having – and the FDA boundaries are really related to safety of the product, you know, it goes into a body – so you want to make sure you don't kill anybody. [*Laughter*] And within those boundaries, yes, it does make it a little more difficult at times to hit all the properties you want because you can't just put anything in that. For example, in glasses, there are a couple things that do really nice things to glass properties, but they're not exactly biologically friendly, so we can't put those in. But within that framework of needing to achieve certain things, everything else, you know, you can explore the entire space. And, you know, having something that already is set for you lets you play with other stuff" (T3R5).

She goes on to describe how these constraints contribute to a sense of security for creative teams, as well as more useful creative team outcomes:

> "I think the boundaries give you security. There is [often] a lot of insecurity – there are a lot of things that are always changing…and it affects the confidence with which you go about doing something, I think. If you know where the limit is, you're much more likely to very confidently execute an experiment and put it into context. Whereas if you don't know where the boundaries are, you can run awesome experiments, and in the end, it's perfectly useless. Yes, it's cool, but it doesn't tell us anything, and it's not useful. And in the end, it won't make it into a product that makes money, and we're here to make products that make money" (T3R5).

Provoking new approaches. Finally, constraints can enhance team creativity by providing an opportunity and an excuse for doing things differently. Organizations striving for innovation must manage a delicate tension between the need for predictability, control, and reliability, and the need for creativity and dynamism (George, 2008). Often, even in highly innovative organizations (and especially larger organizations), the drive for predictability, control, and reliability takes precedence. My analyses suggest that constraints provide both an opportunity and an excuse for creative teams to search for novelty and break free from the status quo. More specifically, constraints may preclude traditional solutions to problems, requiring creative teams to explore alternative perspectives and approaches. This helps unlock teams' current ways

of thinking or doing, requiring them to be more creative out of necessity. For example, facing an extremely aggressive 6-month timeline, the Coatings team needed to take an unconventional approach to accomplishing their goals. The deadline provided them with the excuse to do things differently. As one leader described,

> "It empowered us to move things faster. For example, I think in the kickoff meeting the term 'this is not business as usual' was said six or seven times by the lead management. And so I looked for some help from the information staff doing this literature and patent search, I said the same thing. This was said seven times, 'not business as usual.' You know, 'You've got to clear your plate and get this search going for us, because [the CEO] wants this figured out in six months.' And, you know, they sure did" (T1R6).

At the same time, the obstacles that can be presented by some constraints can stimulate creativity because the team is motivated to find a way around them:

> "So you kind of have, you know, those constraints [where] your management says no. [*Laughs*] There's more than a few examples where somebody says no, and it motivates somebody so much that they figure it out, because they're like, 'This guy doesn't really – he's just making a snap judgment. He doesn't really know,' you know. You want to show him up. It's almost like trash talking before a game, you know, this person says, 'Oh that's not gonna happen,' and you're like, 'I'll show you'" [*Laughs*] (T1R6).

Just as teams may become more flexible in order to find pathways around constraints, the presence of constraints may provide an excuse for the surrounding *organization* to become more flexible in order to clear the obstacles. Members of the Software team described how their unusually tight timeframe at an earlier stage of the project enabled them to creatively circumvent institutional bureaucracies that would have otherwise slowed down the product development process. This enabled them to break free of the traditional approach to Software development to find a creative new solution:

> "We didn't go through and do a lot of scientific theory, and a lot of experiments, and a lot of reviews. We just kind of pounded forward as fast as we could, so we didn't have the phase gates and all the other stuff that comes with the Six Sigma process. We definitely circumvented that. I think we just kind of asked for

> forgiveness instead of permission on that one. We had people outside of our group running interference for us….Just kind of keeping it off to the side and saying, 'Yep, they're working on it, and you'll find out what's going on when the time comes,' kind of concept…The fact that we were able to circumvent some of the traditional processes within [Gigantech], I think helped us to kind of stay less adhesive to some of the traditional mindset, or rules, and go take a different approach. I definitely think breaking the mold a little bit is a good thing, sometimes" (T5R6).

The role of inhibiting and enhancing mechanisms in team creativity

These results reveal seven distinct social psychological processes underlying the ways in which constraints can inhibit and enhance team creativity. On one hand, constraints can inhibit creativity by (a) paralyzing, (b) restricting possibilities, and (c) promoting the status-quo. On the other hand, constraints can enhance creativity by (a) focusing and simplifying, (b) stimulating action, (c) structuring and framing, and (d) provoking new approaches. Some of these mechanisms are reflective of different team responses to the same constraints. As demonstrated in prior analyses, how constraints affect team creativity depends on the type and severity of the constraint, and on the team dynamics. These factors shape teams' perceptions of constraint and, therefore, their response to it. The four focal teams provided examples of how the same types of constraints can lead to enhancing mechanisms or inhibiting mechanisms in the team. For example, where a process constraint such as time limitations is particularly severe, is interpreted negatively, or is faced by a team with disabling team dynamics, it is likely to inhibit team creativity by demotivating and paralyzing the team. Conversely, in an enabling environment, teams may perceive the time constraint as a creative challenge, igniting a motivational flame that inspires the team to action and sparks their creativity. Similarly, product constraints such as business need constraints could either limit the team to suboptimal or status-quo solutions, or provide them with a helpful shared

platform from which they can be creative, depending on the team dynamic and interpretation of the constraint. These mechanisms therefore illustrate the importance of the type and severity of the constraint and the team dynamic in influencing how constraints will affect team creativity.

CHAPTER 5

DISCUSSION

The purpose of this dissertation was to understand the role that constraints play in the creative processes of work teams. Conducting inductive field research with ongoing new product and technology development teams in a large corporation, I set out to develop a typology of constraints affecting creative teams in organizations, and to build grounded theory about constraint and creativity by engaging the broad research questions "When do constraints affect team creativity?" and "How do constraints affect team creativity?"

This research uncovered a variety of salient constraints that played a role in the creative processes of new product and technology development teams, including limitations of time, product requirements, equipment, customer and market needs, business needs, intellectual property, human resources, and money. These constraints can be placed into two main categories: Process constraints and Product constraints. Process constraints include limitations of time, equipment, human resources, and money, all of which limit the realm of possible approaches to the project (i.e., they constrain the project *means*). Product constraints include limitations from product requirements, customer and market needs, business needs, and intellectual property, all of which limit the realm of possible solutions to the project (i.e., they constrain the project *ends*). Analyses revealed both process constraints and product constraints to be normal and often expected constraints on the creative process. Both process and product constraints were observed

to have negative connotations as well as positive connotations, and both have the potential to negatively or positively affect team creativity. Overall, however, process constraints were more likely to inhibit creativity, while product constraints were more likely to enhance creativity. This is in part due to the different nature of process and product constraints. By limiting the set of possible approaches that can be taken by the team, and thereby the team's freedom to enact the creative process as they wish, process constraints tend to reduce team empowerment and intrinsic motivation. This has a deadening effect on team creativity. Product constraints, on the other hand, limit the set of possible solutions to the problem. These constraints tend to benefit team creativity by focusing the group around clearer goals and providing a common structure for the team creative process.

Under different circumstances, constraints also affect team creativity differently. Research question 1 asked "When do constraints affect team creativity?" Cross-case analysis revealed that group dynamics impact how team members interpret constraints, and these interpretations play a crucial role in how the constraints impact team creativity. Two key patterns of team dynamics emerged across the four teams that were related to constraint inhibiting or enhancing team creativity. These can be characterized as enabling dynamics and disabling dynamics. These were malleable but temporally stable social dynamics in the teams, related to collaboration, communication, task structure, leadership, and the social environment. Disabling team dynamics were indicated by poor collaboration, communication, structure, and interpersonal connection in the team. In contrast, enabling dynamics were indicated by clarity, curiosity, openness, equity, partnership, and playfulness in the team. These dynamics shape the perspective lens

through which teams interpret constraint. Teams experiencing disabling dynamics, struggling to come together as a team amidst their disparate perspectives, tended to perceive constraint as *obstacles* to their creativity. Therefore, these teams demonstrated greater resistance to constraints. In contrast, teams experiencing enabling dynamics, in which members showed unity, collaboration, and openness to alternative perspectives, tended to perceive constraint as *opportunities* for creativity. These teams demonstrated a greater collective acceptance and even embrace of constraints, even when those constraints were more severe. Such psychologically safe, structured, empowering, and purposeful environments allow teams to feel comfortable playing with ideas (including alternate ideas), and provide them with the freedom to do so. Teams experiencing enabling dynamics also actively imposed constraints on themselves because they found them to enhance their creativity. The dynamics of the team therefore play a central role in shaping whether teams respond to constraints in ways that will inhibit or enhance their creativity.

Research question 2 asked "How do constraints affect team creativity?" The aim of this question was to understand the mechanisms through which constraints inhibit or enhance team creativity. The data revealed a series of distinct social psychological processes underlying inhibiting and enhancing pathways. Specifically, constraints inhibit creativity by de-motivating or paralyzing the team, forcing suboptimal solutions by restricting the range of possibilities, and causing teams to fall back on tried-and-true approaches and status-quo solutions. On the other hand, constraints enhance creativity by simplifying the problem and focusing the team's creative efforts, providing a stimulus that motivates creative action, setting boundaries that provide a framework or structure

from which to create, and providing an opportunity and an excuse to approach a problem in novel ways. These mechanisms illustrate how the same types of constraints can affect team creativity quite differently depending on team dynamics and the severity of the constraint (e.g., minimal, moderate, or severe limitation).

A visualization of these findings, and their relationships to each other, appears in Figure 5.1. This figure pictures team context and dynamics as a lens through which teams interpret the constraints they face, which subsequently affects whether and how those constraints inhibit or enhance team creativity. This visualization is intended to be a general roadmap to the key conclusions of this study, rather than a comprehensive model of constraint and creativity.

In sum, the findings from this dissertation suggest that while constraints can disable team creativity, with the right kind of constraints in the right environment (and the right mindset), creative teams can benefit considerably from constraints. How teams perceive the constraints they face plays a vital role in whether those constraints will help or harm their creativity. Indeed, this research demonstrates that not only are highly creative teams able to successfully manage a variety of constraints, but that they accept their role and even actively invite them into the creative process, seeing constraint as opportunity rather than obstacle.

The paradox of constraint

Contraints introduce tension to the creative process by limiting the set of possible process or product pathways available to creative teams. This tension is representative of a paradox for team creativity: a tension of freedom and constraint. On one hand, creative teams don't like to feel limited or have freedoms taken away. On the other hand, those

limitations can provide helpful boundaries to both provoke and structure the collective creative process. The creativity literature is rife with paradoxical findings (George, 2008), and some scholars have even suggested that creativity is reliant upon tension (Csikszentmihalyi, 1997). This dissertation extends creativity theory by bringing these tensions to the surface and examining when and how they are productive or destructive for creativity. The findings of this research suggest that the teams for which constraints enhanced their creativity were aware and accepting of the paradox of constraint. They understood that they needed both freedom and constraint to be successful, and often they embraced the constraint, bringing it into the team process and making it endogenous. These results are consistent with research on other types of tensions and paradoxes in organizational life. Cameron and Quinn (1988) note that "too often actors impose an either/or choice to treat tensions as dilemmas that could more fruitfully be approached from a both/and perspective" (Smith & Lewis, 2011: 387). However, when actors can embrace the tensions and immerse themselves in the seemingly opposing forces, it puts them on a virtuous trajectory that enables them to see them instead as interdependent dualities – opposites that exist within a unified whole (Smith & Berg, 1987; Smith & Lewis, 2011).

The dominant theories of creativity are predicated on the idea that constraint is the opposite of freedom, and that freedom is essential to creativity while constraint kills it (e.g., Amabile, 1988; 1996). My dissertation challenges the assumption underlying this dominant theoretical perspective (that constraints reduce intrinsic motivation, and therefore reduce creativity) by demonstrating that for teams able to accept and even embrace constraints, constraints actually *stimulate* intrinsic motivation. In an

environment of enabling team dynamics, it becomes a sort of game for creative teams, providing the opportunity to play with ideas that may lead to breakthrough innovations, bounded by the safety of the rules and boundaries of the game (constraints) and the psychological safety of an empowering context (process freedom). In this dynamic, freedom and constraint are not oppositional but rather interdependent parts of a system. Constraints set the boundaries for freedom, and freedom helps to extend the boundaries. There is therefore freedom *in* constraint. Great creative potential exists in the tension of this equilibrium, and successful creative teams find ways to use this tensile energy to their advantage. Those who don't will not only fail to benefit from the constraint, but will likely suffer from it.

As revealed in this research, maintaining this equilibrium can be challenging, and when constraint trumps freedom or freedom trumps constraint, creativity will suffer. Of course, constraint is not always helpful; far from it, in fact. This research suggests that the type of constraint (process constraint vs. product constraint) and severity of the constraint (e.g., minimal, moderate, or severe limitation) are vital to the impact that constraint will have on team creativity. In particular, constraints that diminish process freedom (i.e., process constraints) or that are too restrictive will harm creativity. Conversely, an absence of constraint can also lead to reduced creativity due to debilitating freedom.

While the findings of this study call into question the *conclusion* of the "intrinsic motivation hypothesis" that constraints kill creativity (Amabile, 1988; 1996), they actually provide strong support for the core underlying assumption that intrinsic motivation is vital to creativity. As revealed here, most creative professionals in organizations are motivated toward challenging, "unsolvable" problems. Such intrinsic

motivation toward difficult creative problems was found to be a crucial aspect of teams' capacity to respond to constraint constructively. In other words, intrinsic motivation may be a precondition to teams benefitting creatively from constraint, and as shown earlier, it can also be stimulated by constraint.

Contributions of this research

This research makes several contributions to scholarship on creativity in organizations. First, although scholars have theorized about the role constraints play in creativity, suggesting that constraints have a mostly negative impact on creativity (e.g., Amabile, 1988; 1996), only a limited amount of research has actually examined these questions directly. Of the extant research on the topic, results have been mixed and inconsistent, resulting in calls for further investigation into some of the assumptions underlying dominant theories of creativity (George, 2008; Shalley et al., 2004; Zhou & Shalley, 2003). I answer those calls by offering a constraints-oriented perspective on creativity in teams; one that assumes that constraint is a central, expected, and unavoidable part of the creative process. By explicitly examining when and how constraints affect team creativity, both negatively and positively, I contribute a theoretical lens that helps make sense of the seemingly contradictory research findings on the impact of constraint on creativity. This research extends current creativity theory by suggesting that the impact constraints have on creativity depends on the type of constraint, the severity of the constraint, and the social environment in which the constraint is embedded. While some previous research has suggested that environmental factors can moderate the impact of constraints on creativity, these investigations have focused on organizational-level factors such as a supportive environment for creativity in the

organization (Baer & Oldham, 2006; Gilson et al., 2005). The present study contributes to this literature by suggesting that the social environment of the team impacts team creativity over and above the impact of the broader organizational context. This finding highlights the vital importance of group processes and dynamics in shaping how teams interpret constraints, and whether those constraints will inhibit or enhance team creativity.

Relatedly, the present study makes a valuable contribution to creativity research by uncovering the role of perception in how constraints affect creativity. Specifically, I found that how a team interprets the constraints they are facing plays a crucial role in whether those constraints will inhibit or enhance team creativity. Although researchers have begun to examine the impact of various constraints on creativity, prior studies have not explored whether or how subjective perceptions of constraint affect these relationships. The finding that interpretations of constraint shape how constraints affect team creativity is likely relevant to individual-level creativity research as well. It also brings into alignment the contradictory findings on the impact of constraints on creativity, suggesting that it is not simply about the type of level of constraint, but also how teams or individuals perceive those constraints. Therefore, future research should continue to examine and account for creators' subjective perceptions of constraint in addition to the more "objective" attributes of constraints. Although not explicitly about constraint interpretation, Amabile and colleagues (2002) take a step in this direction, suggesting that how time constraints make creators feel (e.g., that they are "on a mission" vs. "on a treadmill") impacts whether that time pressure will help or hurt their creativity. Prior scholarship has illustrated how shared properties of a group or collective emerge

from members' shared perceptions, affect, and responses where interdependence is high (Drazin et al., 1999; Kozlowski & Klein, 2000; Morgeson & Hofmann, 1999; Sandelands & Stablein, 1987; Weick & Roberts, 1993). Future longitudinal research could examine the specific processes by which teams' shared interpretations of constraint emerge, and the effects of divergent intra-team interpretations of constraint.

Third, my dissertation research contributes to the creativity literature by investigating the relationships of a broad array of constraints to creativity, and by considering them simultaneously. To date, most research on the impact of constraint on creativity has focused exclusively on time constraints (e.g., Amabile et al., 1996; Amabile et al., 2002; Baer & Oldham, 2006; Hennessey & Amabile, 2010; Ohly et al., 2006), with some additional work on resource constraints (Amabile & Gryskiewicz, 1987; Csikszentmihalyi, 1997; Shalley & Gilson, 2004) and standardized routines and processes (Gilson et al., 2005; Mumford et al., 1997; Soriano de Alencar & Bruno-Faria, 1997; Sutton & Hargadon, 1996). By studying the similarities and differences across multiple different types of constraints, I was able to develop a typology of product and technology development constraints that brings higher order structure and understanding to the questions of when and how constraints affect team creativity. These categories of constraints are likely to be relevant for many types of creative work in organizational settings, even beyond R&D work. The unearthing of the distinction between Process constraints and Product constraints, in particular, helps resolve the apparent paradoxes in the literature to date by demonstrating that process and product constraints act differently and are interpreted differently in ways that impact team creativity for better or worse. In addition, this study is the first to consider a comprehensive set of constraints

simultaneously. Prior studies have focused on the effects of single constraints, rather than examining multiple constraints altogether. The findings of my research suggest that the impact of constraints on team creativity depends on the type, amount, and perceived severity of the constraints. Therefore, it is important for future research to consider the full set of constraints faced by creative teams and individuals and their shared impacts or interactive effects.

By focusing primarily on what I call process constraints (especially on limitations of time and resources), creativity researchers have privileged a particular (mostly negative) view of constraint. My dissertation research expands the definition of "constraint" in ways that are helpful to resolving seemingly contradictory research findings and theoretical perspectives in the field. Amabile's (1988; 1996) original conceptualization of constraints related to creative endeavors were "external constraints," defined as factors introduced by the social environment that are intended to control an individual's engagement in a task. This conceptualization of constraints is grounded in particularly restrictive and directive types of constraints, such as managerial control, externally imposed deadlines, and expected evaluation, over which the individual or team has little or no control. This conceptualization is arguably more closely related to "control" than to "constraint." However, the term "constraint" has come to be applied more broadly in the creativity literature to include other types of constraints, while still retaining the theoretical assumptions from Amabile's original perspective that constraints inhibit creativity. This has created a disconnect in the literature, as the types of constraints described by others as helpful to creativity, such as standardized routines and processes (Gilson et al., 2005; Sutton & Hargadon, 1996), project boundaries (Stokes,

2006), and even some time pressures (Amabile et al., 2002; Baer & Oldham, 2006; Ohly et al., 2006), cannot be captured by this narrow definition. By defining constraint more broadly, as "a state of being restricted, limited, or confined within prescribed bounds," I am able to capture a wider array of constraints for which the limitations they introduce are not necessarily harmful to creativity, and may even be helpful. This more neutral conceptualization allows for a more comprehensive and balanced theory of the role constraints play in the creative processes of teams and individuals, both negative and positive. I argue that this more neutral definition, as evidenced by the results of this study, is a more accurate representation of how creative professionals in organizations see and experience constraint.

Fifth, my dissertation research contributes to the literature on creativity in organizations by explicating the underlying social psychological mechanisms through which constraints affect creativity. While scholars and practitioners alike have alluded to positive benefits of constraint for creativity (e.g., Dadich, 2008; DeRue & Rosso, 2009; Mayer, 2006; Stokes, 2006; Tharp, 2003; Vandenbosch & Gallagher, 2004), and recent research has demonstrated creative benefits of constraint (e.g., Baer & Oldham, 2006; Gilson et al., 2005; Ohly et al., 2006; Sutton & Hargadon, 1996), little research has provided clear insight into the processes underlying these phenomena. Of the limited set of research that does, the underlying mechanisms are often left at the theoretical level. For example, while Baer & Oldham (2006) draw on activation theory (Gardner & Cummings, 1988) to explain how time pressure can stimulate individual creativity, creator activation was not tested for in the study. Much of the creativity literature in general has focused on identifying contextual antecedents related to creative outcomes,

while overlooking the processes underlying these relationships. By examining the group-level processes by which constraints enhance team creativity, I shine a light on the specific social psychological processes through which creative teams leverage constraint to their benefit. In so doing, I bring greater depth to previous research linking constraint to creativity, both at the team level and likely the individual level. I also heed calls to illuminate the "black box" of team creativity (Kurtzberg & Amabile, 2001) and for more process-oriented perspectives on creativity (George, 2008).

The mechanisms underlying the *negative* effects of constraint on creativity have received considerably more theoretical and research attention, although the present study expands and elaborates on these as well. Amabile (1988; 1996) theorized about the processes through which constraints inhibit creativity, suggesting that external constraints reduce intrinsic motivation, which therefore inhibits creativity. This hypothesis has received solid, yet mixed support in empirical research (Shalley et al., 2004; Zhou & Shalley, 2003). One reason for these inconsistent results may be that (a) constraints don't always inhibit intrinsic motivation and/or creativity, and (b) where they do, it may be through other social psychological mechanisms. Indeed, my research revealed that constraints can inhibit creativity through other distinct mechanisms (e.g., by restricting possibilities and promoting the status-quo). And perhaps most importantly, in the right team environment, even external constraints can enhance creativity by actually *increasing* intrinsic motivation. The findings of this study therefore bring additional nuance to what the intrinsic motivation hypothesis of creativity has to say about constraint, which Amabile herself has also revised over time (e.g., Amabile et al., 2002;

Hennessey & Amabile, 2010). These findings also highlight other distinct pathways by which constraint can inhibit and enhance creativity.

Sixth, my research makes an important contribution to the literature by examining the effects of constraint on creativity at the *team* level. With a few exceptions (e.g., Sutton & Hargadon, 1996; Gilson et al., 2005), most research on constraint and creativity has been conducted at the individual level. This is important, because group-level research has tended to take a more positive orientation to constraint than has individual-level research.[7] Group creativity requires convergence as well as divergence (Stasser & Birchmeier, 2003), and therefore it may be that the focusing, structuring, and motivating effects of constraints are even more valuable to teams than to individuals. Others have previously noted how the mechanisms underlying the production of creative outcomes in teams are likely to differ in significant ways from the processes underlying individual creativity (Hargadon & Bechky, 2006; Kurtzberg & Amabile, 2001; Paulus & Nijstad, 2003). The present research therefore takes an important step forward by developing a theory of the role of constraint in team creativity, and by putting the focus squarely on the group contexts, dynamics, and mechanisms underlying these relationships.

The imbalance of research on individual-level creativity has been a pattern in the broader literature on creativity in organizations as well. The vast majority of the extant literature focuses on individual-level creativity and its determinants. However, much of the creative work in organizations takes place in project teams, and at an ever-increasing rate (Kurtzberg, 2005). This discrepancy has left theorists to apply findings from research

[7] Although this is changing as recent research is increasingly demonstrating that constraint can enhance individual creativity (e.g., Amabile et al., 2002; Baer & Oldham, 2006; Ohly et al., 2006).

on individual-level creativity to the team-level, with limited consideration of the unique and complex dynamics of creative activity in teams (see George, 2008). By grounding my research at the team level, I therefore respond to calls for more theory and research devoted to creativity in groups and teams (Amabile, 1996; Gilson & Shalley, 2004; Kurtzberg & Amabile, 2001; Shalley et al., 2004), adding to the small but growing amount of work genuinely focused on group creativity and the distinct processes underlying it (e.g., Gilson et al., 2005; Goncalo & Staw, 2006; Hargadon & Bechky, 2006; Hargadon & Sutton, 1996; Kurtzberg & Amabile, 2001; Long Lingo & O'Mahony, 2010; Paulus & Nijstad, 2003; Sawyer, 2007; Sutton & Hargadon, 1996). And by building emergent theory from the direct study of ongoing creative teams, the findings of this study add depth and breadth to current creativity theory.

Another strength of this study is the inductive field research design, examining team creativity through the study of real creative teams in an organizational setting. Organizational contexts have powerful influences on the behavior that occurs within their boundaries, and yet the organizational context has been surprisingly vacant from creativity theory to date (Drazin et al., 1999; George, 2008; Sutton & Hargadon, 1996). Much of the foundational psychological theory of creativity was developed from the study of exemplarily creative individuals in artistic and scientific settings ("creative geniuses"), as well as a fair amount with children (Amabile, 1988; 1996). Much of the theoretical foundation of the current literature on creativity in organizations has been built from these same theoretical assumptions. Of the research focusing specifically on group or team-level creativity, much has been conducted in laboratory settings with undergraduate students (George, 2008). While this scholarship has made essential

contributions to the field's understanding of creativity, it cannot adequately capture the role the organizational context plays in the creative process. Indeed, the assumptions and expectations surrounding the production of creative products in organizations is often completely different than, for example, the assumptions and expectations surrounding the production of a creative artwork. Creative work in organizations is always accompanied by extrinsic rewards, such as monetary compensation, is necessarily constrained by the expectations and priorities of multiple stakeholders in a time-sensitive and competitive environment, and usually requires cross-functional collaboration. Studying team creativity in a field setting allowed me to account for the strength and uniqueness of the organizational context and to understand and theorize about the constraints that arise from these contexts and their impact on creativity. This brings external validity to the theoretical perspective that emerged from this study.

In addition, by taking an inductive and process-oriented approach to my research, I was able to collect richly descriptive data that allowed me to build a deeper understanding of the role constraint plays in team creativity. Although survey and laboratory research provide greater opportunities to examine causal relationships, we continue to know very little about the actual behaviors and processes in teams that contribute to creative team outcomes (George, 2008). This is especially true in terms of what role constraint plays in the creative process. Therefore, an inductive strategy, ideal for building theory where little exists (Singleton & Straits, 1999), allowed me not only to investigate a broad set of constraints in-depth, but it also allowed me to look "under the hood" to understand the team processes and dynamics related to how teams responded to them. All of these were revealed to be crucial to when and how constraints affect team

creativity. This research therefore builds on a tradition of scholarship focused on building emergent theory about the distinct and dynamic processes underlying group creativity (e.g., Hargadon & Bechky, 2006; Hargadon & Sutton, 1996; Sutton & Hargadon, 1997).

Finally, I contribute to the field by highlighting the importance of usefulness to the generation of creative solutions. Creativity is defined in the literature as the production of ideas or solutions that are both novel and useful (Amabile, 1988; 1996). Despite the bipartite nature of creativity by definition, creativity scholars have historically privileged novelty in their theorizing, downplaying or paying less attention to the role of usefulness. The mechanisms revealed in the present research underscore the importance of the usefulness component as well as the novelty component of creativity, suggesting that both play vital and essential roles in creative outcomes. While solution usefulness is, by definition, important to creativity in any setting, it makes sense that it is even more vital to creativity in organizations, in which creative activity is also often strategic business activity. The findings uncovered in this study suggest that constraint-triggered mechanisms which inhibit creativity (i.e., by demotivating, restricting possibilities, and promoting the status-quo) do so primarily by reducing solution novelty. This may be why prior theorists have so privileged the inhibiting aspect of constraint; because they have put the greatest emphasis on the novelty of solutions. On the other hand, constraint-triggered mechanisms which enhance creativity are split between those related to utility (focusing and simplifying; structuring and framing) and novelty (motivating creative action; provoking new approaches). The essential novelty/utility duality should be made more explicit in creativity theory and research, and future

research may examine further whether organizational contexts and other contexts (e.g., artistic creativity) differ in their demands for each of these priorities.

Implications for practice

The insights gained from this research have important implications for the management of team creative work, and perhaps individual creative work in organizations as well. Creative teams face a multitude of constraints that can impact the way they organize and execute their work, while being called upon by their organizations to develop innovative products, services, and technologies that will drive long-term viability. This topic is particularly timely in light of the highly constrained current economic conditions, in which organizations must find ways to do more with fewer resources and in less time. If creative teams and their leaders can identify strategies to more effectively manage constraint, they will be in a position to develop more creative products and solutions. So how can the tensions inherent to constraint be managed, or even leveraged, in ways that help teams to realize their creative potential? First, it is important to strike an appropriate balance between freedom and constraint. As was discussed earlier, finding the right balance can be very tricky, and can change depending on the nature of the product and the types of constraint the team is facing. Generally speaking, the findings of this study suggest that creative teams should have enough constraint to structure the work, motivate them to action, and to provide a common scaffolding from which the team can create together. At the same time, they must also have the flexibility and autonomy to run free within those boundaries, or to expand or break away from them when needed.

Where constraints are self-selected, choosing the right kinds and the right levels of constraint is also very important. Product constraints can provide the common

framework teams need to be creative together, while Process constraints should be monitored and limited to ensure that teams have sufficient time, space, and resources to enact their creative process in the ways they best know how. In addition, while moderate levels of constraint can provide a spark and focus that benefit creative teams, constraints that are too severe or that feel too burdensome too the team are likely to quickly derail and de-motivate, and lead to hasty or status-quo solutions. Conversely, this study also revealed that too much freedom can at times be as detrimental as too much constraint.

In any circumstance, the organizational context and team context are vital to the trajectory that constraint will take in creative teams. Gigantech is an exemplar of an organizational culture that explicitly encourages and rewards innovation, and organizational structures and practices that facilitate innovative thinking and cross-boundary collaboration are carefully maintained. Even still, this research revealed that the four individual project teams that were the focus of the study varied considerably in terms of team norms and dynamics, and that these dynamics were related to the team's creative capacity in response to constraint. This important finding suggests that managers should not overlook the importance of establishing and promoting enabling dynamics and practices at the *team* level in addition to the organizational level. Team leaders' and members' approaches to organizing and enacting the team project can vary considerably. Therefore, an organizational context facilitative of creativity and innovation is a necessary but not sufficient condition for team creativity. Managers must also provide team leaders and members with expectations and training for group processes that promote goal clarity, collaboration, open communication, and interpersonal connection.

This research also reveals the importance of teams' interpretations of constraint to how those constraints are likely to impact team creativity. The teams in this study that demonstrated the greatest creative capacity in response to constraints also were those in which members and leaders were most comfortable with constraint, saw it as a normal and even a helpful part of the creative process, and were prescient about the pros and cons of constraint while being comfortable with the paradoxes therein. This suggests that team creativity benefits greatly from members' active awareness of the types of constraints they are likely to face in the project, and knowledge about how these constraints can both enhance and inhibit creativity. Managers would benefit by educating technical staff about constraints, building awareness of anticipated constraints and setting the expectation that they are normative. By making constraints explicit and building anticipation and acceptance of them (rather than defensiveness), teams will be better prepared for constraints and more capable of leveraging them to their creative benefit. Managers can nurture the development of paradoxical thinking among the technical staff (Smith & Lewis, 2011), for example, by helping them recognize the tension between freedom and constraint while understanding that both are necessary and even desirable for creativity.

Finally, where managers impose constraints on creative teams, it is important that those constraints be perceived as authentic. This research suggests that if team members believe that a constraint is being used as a strategic tool, or that the constraint is artificial, they will ignore it or respond negatively to it. This was the case, for example, in the Coatings team, where the aggressive six month timeframe was not perceived as a genuine constraint. Some mentioned that they felt it was being used by higher ups as a

motivational tool to inspire collective action. As a result, team members largely ignored the six month timeframe, assuming that it would not be possible to achieve the goal in that amount of time and that it didn't really matter (i.e., there would be no real consequences) if they did not. That being said, this research does show that teams and team leaders strategically self-imposed constraints in a way that enhanced team creativity. This suggests that constraints can be applied to projects strategically, but that they are most effective when the team is engaged in their selection.

Limitations

Along with the benefits and contributions of this research also come several limitations. First, there are limitations related to the inductive methodology employed in this research. An inductive research method was chosen because of the exploratory nature of my research questions and the lack of extant theory and research on the topic. This method provided for richly descriptive data, grounded in the experiences of creative teams engaged in real ongoing projects in an organizational setting, which were ideal for understanding and theorizing about the complex realities and paradoxes inherent to constraint and creativity. However, while such data reveal vital relationships among variables such as constraint type, constraint severity, team dynamics, and team response to constraint, they do not provide grounds for strong assumptions about causality. Laboratory research to test and extend the theoretical ideas and relationships developed here would therefore be beneficial.

Second, although this study was designed to understand the group processes related to team interpretation and response to constraint, the data collection effort unfolded over the course of three months, and therefore captures only a portion (sometimes only a small fraction) of the lifecycle of the projects studied. As a result,

these data cannot provide thorough historical accounts of how the projects and team dynamics unfolded throughout the course of the project. As discussed earlier, respondents from some teams described changes in team dynamics over time that seemed related to the team's capacity for creativity in the face of constraint, or the team's interpretations of those constraints. Therefore, it remains unclear by what specific processes enabling and disabling team dynamics emerge, and the role of project history and interpersonal history in the development of those dynamics. Longitudinal research designs would better address questions such as how these dynamics may develop over time, what role the project stage plays in these matters and the team's responses to constraints, how individual differences play out in the team creative process, and how teams and team members come to be more or less adept at entertaining and maintaining paradoxical ideas about constraint. Such methods would also help clarify the degree and frequency with which teams slip in and out of enabling and disabling dynamics over time, providing a deeper understanding of the nature of these dynamics, how they unfold or change over time, and what impact that has on creativity and interpretation of constraint.

Third, this study is limited by the fact that the core data were self-reported interview data. These data were essential to the goals of this study to capture "thick and rich" accounts of dynamic team creative processes. However, these data are of course inherently colored by the perceptions and experiences of the respondents themselves. Although it was easier for me as a researcher to be able to observe team dynamics and norms in the formal meetings I attended and through the informal interactions I observed and experienced, it was more difficult to observe moments of creative epiphany, which may happen anywhere and in any combination of team members. Therefore, I needed to

rely on team members' accounts and evaluations of creative processes and creative outcomes. It is possible that when team members described *feeling* creative, they were not necessarily producing more creative outcomes. The strong within-team agreements on these matters, including team member interpretations, and the corroborating observational data bolstering them, provide confidence in the conclusions drawn herein. And importantly, the goals of this study and method were to understand the underlying circumstances and team processes related to creativity-enhancing and creativity-inhibiting constraints which had not been investigated previously. Still, future research testing these ideas would benefit from collecting more objective measures of variables like creative outputs and other team outcomes, and the team behaviors related to them.

Next, the conclusions drawn from this research are also contextualized to, and therefore colored by, the organizational context in which they are situated. As discussed earlier, Gigantech is known to be an exemplary creative organization, which established many norms and practices around innovation over many decades. The technical staff who comprise the product and technology development teams studied also bring unique and high levels of training and expertise to their field. All of these factors may shape the organizational narrative about constraint and its relationship to creativity, which may have been evoked by respondents. This study is therefore limited by the special context in which this research was conducted, giving some caution to readily or fully extending the findings of this research to other organizational settings. Still, exemplary cases like that of Gigantech are very useful for developing grounded theory about specific and complex phenomena, particularly where the researcher seeks to bring a fresh perspective to extant theory, as in the case of this study (Eisenhardt, 1989). In addition, the methodological

rigor of the study was bolstered by the variation among the four teams studied, and the cross-comparison of these multiple cases (Eisenhardt, 1991). Still, additional insights could be brought to bear on these research questions by examining them across many organizational contexts, with different types of creative teams and creative professionals, and through other research methodologies.

Finally, this study suffers from limitations inherent to the study of group-level processes and phenomena in an organizational setting. While groups in a laboratory setting can be more clearly defined, the boundaries and membership of groups in organizations can be much more permeable. As a result, it can make the definition of a team and an understanding of its activities difficult. This is certainly the case in new product and technology development teams at Gigantech, where technical staff assist and collaborate with a broad array of colleagues, and may participate occasionally in projects for which they have no formal role or responsibility. In terms of the present study, this raises the question of how much of the creativity of these teams happens inside or outside of the team, which of course has bearing on an understanding of how team interpretations of constraint affect team creativity. Longitudinal research, in the field or otherwise, could provide a better understanding of where and when creativity happens in teams, and how this may inform theory about team creativity.

Future research directions

The present research on constraints and creativity yields several exciting directions for future research. First, as suggested earlier, while this study sought to build a typology of constraints for creative work in organizations and to explore the underlying circumstances and mechanisms through which constraints affect team creativity, quantitative research methods such as laboratory and survey research would be beneficial

to test the theoretical conclusions developed herein. Such methods would not only allow for testing and validating the findings of this study, but would also provide greater understanding of the causal directionality of these relationships and how contextual and behavioral variables affect them. For example, although the relationship between enabling team dynamics and team creativity in the face of constraint is clear, it remains uncertain whether these enabling dynamics precede creativity or whether effective team creativity yields more enabling dynamics. It can be assumed that this is likely a reciprocal cycle of relationships, but longitudinal research would offer better evidence.

Also mentioned earlier, the field would benefit from cross-organization research testing and examining the findings of this study. It may be that the relationships found here would not extend fully to other organizational settings, perhaps where practices and expectations for innovation are less prominent. Gigantech has built its organizational identity around innovation, and has deliberately nurtured an organizational culture encouraging of cross-boundary collaboration and ground-breaking fundamental product and technology development that drives organic growth. While team dynamics were shown to be crucial to the ways in which teams interpreted and responded to constraints at Gigantech, enabling team dynamics are likely even more important in other types of organizations, which may have fewer institutionalized practices in place to facilitate innovation and the cross-pollination of ideas. In addition, although the core constraints explicated in this study are likely to be common to a wide variety of situations involving creative activity in organizational settings, there may be other variables unforeseen by this study related to organizational context or constraint type that play an essential role in team creativity under constraint. As suggested by the slightly different conclusions

derived from this research and that of prior research on artistic creativity outside of organizational settings (e.g., Amabile, 1988), it may also be that constraint affects team creativity differently depending on the type of creative work the team is doing. Much of the expected creative work in organizations is centered in research and development, however employees can be creative in a vast array of jobs and of course in organizations that aren't as explicitly oriented to innovation as is Gigantech. Cross-organizational research should therefore help to uncover such factors and expand the framework developed here.

Relatedly, although it is assumed that many of the constraints identified in this study would be salient constraints in other creative work contexts as well, it remains unclear to what degree these constraints are specific to this particular organizational context. There may be different constraints, unaccounted for by this research, that are salient to creative teams in other creative settings, and these may operate differently than the constraints uncovered by this study. Cross-organizational research would help clarify the degree to which the constraints identified herein, and their impact on team creativity, applies more broadly to other creative contexts.

Future research should also consider other contextual factors at the team-level that may play a role in when and how constraints affect team creativity. Although the present study benefitted from a deep dive into the creative processes of four product and technology development teams, there may be other contextual factors not captured by this methodology that impact team creativity in the face of constraint for better or worse. For example, the history of a team and the way in which it was mobilized has been shown to affect team performance later (Ericksen & Dyer, 2004). With respect to the impact of

constraints on team creativity, it is likely the case that team norms established at the initiation of the project become routinized in the group process and influence the team dynamic. As demonstrated in this study, this can have important implications for how teams respond to constraints. In addition, product and technology development teams are comprised of members with previously existing relationships. Many of these teams were self-initiated at the early stages, where technical staff sought the collaboration and expertise of trusted colleagues, while other teams were formally organized by leaders. The quality of these existing relationships, and the extent to which team members knew each other prior to the project, may affect the team's processes, effectiveness, and response to constraint (DeRue & Rosso, 2009). Therefore, future studies should examine the role that the history of the team and member relationships has in how creative teams perceive and respond to constraints, as well as other contextual factors related to the team.

Researchers should also investigate what impact project stage has on team interpretations and responses to constraint. Although the four focal teams varied somewhat along the project lifecycle, all of them were formally organized and funded projects with origins dating back at least a couple of years. None of them were at the earliest stages of formation or ideation (e.g., in the skunkworks stage), where visibility and pressures are much lower and freedom much greater. While the results of this study did not reveal notable differences by project stage, I cannot adequately account for what impact project stage may have on when and how constraints affect team creativity, and whether teams at very early or very late stages of the project experience different types of constraints that impact team creativity differently. Scholars have called for research that

considers the role of project stage on creativity (e.g., DeRue & Rosso, 2009). Indeed, some respondents of this study suggested that constraints impact team creativity differently at different stages of the project. Among the handful of comments respondents made about this issue, the consensus seemed to be that in general, constraints are more beneficial to team creativity at earlier stages of the project. For example, one member of the Coatings team said,

> "There's a point – there's like, you know, several stages of creativity, right? And the innovation part – the implementation of a great idea – I think is when you need the constraints removed and the money flowing. But at the creative part, where you're just getting them something that might work, I think constraints help; they motivate people somehow" (T1R6).

It stands to reason that Product constraints are likely to be more beneficial at earlier stages of the project lifecycle, when they can provide needed focus and common structure for the team creative process. Similarly, with the possible exception of time constraints, Process constraints such as limitations of equipment, human resources, and money also seem to have more potential for creative benefits at earlier project stages, when they can simulate creative action and novel approaches, but harmful at later stages when teams need ample resources to execute their work. Although the data of the present study were not able to account for such potential differences, future research should examine these questions through longitudinal designs.

Similarly, the present study is unable to account for potential differences related to the scope of the innovation pursued by the project team. Although the four focal teams varied in terms of how "significant" or groundbreaking the innovations were that they were working towards (e.g., fundamental new chemical properties vs. innovative software development), all were significant enough to be pursued by the organization

according to its benchmarks for financial viability (typically, the potential for tens of millions of dollars in revenue). And while some of the teams were pursuing larger-scale innovations than others, the data collected make it difficult to draw meaningful conclusions about what influence different scales of innovations have on how constraints affect team creativity. However, this is an important question for future research. It is possible that when the scope of the desired innovation is larger, or more groundbreaking, constraints may have a more negative impact on team creativity. One respondent discussed this hypothesis, suggesting that consideration must be given to the scope of the desired innovation:

> "People misuse the term (creativity)…because they apply it to so many different things. There are different levels of creativity. There's technical creativity, then there is the kind of creativity with coming up with totally brand new things…and those are different buckets. Technical innovation is much simpler because you usually have goals in mind. And this is really about how to narrow it, make it more well-defined. [With] innovation on a scale of a solution to a technical problem, I think constraints are needed to move the project forward... [But] as you move the scope [of the innovation] from much more narrow to much broader, the constraints will start to hurt you because…you are not allowing, to some degree, team members to go beyond the constraints… So if you [want to] come up with a completely brand new idea for a society on a level much, much higher...in my opinion, that has to have [more] freedom associated with it" (T4R5).

On the other hand, it may be that larger scale innovations actually benefit more from constraints because they provide inspiration, focus, and a framework for the project and the team creative process. Of course, it may also depend on the type of constraint. The field would benefit from future research exploring these questions.

As was discussed earlier, an important question arising from this study is whether the patterns of team dynamics identified in this research are categorical or continuous variables. Although my analyses suggested that these patterns of collaboration, communication, task structure, leadership, and social environment "hung together"

categorically as distinctly enabling and disabling dynamics, it may be that these are dimensions on which teams can vary independently. If so, this would have implications for theory about constraints and creativity. As an in-depth study of a small sample of teams, this research was necessarily limited in its scope. Future research would therefore be beneficial to test and expand upon these assumptions.

Relatedly, this study suggested that teams seem to demonstrate patterns of either enabling or disabling social dynamics. What is unclear from this research, however, is whether both enabling and disabling dynamics are normative in this setting (or in other creative settings for that matter), or whether what were observed as enabling dynamics in the Electronics and Software teams were actually positively deviant behaviors (Spreitzer & Sonenshein, 2004). If these enabling dynamics are positively deviant behaviors rather than normal team dynamics, then a theoretical perspective on constraint and creativity would need to consider what organizational- team- and individual-level factors contribute to such enabling dynamics in teams.

Future research could also explore what impact individual differences have on how constraints affect team creativity. Although the unit of analysis for this study was the team, and interviews and observations therefore focused specifically on team-level processes and behaviors, creative teams are of course comprised of individuals, and the unique attributes of the individuals on the team may impact how constraints affect team creativity. There are many ways in which individuals on creative teams may differ. In the present study, an important distinction among team members were functional differences; particularly Materials lab vs. Production lab differences and Corporate Research lab vs. Divisional Product Development lab differences. As described throughout the study,

these functional differences, which also carried with them differences in educational background and training, were often underlying team conflict, which affected the ability of teams to leverage constraint to their creative benefit. Since all of the teams in this study were cross-functional, however, it was difficult to analyze the impact of these individual differences on team creativity, beyond the team dynamics aspect discussed earlier. Still, a number of respondents recounted the challenges presented by differences in perspective between the Materials lab scientists and the Production lab engineers. One engineer in the Production lab described how engineers were inclined toward more clear-cut problems while scientists preferred more open-ended inquiry:

> "We are engineers and that's how engineers' brains work. You work the best when you're finding solutions to a specific problem. And scientific brains – I'm sure there is some similarity, but I'd like to think that they more work in the way, 'Okay, well, how could I come up with a new material?' which doesn't necessarily solving a problem…I mean, there is a big gray area" (T4R5).

Although the four focal teams did not offer sufficient variance to analyze these distinctions in terms of their impact on team creativity, it is certainly plausible that the composition of the team, such as the balance between scientists and engineers, might influence how constraints affect team creativity.

There are several other individual differences that could also be examined in future research as well. One of these is domain expertise, which has been frequently linked to creativity (Amabile, 1996). Almost all of the respondents of the four focal teams had high levels of training (usually graduate degrees), and many years of tenure with Gigantech. Therefore, domain expertise was an assumption underlying the findings of this study. However, although there was limited variation in domain expertise among the teams in this study, domain expertise and experience can vary widely among individuals,

and this may make a difference in how constraints affect team creativity, particularly with respect to teams' ability to perceive constraints as potentially helpful. The less domain expertise the members of a team have, it seems the less likely they will be able to put constraints in context and to entertain the paradoxical nature of constraints, as constraints will likely be perceived as obstacles. They will also likely have a harder time finding creative solutions in the face of constraint, because they have less expertise to draw from in the problem domain. One respondent described the value of domain expertise in putting constraints into perspective and continuing to be creative amidst what seem like aggressive time constraints:

> "I think the people that have been in the corporation for a while, so let's say 15 to 20 years, and we've got a lot of new folks that are just getting on board, so the ones that have been here maybe less than a year to maybe two or three, hear that time thing and they're kind of freaking out a little bit about it." (T1R2).

On the other hand, however, too *much* domain expertise may be harmful to creativity if it inhibits teams from seeing new alternatives or approaches (Smith, 1994; 2003). For example, one respondent described how some people just fall back on the solutions they know best, based on their own expertise:

> "It is interesting watching it – people always solve the problem with what they know best. *[Laughs]* Like if I use a chainsaw every day and someone comes to me with a problem, I'm not gonna recommend using anything other than chainsaw. *[Laughs]* (T4R3).

That is why, as described earlier, it seems diversity is so crucial to team creativity; to help filter out the 'noise' of individual members' domain expertise.

Another key individual difference worth future research attention is the inherent creative capacity of individual team members. Much creativity theory and research suggests that individuals can differ widely in their potential for creative performance,

irrespective of context (Amabile, 1996). This was a theme echoed by a number of respondents at Gigantech as well; that some individuals are just simply more creative than others. As a result, leaders go to great lengths to hire people they consider to be inherently creative. For example, one leader of the Software team described his approach to identifying creative people during the hiring process:

> "You can determine that pretty quickly. I usually like to ask them questions about what they like to do outside of work and what I look for are people that are tinkerers, that like to, you know, read, to explore, to, you know…that their whole life is sorta centered around learning new things and exploring new things. I ask them, 'What do you do?' And [if they say], 'Oh, you know, in my spare time I like to build up computers and I do a little programming, a little this,' you know – that's the type of person I want" (T5R8).

Others also noted how the creativity of individual members is of great consequence to the creativity of the team, and that certain people just "have it":

> "I think the right people is definitely [essential]. There's certain people in my group who just always have the best idea. You know what I mean? Like I don't know what it is. But like they – the ideas they have are good and doable. And then there's other people who don't. *[Laughs]* I don't know where I fall yet" (T4R3).

Another respondent, who grew up amidst an oppressive political regime in another country, suggested that the creativity of individuals may be powerful enough to overcome virtually any constraints. He used an example of innovation that occurred among prisoners in concentration camps in his home country:

> "People are literally in concentration camps innovating incredible things, [and] I tend to think that innovation and your desire to come [up] with new things has nothing to do with your freedom. It's a natural desire of a human to entertain himself or herself by coming up new things. It's not necessarily a part of the job. I mean, I can't turn it on, turn it off. It's just the way some people are built. You take those people, you put them in a free society like here, at Gigantech, they were just fine. Take those people and move them to camps, put them into jail, and they just do the same thing. [I'm] exaggerating, of course, I know [it's] not that simple, but I mean, it's one of the most kind of striking examples of how the human brain just needs to have that exercise and wonders of coming up with new things" (T4R3).

This may suggest that teams comprised of more creative people will have a greater likelihood of being creative in any circumstance, including when facing constraints. Although this study did not assess the creativity of individual team members, this is an important question for future research on team creativity.

Another fascinating direction for future research would be investigating whether the mechanisms uncovered in this study that underlie how constraint affects team creativity operate similarly at the individual level as well. One study by Baer and Oldham (2006), drew on activation theory as a theoretical mechanism to explain why moderate time constraints can enhance individual creativity. While that explanation would be consistent with the motivational mechanism uncovered in my research, Baer and Oldham did not test it empirically. Although it has been suggested that individual creativity and team creativity operate similarly (e.g., Amabile, 1996), there remains little research examining this explicitly. And of course, the findings of this study suggest that there are crucial differences to team creativity that cannot be accounted for by theories of individual creativity. I noted earlier that this may be why results from studies of constraint and creativity have been so inconsistent. One important difference is that creativity at the individual level doesn't require the same need for a convergence of ideas and perspectives in the generation of a creative solution. Perhaps then, when it comes to individual creativity, constraint is indeed more likely to inhibit creativity than enhance it. It's clear that more research is needed to compare these processes across the team and individual levels. Research exploring the impact of a more comprehensive variety of constraints on individual creativity (beyond time constraints) would also be helpful in illuminating this question.

Finally, this research illustrates the influence of the perception of a constraint on how that constraint affects team creativity. What is considered a "constraint" is of course a subjective construction. While previous research around the topic of constraint and creativity has used objective measures of constraint, I believe that something can only be considered a constraint if it is perceived as such by those who must face that limitation. However, this may be an empirical question. Future studies can investigate this issue by comparing both objective and subjective measures of constraint, examining whether subjective interpretations of constraint have a stronger relationship to creativity (either positive or negative) than objective measures of constraint.

As a budding area of inquiry in the study of creativity, there are many opportunities for work that clarifies and expands our understanding of how constraints affect creativity. It is my hope that the theoretical insights of this study offer a useful platform upon which future research can expand.

CHAPTER 7

CONCLUSION

The literature to date speaking to the impact of constraints on creativity has traditionally viewed constraints negatively, as unwelcome external conditions that kill creativity. The conventional narrative underlying this perspective is that one needs to relax constraints as much as possible in order to get creativity. To the contrary, this study reveals that for creative teams in organizational settings, there can be freedom in constraint; it's knowing what to do with them when they emerge, finding the right constraints in the right balance, and crafting an environment in which they can be perceived as opportunities rather than obstacles. The well overused cliché about creativity is "thinking outside of the box." While this metaphor assumes an empty box, my dissertation research demonstrates that there are valuable tools right within the box that can be used to bolster team creativity if the creators know where to look to find them.

Figure 5.1. A visualization of findings: when and how constraints affect team creativity

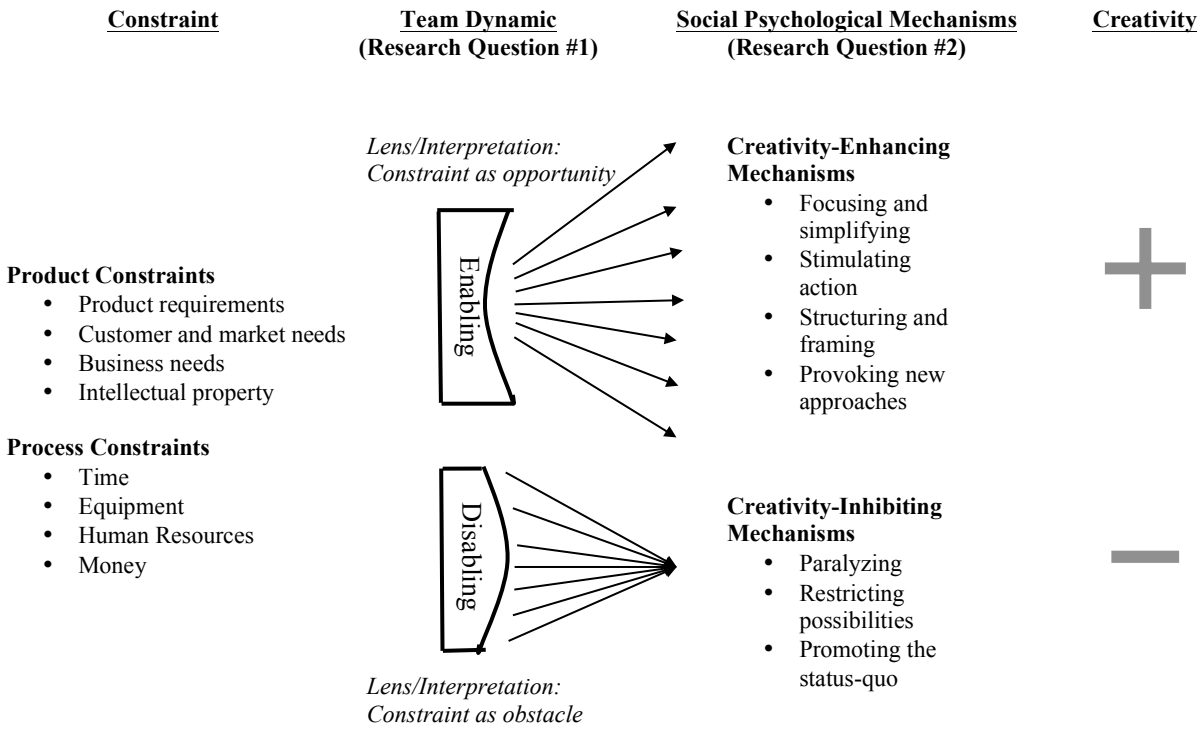

Table 4.1. Team summary

Team	Project purpose	Team size	Number interviewed	Functions represented	Project stage	Scope of innovation
Coatings	New coating with 3 unique properties for many industries	10	8	2	Early-Mid	Large
Medical	New material with unique properties for medical industry	6	6	3	Mid-Late	Medium
Electronics	New electronics technology, produced via new production methods	8	4	3	Mid	Medium
Software	New consumer-interfacing software innovation	8	7	2	Late	Medium

Table 4.2. Constraint categorization hierarchy

Category	Constraint Type	# of Unique Sources (of 25)	Total # of References
Process Constraints			
	Time*	21	30
	Equipment*	9	9
	Human resources*	5	8
	Money*	5	5
	Technology	3	3
	Process legacy	2	2
	Manufacturing capability	1	1
	Organizational structure	1	1
Product Constraints			
	Product requirements*	13	18
	Customer and market needs*	8	10
	Business needs*	7	12
	Intellectual property*	7	8
	Product legacy	3	6
	Regulations	1	1
	Public health	1	1

***** Core (salient) constraint

Table 4.3. Core constraints and levels of agreement by team

Constraint Type	Coatings Team	Medical Team	Electronics Team	Software Team
Process Constraints				
Time	**7/8***	**4/6***	**3/4***	**7/7***
Equipment	**6/8***	2/6	1/4	0/7
Human Resources	0/8	**4/6***	0/4	1/7
Money	0/8	**3/6***	1/4	1/7
Product Constraints				
Product requirements	**7/8***	2/6	**2/4***	2/7
Customer and market needs	2/8	2/6	**2/4***	2/7
Business needs	1/8	**3/6***	1/4	2/7
Intellectual property	**5/8***	1/6	0/4	1/7

***** Core (salient) constraint

Table 4.4. Matrix of team dynamics codes by project team

	Coatings	Medical	Electronics	Software
Collaboration				
Enabling Dynamics				
Collaboration	X			X
Pursuing team goals			X	X
Disabling Dynamics				
Chemicals lab vs. Production lab	X		X	
Difficulty bringing team together	X	X		
Lack of collaboration	X			
Turf issues	X			
Communication				
Enabling Dynamics				
Healthy tensions			X	
Open communication	X			X
Disabling Dynamics				
Limited team interaction	X		X	
Poor communication	X	X		
Task structure				
Enabling Dynamics				
Accountability				X
Flexibility				X
Freedom; autonomy	X			X
Process freedom		X	X	
Disabling Dynamics				
Flexibility lacking		X		
Leadership				
Enabling Dynamics				
Freedom from micromanagement			X	X
Leaders insulate team				X
Managerial support				X
Advocating leadership				X
Disabling Dynamics				
Lack of genuine leadership authority	X			
Social Environment				
Enabling Dynamics				
Cohesiveness			X	X
Humor				X
Playfulness				X
Similarity				X
Trust			X	
Disabling Dynamics				
Overly task focused	X			
Personal problems		X		
Team conflict	X	X	X	

Table 4.5. Creativity-inhibiting and creativity-enhancing mechanisms

	Categories	Open Codes
Creativity-Inhibiting Mechanisms		
	Paralyzing	
		Response – stress
		Response – paralysis
		Response – distraction
		Response – inhibition
		Response – limited communication
	Restricting possibilities	
		Response – less novel solution
		Response – restricted options
		Response – less than optimal solution
		Response – limited exploration
		Response – short-term orientation
	Promoting the status-quo	
		Response – tried & true solutions; path of least resistance
		Response – iterative action; trial and error
		Response – pursue low-risk solution
		Response – settle for less
Creativity-Enhancing Mechanisms		
	Focusing and simplifying	
		Response – focus; prioritize
		Response – directing efforts
		Response – benchmarking
		Response – clarified goal
		Response – forced to simplify; more elegant solution
		Response – focusing on end purpose or user
		Response – meet customer needs
		Response – narrowing; focusing
	Stimulating action	
		Response – motivated action; get out of rut
		Response – reframe constraint as a challenge
		Response – rise to challenge

		Response – assert expertise; prove them wrong
		Response - persistence
	Structuring and framing	
		Response – framing
		Response – boundaries provide security for exploration
		Response – laying a foundation to expand from
		Response – provided a common foundation for the team
		Response – work within limitations
		Response – time to explore
	Provoking new approaches	
		Response – forced to see things differently
		Response – frame-breaking
		Response – open new solutions and pathways
		Response – work around constraint
		Response – keeping low profile; running interference
		Response – bring in outsider perspective
		Response – work around it; alternate solution
		Response – path-clearing
		Response – identify and remove obstacles
		Response – ignore deadline
Miscellaneous Codes		
		Response – collaboration
		Response – identify common goals
		Response – more dynamic as a team
		Response – perspective-taking
		Response – team cohesion
		Response – delegate according to individual differences
		Response – fun; intrinsic motivation
		Response – social networking

Table 4.6. Representative quotes for creativity-inhibiting and creativity-enhancing mechanisms

Mechanism	Representative Quote
Creativity-Inhibiting Mechanisms	
Paralyzing	"What I've seen just recently is that it has totally paralyzed [the team's] ability to get things done. And that's bad – that's really bad…And the response is 'Okay, then I'm just going to do nothing.' And that's a really big risk for this project" (T3R5)
Restricting possibilities	"I'm, obviously, giving you an example [of] something that may be going on in your brain of convincing you why you shouldn't be doing that experiment, and instead you should be doing…a more mainstream, expected type of thing. … You kind of catch yourself in this sort of continuous loop of self-analyzing potential impacts" (T3R1)
Promoting the status-quo	"You tend not to have this outside-the-box thinking. You tend to do either what someone else has tried or what's already easiest to do, because there's a method there. You can't take the difficult path because you don't have time…You choose a simpler path, which might not be the most creative path" (T1R7)
Creativity-Enhancing Mechanisms	
Focusing and simplifying	"It's a lot easier to innovate…if you know what the heck you're trying to get to. You know, having a clear goal [of] things that you have to achieve is a good thing" (T1R5)
Stimulating action	"A lot of times, especially [in] engineering, and especially [in] the research lab, where you have a lot of time, you can sit there and kind of stare at it for a while and not [act]…And I think having a, 'We need it at this point,' kinda thing is actually really beneficial because it makes you do something rather than just think about it or talk about it" (T4R3)
Structuring and framing	"I've found that within boundaries – if you have have defined boundaries, you know what's expected, what you have to absolutely do – creativity actually blossoms. For example, in glasses, there are a couple things that do really nice things to glass properties, but they're no exactly biologically friendly, so we can't put those in. But within that framework of needing to achieve certain things…you can explore the entire space. And, you know, having something that already is set for you lets you play with the other stuff" (T3R5)
Provoking new approaches	"We didn't go through and do a lot of scientific theory, and a lot of experiments, and a lot of reviews. … The fact that we were able to circumvent some of the traditional processes within Gigantech, I think helped us to kind of stay less adhesive to some of the traditional mindset, or rules, and go take a different approach. I definitely think breaking the mold a little bit is a good thing sometimes" (T5R6)

APPENDICES

APPENDIX A.
Recruiting email for study

CREATIVITY AND CONSTRAINT IN TECHNOLOGY DEVELOPMENT

Hello <<Team Name>> Team Member:

<<Team Name>> has been selected as one of the 5 teams to be part of this project titled "Creativity and constraint in technology development" - a research project examining the creative process in technology development teams at [Gigantech] – and as a core team member, you are invited to participate.

1. Who will conduct the study?

Brent Rosso is a doctoral candidate in Organizational Psychology and Management & Organizations at the University of Michigan. Brent's research focuses on the creative process in teams. This study is a part of Brent's doctoral dissertation research on the role of constraint in the creative processes of technology development teams.

2. What is the expected duration?

One 90 minute interview, and observations of team meetings.

3. What is the agenda for the interview?

The interview will explore project goals related to creativity, constraints faced in the course of the project, how the team is dealing (has dealt) with these constraints, impact on team processes and creative performance, and team strategies and norms for managing the creative process. Brent will audiotape the interview in order to transcribe for his data analysis.

4. Will it be confidential?

CDA has been signed and submitted (*See attached file: BrentRosso-CDA.pdf*). [Gigantech] will have rights to review Brent's study/thesis before publication to ensure security of [Gigantech] proprietary knowledge.

5. Participation

Your participation in this study is voluntary, and you will not be penalized should you choose not to participate. If you are willing to participate, please let me know.

6. Questions ??

If you have any questions, please feel free to contact me.

[Gigantech Employee Contact Signature]

Appendix B.
Interview protocol for pilot research

I can't thank you enough for being willing to speak with me today. I'm really looking forward to this opportunity to learn from your insight and experience as a leader of creative teams. The aim of this research project is to better understand the creative process in organizations, with a particular focus on how creativity happens in project teams. I sought you out because of your tremendous expertise in the area.

There are 4-5 key topics that I'd like to explore with you today, and it should take about an hour. During our conversation, I will be taking notes on what you are saying, and I will also be recording our conversation to ensure I don't miss anything. If, for any reason, you'd like a part of our conversation to be confidential, please let me know. Before we begin, I just want to verify again that I have your consent for recording our conversation? Are there any other questions you have for me before we start?

1. Great. I'd like to begin by learning a little more about what you do at [company] and the role creativity plays in what you do.

- What are the types of needs, goals, or problems for which your division relies most on creativity?

2. Now I'd like to explore how your teams tackle creative projects. Could you please walk me through a recent creative team project that was particularly successful? (from beginning to end)

- What were the timelines and expected deliverables?
- How much freedom was the team given (with regard to both processes and outcomes)?
- How were resources allocated?
- What were the key challenges? How did you address them?
- Were there any unexpected surprises?

3. When you think about other successful creative projects you've been a part of, what do you see as the most important ingredients of creative work?

- What are some of the specific work processes, practices, or routines that you have found most effective in stimulating team creativity?
- What are the environments (physical, social, spatial, or otherwise) that you have found most likely to enable team creativity?
- Are there certain ways you configure, assign, or organize project teams in order to maximize creativity?
- Are there certain "ideal" conditions under which team creativity is most likely to occur (or to occur more rapidly)?
- Other factors?

4. I'm particularly interested in understanding how creative teams manage, and even capitalize on, constraints. What are the most significant constraints your project teams face in their creative work? (could you give me an example?)

- What role do you see obstacles or constraints having on your team projects? (alternative: what effect do these constraints have on the team process or the creative performance of the team?)
- How do you/they typically respond to or manage these constraints?
- In which ways have these constraints stifled or hindered creativity?
- Have you seen any *positive* benefits to these constraints with regard to enabling creativity?

5. Finally, before we finish, I'd like to get a better understanding of how you define "creativity." When you use the word "creativity," can you tell me what that term means to you?

- Are there particular ways in which you determine whether or not something is creative?
- Are there certain defining characteristics, activities, or properties inherent to creativity?

Thank you so much for sharing your insight and experience with me. This has been tremendously valuable for my research, and I greatly appreciate you taking the time to speak with me. Would you mind if I keep in touch and follow up with you later if needed for additional details on some of these questions? Also, is there anyone else you might be able to refer me to with expertise in creative work?

Appendix C.
Interview protocol for key informants

INTRODUCTION:
Thank you for being willing to speak with me today. I'm looking forward to the opportunity to learn from your team's experience in the _____ project. The aim of my research is to better understand the creative process in new product and technology development teams. I define creativity as the production of ideas or solutions that are both novel and potentially useful to the organization. In this sense, creativity is one precursor to innovation, which is the *implementation* of creative ideas or solutions.

Our conversation will last approximately one and a half hours, during which time I will explore episodes in the product/technology development process in the _____ project. During our conversation, I will be taking notes on what you are saying, and I will also be audio recording to make sure I don't miss anything. Your responses will remain anonymous and your identity, and that of the team, will be protected. However, if for any reason you'd like a part of our conversation to be off-the-record, please let me know and I will turn off the recorder. In addition, you may decline to answer any question and to end your participation in the interview at any time.

Do you have any questions before we start? Then would you please sign this form for me indicating your consent to participate in my study? Thank you.

BACKGROUND:
1. I'd like to begin by learning about your role in the organization and on this particular team. Tell me about your background and your role in the _____ team.

2. I'd also like to learn more about the nature of this particular project. Could you tell me about the goals of the project, what the history of the project is, who the key leaders and stakeholders are, and who else the team is collaborating with.

CREATIVE TEAM PROCESS AND EFFECTIVENESS:
3. As you know, my research is about the creative process in work teams. What role does creativity play in your team's work?

- What are the types of goals, needs, or problems for which the team relies most on creativity?

I'd like to learn more about the project by hearing about what is going well in your team's creative process, and what could be improved.

- First, how would you describe your team's creative process?
- When you think about the way the team is working together, what would you say is going well in the team's creative process?
- What would you say could be improved in the team's creative process?

CONSTRAINTS AND UNDERLYING MECHANISMS:

4. I'm particularly interested in exploring episodes in which your team responded to or even introduced constraints into the project work process. I define constraint as a state of being restricted, limited, or confined within prescribed bounds. A constraint could be something that comes from outside of the team or from within the team. What are the constraints that your team is facing or voluntarily introducing into the project?

Of these constraints, which would you say has had the greatest impact on the team's creativity (for good or bad)?

- Where did this constraint come from?
- When and how was it introduced?
- In your experience, is this type of constraint typical for this kind of work?

5. What was the initial impact of this constraint on the team?

6. How is your team currently responding to this constraint? (How has your team dealt with similar constraints in the past?) Please be as specific as you can.

7. What has been the impact of this constraint on the way your team works?

- In what ways has this constraint affected the team's goals?
- In what ways has this constraint affected the team's tasks and work processes?
- In what ways has this constraint affected the team's work motivation?
- In what ways has this constraint affected the interpersonal dynamics of the team?
- Did the mood of the team change when this constraint became apparent?

8. What has been the impact of this constraint on the creative performance of the team? What has been the impact of this constraint on *other* elements of team performance or functioning? How would you rate your team's creative performance in general?

9. What have leaders done in response to this constraint?

10. What has been the impact of this constraint on the way the team interacts with others (people or entities) *outside* of the team?

11. What other factors, internal or external to the team, have been affected by this constraint? What other issues, if any, do you think this constraint is related to?

CONTEXTUAL CONDITIONS:

12. How would you characterize the environment in which your project team is working (socially, culturally, physically, or otherwise)?

13. How much freedom would you say the team has in how the team completes its work?

14. How would you describe the leadership style of those with formal or informal leadership roles in the team?

15. What would you say are the factors – related to team composition, team processes, or the environment in which the team is working – that have the greatest impact on a project team's ability to generate creative ideas and solutions? To what degree would you say these are present in your team? In what ways could improvement be made in these areas that would enhance your team's creativity?

CONCLUSION:
Those are all of the questions I have. Is there anything you'd like to add that might be relevant to my research?

Thank you very much for taking the time to speak with me. Your perspective has been tremendously valuable for my research, and I'm grateful for your insight. Would you mind if I follow up with you later if needed for additional details?

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