FRAMING THE FUTURE: COGNITIVE FRAMES, STRATEGIC CHOICE AND FIRM RESPONSE TO THE FIBER-OPTIC REVOLUTION

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Abstract

Much research has sought to understand why technological discontinuities are difficult for firms to manage. While the literature devotes little attention to the role played by managerial cognition, in such equivocal situations as those created by rapid technical change, executives’ cognitive frames of the environment, not the “objective” characteristics of the situation, should be essential for shaping outcomes. Despite an increasing emphasis on managerial cognition in the strategy field, there have been limited attempts to link cognitive frames to strategic choice and action in the face of dynamic events. Thus, my research seeks to shed light on the following question: to what extent and through which mechanisms do managerial frames about the technology and environment affect firm strategic response to technical change? My dissertation is a multi-method examination of this question in the specific context of communications technology firms’ responses to the fiber-optic revolution.

First, I examine the macro patterns and consequences of frames for strategic action. An analysis of a panel dataset of 72 communication technology firms (over the period 1982-2001) testing the effect of top managers’ frames about the importance of optical technologies on strategic action (in the form of patenting in the optical arena) shows that, even when controlling for a number of plausible alternative explanations, there is a strongly positive and significant association between frames and subsequent strategic actions across a wide range of firms.

Second, I unpack the micro mechanisms connecting cognitive frames and strategic choice. A qualitative exploration of one firm, employing ethnographic techniques to examine cognition “in the wild” of strategy making, follows several strategic projects to understand not just the decisions themselves but how they are produced in the course of situated action. Drawing on framing theory in the social movements literature, I develop a model of “framing contests” in which frames and framing strategies are tightly intertwined with interests and political strategies in producing strategic choices about technology investment.

Third, I integrate the macro and micro perspectives to build a structurational model of framing that addresses the essential tension between adaptation and inertia in the face of technical change.
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Preface and acknowledgements

John Seely Brown once said that “all insight is rooted in conversation.” This thesis only exists because of the conversations that I have had with many people both within the Academy and outside. If it takes a village to raise a child, it takes a community to write a dissertation. While I assume full responsibility for the words contained in this text, I also want to give credit to the amazing community of people that helped make it possible.

Of course, academic work is about participating in a series of conversations, sometimes in person but often through the written word. It seems to me that getting a doctorate is a journey to discover which conversations one wants to be part of. The conversation which I hope I have entered is one inspired by Joseph Bower, Robert Thomas, Andrew Pettigrew, Diane Vaughn, Henry Mintzberg, Bruno Latour and Steve Woolgar and others who have explored questions of strategy and technology using ethnographic field methods. This thesis is a small attempt to look at strategy in the way that Latour and Woolgar looked at science: the chapters included here are my first steps at constructing a “Strategy Life” to parallel the images of “Laboratory Life” that they created. And, I hope that through this effort I can enrich the field of strategy by connecting these insights about the day-to-day world of strategy-making to the more macro perspectives that predominate in the strategy literature today.

I feel that I have had the perfect thesis committee for this undertaking: Rebecca Henderson, Wanda Orlikowski and Charlie Fine. I came to Sloan for the chance to work with Rebecca and she didn’t disappoint. She helped shape my interests into something that mattered to the field of strategy, pushed me to respond to all of the plausible alternative explanations, allowed me to follow my own passions, provided funding when I needed it and stood by me as I navigated the rapids of the job market. I could not have asked for more in a Committee Chair. I met Wanda as a student in her course on technology and organizations (absolutely the best class I have ever taken in my life). She was responsible more than anyone for helping me make the transition from consultant to academic and for getting me to reflect on what kind of scholar I wanted to be. As a member of my committee, she encouraged my cross-disciplinary explorations, kept me honest to my methods and forced me to pay attention to the assumptions embedded in language. Charlie was steadfastly encouraging of the project and instrumental in getting me connected with the MIT Microphotonics Industry Consortium which provided me with funding, field sites and intellectual stimulation.
In addition to my formal committee, a number of faculty, whom I am proud to count as my friends, served in my “shadow committee,” giving me advice and shaping my thinking: Mary Tripsas, Fiona Murray, Paul Carlile, Leslie Perlow, Mike Tushman and Scott Stern. Mary, Fiona and I have formed a sort of research triad as we all coauthor with each other. It is thrilling to have such wonderful women colleagues in the management of technology field. I love that we have combined our work collaborations and personal friendships so well. Paul continues to keep me focused on the values of practice scholarship. Leslie has helped me think about how to communicate the findings from my field work and has gone out of her way to encourage doctoral students using qualitative methods. Mike taught an early course that indoctrinated me into the management of technology field and has gone beyond the call of duty as a champion of my work (including as an advocate and letter-writer for the job market). It was a terrible loss to Sloan when Scott took a position at Kellogg, but I am glad that he has remained a part of my “invisible college.” He was instrumental in recruiting me to the Sloan doctoral program and helped me navigate my way through the economics courses I needed. Every time I talk with him, we have amazing conversations that completely reorient my thinking. He has the rare ability to really listen and then reframe the ideas in new and unfailingly insightful ways.

Sloan and MIT more broadly have been tremendous resources for me in my studies. I am grateful to the Technology, Innovation and Entrepreneurship professors (especially Jim Utterback) and the Sloan faculty overall for being interested in and supportive of my work (especially those faculty who committed time to guiding doctoral students and teaching doctoral courses). John De Figueiredo, Bob Gibbons, Jesper Sorensen and Ezra Zuckerman deserve special mention, both for their general commitment to doctoral students and for their specific contributions to my scholarly development. In particular, it was Bob’s question – “Isn’t this really a story about interests?” – that led to the rich explorations into the interrelationship between frames and interests that has become the central theme of my dissertation. A number of staff members also made the experience at Sloan more enjoyable, especially, Loretta Caira, Sharon Cayley, Cher Hugus, Anita Kafka, Carrie O’Brien and Justin Travis.

However, I got the most regular support and insight from my fellow doctoral students. Matthew Bidwell, Henrik Bresman, Forrest Briscoe, Isabel Fernandez, Sean Safford, Andrew Von Nordenflycht and I created our “Slump Management” group initially to avoid the third-year slump after the general exams, but it also came to be a source of insight and support during the dissertation writing and job market. This group has provided a safe haven in an academic world bereft of positive feedback. Now that all of us are moving away from Cambridge, we have vowed to maintain our e-mail list as a virtual community where we can continue to express our
worries and questions and hopes. Carlos Martinez has also been a great intellectual partner and personal friend during these years at MIT.

Getting the right data from the right setting is what makes or breaks a thesis. I have been extremely lucky to get connected with the MIT Microphotonics Industry Consortium and its Communications Technology Roadmap project, directed by Lionel Kimerling, George “Buzz” Kenney, Rajeev Ram, Charlie Fine and Elizabeth Bruce. Not only did they provide me with funding and access to research sites but they also pushed me to articulate my insights in ways that were relevant to the Consortium executives. I have benefited tremendously from this collaboration. I am also grateful for the support of the Industrial Performance Center directed by Richard Lester which provided me with funding and office space when I really needed it.

I was lucky in finding my field site, a company that I have called “EQUIPCO.” I cannot thank all of my informants by name here because I have disguised their identities and that of the company for reasons of confidentiality. “Vince Weston” and “Hugh Collins” were particularly essential to making my experience productive and enjoyable. I will miss our regular lunches and cups of tea. “Brad Copeland,” the head of the Advanced Technologies Group in EQUIPCO, was my sponsor. It was his interest in improving the strategy-making processes in his organization that made my research possible. He gave me full access to all strategy discussions, documents and people in his group. He wasn’t worried about “airing dirty laundry,” because he felt he could learn something from the process – a brave stance to take during one of the most difficult periods the communications technology industry had ever faced.

The large-sample, quantitative study required a tremendous amount of data collection that I could not have accomplished without the research assistantship from a number of talented undergraduate students at MIT: Andreea Chisca, Alex Forrest, Jesse Gutkowski, and Lynn Kamimoto.

My experience has been considerably enriched by the friendship of three extraordinary women, Laura Black, Sachi Hatakenaka and Kate Kellogg. We all came to our doctoral work as a second career and have encouraged each other as we adopted and adapted our academic identities. Watching Laura and Sachi finish a few years ago gave me hope that it was indeed possible, and they have continued to encourage me even as they have moved many thousands of miles away. Together, we discovered Mary Oliver’s poem “Wild Geese” (which starts out, “You do not have to be good. You do not have to walk on your knees for a hundred miles through the desert, repenting...”) that helped us escape the paralysis of perfectionism inherent in our natures and in the academic undertaking. Kate, despite her many personal and professional obligations, has never failed to make time for a weekly lunch or coffee. It was she who finally pushed me to
insight in my field work: she assured me I had something new to say and urged me to take my explorations of the social movements literature seriously. She has always been the first to cheer me on.

I was rescued most often from the low points that come during one’s doctoral work by the children in my life – godchildren, niece, nephew and others – especially Lilia, Dalton, Natassia, Arabella, William, Alastair, Max, Stephanie, Alexandra, Sophia, Jake and Julien. Being with these kids put the trials and tribulations of research in perspective and brought me more joy than I can express. I thank all of their parents for sharing them with me. There were many friends from outside my academic life who helped along the way, too, including David Ashen, Bridget Elias, Thea Page, Sylvia Mathews, Bill Snyder, Noah Walley and Kristina Wollschlaeger.

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Sarah Kaplan
Cambridge, Massachusetts
May 27, 2004
Chapter One

Framing the future, introduction to the research

In this dissertation, I examine how firms have made strategic choices in the context of the unfolding fiber-optic revolution. Optical technologies are today the “asphalt” of the Internet superhighway. Technological advances in photonics aimed at overcoming the interconnection bottleneck have reshaped technological choices, economic models and the competitive landscape among technology providers. The evolution of these optical technologies occurred over the past 20 years, culminating in the telecommunications “bubble” in the late 1990’s and the subsequent crash in 2001-2002. In the chapters that follow, I explore how firms in the communications technology industry have responded to the discontinuity created by the emergence of fiber-optics and, in particular, how managers’ frames about the future (the nature of the technology and the potential solutions) shaped outcomes.

Here are some images from the year 2000.

**Corvis:** “Our vision is clear. We believe that optical technologies can provide higher capacity, lower-cost and more efficient communication networks. This vision has been shared by engineers and scientists for many years. In fact, Alexander Graham Bell is said to have considered optical communications more than a century ago, but he discarded it in favor of electrical communications because optics technologies were not yet feasible. But now, all-optical networks are feasible and we see the dawn of a new era in communications. We see the power of light transporting information over thousands of miles, uninhibited by the electrical equipment that has congested communication networks in the past. We see our customers deploying networks that eliminate excess equipment, enabling them to deliver innovative services at a fraction of today’s costs.” (David R. Huber, President and CEO, Corvis, Letter to Shareholders, 2000)

**Lucent:** “This was a tough year for Lucent Technologies. While a number of factors contributed to the company’s financial performance in fiscal year 2000, clearly, missing a major growth opportunity in the optical networking market with our OC-192 product was a big setback. As a result, we saw less-than-expected revenues and lower gross margins in our optical networking business - which makes the high-speed networks that help service providers move phone calls, video, e-mail messages, Web pages and other data around the world on beams of laser light...Lucent has all the building blocks of tomorrow’s Internet - a triple play of data, optical and wireless solutions, supported by professional services and software. We are aggressively investing in solutions for next-generation networks for customers and in the technologies that will power the broadband and mobile Internet, including Internet infrastructure, optical networking and next-generation wireless systems. We will continue to expand into global markets even as we restructure our business for growth....” (Henry B. Schacht, Chairman and CEO, Lucent Technologies, Letter to Shareowners, 2000)
Cisco: "Over the next two decades, the Internet economy will bring about more dramatic changes in the way we work, live, play, and learn than we witnessed during the last 200 years of the Industrial Revolution. Cisco is well-positioned to help our customers survive the Internet Revolution by turning these changes into competitive advantage. We provide the Internet solutions that will help our customers generate new revenue, reduce costs, increase productivity, and empower their employees... The Internet economy has grown more rapidly than even our most optimistic predictions and fuels the strongest period of economic prosperity in history... This decade, leading companies will develop internally, acquire effectively, and form an "ecosystem" of partnerships in a horizontal, rather than a vertical, business model. Companies participating in an ecosystem – an open standards-based community that works toward a common goal – will emerge as the market and industry leaders of the future. Customers are the real beneficiaries of our ecosystem model because it allows us to remain agile, quickly enter new markets, and provide both breadth and depth of solutions through the ecosystem community. In addition to expanding our ecosystem, we also increased our investment in internal product development by 61 percent and continued to grow through acquisitions. Since 1993, we have acquired or announced our intent to acquire 65 companies. Moving forward, our technology strategy will continue to be driven by internal development complemented by acquisitions and strategic alliances." (John Chambers, President and CEO, John Morgridge, Chairman, Donald Valentine, Vice Chairman, Cisco Systems, Letter to Shareholders, 2000)

Nortel: The Internet revolution has also created major discontinuities in global communications, providing new growth opportunities for our company and its customers. The past teaches us that new industry leaders often emerge in challenging times of change. As a company with a tradition of capitalizing on industry and technological discontinuities, Nortel Networks is poised to seize new opportunities that will solidify our leadership position in the industry... Nortel Networks is well positioned to lead this revolution to a new stage of development for our customers and our industry. The Internet revolution is not so much about the Net itself, but about communication, innovation, speed, and leadership. Our people are committed to applying their talents and innovations to continue building the high-performance Internet and to unleash its potential to serve global society. To unleash the Net's full potential, Nortel Networks is spearheading the development of an all-optical, photonic Internet on which all data traffic, from end-to-end, will move at the speed of light. The construction of the photonic Internet will be an historic milestone in global communications. As the all-photonic network evolves, we are helping our customers deliver innovative services, secure competitive advantage, create new and profitable revenue streams, and develop more productive and lasting relationships with their customers." (Frank C. Carlucci, Chairman, John A. Roth, President and CEO, Nortel Networks, Letter to Shareholders, 2000)

Each of these quotes comes from the Letter to Shareholders of a firm in the communications technology industry at the peak of the communications industry bubble. These letters represent the frames of top managers about the future of the industry. There are many questions about managers’ frames. How are they formed, particular in large, complex organizations with multiple actors? How do they influence strategic choice and action? How are they related to managers’ incentives and interests? In this dissertation, I explore the relationship of managers’ frames to strategic choice and action as firms have responded to the fiber-optic revolution. I argue that an understanding of these relationships provides a deeper understanding of the general problem of firm response to discontinuous technical change.
Much research has sought to understand the effects of technological discontinuities on industries and companies. Empirical evidence shows that discontinuities are difficult for firms to manage but there is no consensus as to why (Christensen and Rosenbloom 1995; Henderson 1995; Henderson and Clark 1990; Schumpeter 1934; Schumpeter 1942; Tushman and Anderson 1986; Utterback 1994). The literature devotes little attention to the role played by managerial cognition, yet it seems likely that mental models are critical because they filter management’s perceptions about what is happening and what action should be taken (Hambrick and Mason 1984). Much of what is known about making strategic choices is inadequate in explaining firm response in periods of rapid technical change when they are faced with confusing data, competing technologies, unclear market needs, competitive threats and doubts about technological viability. In such “weak situations” (Mischel 1968) where the characteristics are not clear enough to dictate action, the executive’s mental model of the environment, not the “objective” characteristics of the situation become the basis for strategic choice (Finkelstein and Hambrick 1988). Despite an increasing emphasis on managerial cognition in the research literature (Huff 1990a; Walsh 1995), there have been limited attempts to link management frames to strategic choice and action in the face of dynamic events (with some notable exceptions, cf., Garud and Rappa 1994; Gavetti and Levinthal 2000; Kaplan, Murray, and Henderson 2003; Tripsas and Gavetti 2000). Thus, my research seeks to shed light on the patterns, mechanisms and consequences that connect managerial interpretations of the technology and the environment and how these affect firm strategic response to technical change.

I use the fiber-optic revolution as a “critical situation” (Giddens 1984: 61) within which to examine the role of frames in firm response to discontinuity. My multi-method research project examines micro-level strategy practices (Johnson, Smith, and Codling 2000; Whittington 1996) of the individuals and groups as they perceive, react to and shape macro-level environmental change (Barley and Kunda 2001; Vaughan 1999). To understand the patterns and consequences of frames on action and the underlying mechanisms that connect them, I conducted a multi-method study that included a large-sample, quantitative analysis examining the connection of top management frames to strategic outcomes in 72 firms over 20 years and a qualitative field study of one incumbent firm in the communications technology industry examining the day-to-day practices by which frames shape strategic choices. Both studies share an emphasis on longitudinal analysis and on understanding managerial cognition prospectively.
The argument unfolds across the remaining five chapters. Chapter 2 provides an overview of the research questions, the research setting and the research methods for the dissertation. First, I review the current understanding of discontinuities, develop a perspective on frames, and show how cognition has been used to date to explain firm response to discontinuities. I highlight the strong alternative hypothesis of managers' interests and then highlight a series of research questions that I address with my empirical research. I argue for the potential of a cognitive explanation of firm response to discontinuity. In particular, I propose several research questions focused on understanding the relationships between frames and strategic action and on the specific mechanisms that connect them. Second, I suggest that an examination of communication technology firm response to the fiber-optic revolution is an ideal setting to examine these dynamics. I describe the evolution of optical technologies and demonstrate that it was, and continues to be, characterized by important uncertainties about the nature of the technology and market evolution. Third, I provide a high level overview of the methodological approach to the dissertation. While the specific methods of each study are covered in their relevant chapters, in this introduction I discuss the basic principles that guided the methodological choices I made for this dissertation: grounded theory building, multi-method, multi-level, and a prospective, longitudinal approach. I suggest that these principles are necessary for the grounded theory-building I aim to accomplish in the dissertation.

In Chapter 3, I report on the results from the quantitative, large-sample study. In this study, I focus on the frames of top management in particular. Using a measure of managerial frames constructed from word counts in the Letter to Shareholders from Annual Reports, I test for an association between frames and strategic choices about investment as represented by patenting patterns. The study establishes the presence of a systematic pattern of association between management frames and strategic action. By its very nature, work of this kind that treats the firm essentially as a macro level whole cannot reveal the causal mechanisms explaining this relationship. The work also raises the question about whether interpretations different within the firm given that there are such important differences in interpretation about optical technologies across firms.

In Chapters 4 and 5, I report on the qualitative, field study within the Advanced Technologies Group in a company called EQUIPCO aimed precisely at exploring these issues.
Chapter 4 describes the research design and analytical approach I took, focusing on the details of the ethnographic techniques I employed and the choices I made about data collection. I illustrate the organizational context both of EQUIPCO and ATG in order to both set the stage for the subsequent analysis of ATG's strategic choice making as well as to establish the scope conditions of the work. I also tell the stories of the five projects and of selected informants. These stories illustrate the tremendous range of interpretations about the internal and external environment that were present within ATG during my study, show how these conflicting frames played out over time and highlight the important interrelationship of frames with interests. In Chapter 5, I focus in on two of the five projects I studied in order to conduct an in-depth analysis of the micromechanisms connecting frames to strategic choices. I use the evidence from Chapter 4 to derive a model for the framing contests through which strategic decisions were made. I explore the nature of the frames themselves, describe the kinds of framing activities used to influence decision outcomes, and show how the framing process interacts with a political process in which individuals pursue their interests in attempting to shape strategic decisions.

Stepping back from the empirical results, in Chapter 6, I use Giddens' (1979; 1984) structuration theory to help integrate the insights from the two studies, drawing together both macro and micro perspectives. I draw out the interfaces between the theoretical principles and the findings from the empirical work to develop a structuration model of framing, that highlights the intrinsic relationship between frames and sources of power in organizations. I conclude with implications of this model for questions of strategic management, including firm response to technical change, managerial cognition research, and the practice of strategy.

* * *

This dissertation is one attempt to unpack firm response to discontinuity and in particular to understand the role of frames in shaping outcomes. Because research has not yet fully pointed the floodlights on this set of issues, I pursued a grounded theory building approach that aimed to integrate across macro and micro lenses on the same problem. The following chapters report on these explorations and an initial set of insights and conclusions.
Chapter Two

Research questions, setting and methods

2.1 Research questions – cognitive frames and firm response to discontinuity
   2.1.1 The nature of discontinuities
   2.1.2 Cognitive frames
   2.1.3 Firm response to discontinuities – emerging cognitive explanations
   2.1.4 The strong alternative hypothesis – interests explain outcomes
   2.1.5 Unanswered questions

2.2 Research setting – the fiber-optic revolution
   2.2.1 A brief history of the fiber-optic revolution in communications
   2.2.2 The fiber-optic revolution as discontinuity

2.3 Research methods – multi-method, multi-level exploration
   2.3.1 Grounded theory building
   2.3.2 Multi-method
   2.3.3 Multi-level
   2.3.4 Longitudinal and prospective

Appendix to Chapter Two – How fiber optics work

What is the potential for a cognitive explanation of firm response to discontinuity? What research setting could help generate new insights? What methods would be most amenable to generating new theory in the area? This chapter provides an overview of the research questions, the research setting and the research methods for the dissertation. It sets the stage for the empirical analyses that follow in Chapters 3, 4 and 5 and the theoretical integration and analysis in Chapter 6.

2.1 Research questions – cognitive frames and firm response to discontinuity

In this section, I examine the research on firm response to discontinuity and the potential for explanations based on cognitive frames. More specific discussions of the literature are
presented in each subsequent chapter as they become relevant for each analysis. Here, I review
the current understanding of discontinuities, develop a perspective on managers’ frames, and
show how cognition has been used to date to explain firm response to discontinuities. I also
highlight the strong alternative hypothesis of managers’ interests and then conclude with a series
of research questions that I address with my empirical research.

2.1.1 The nature of discontinuities

Discontinuities have been understood in the literature as a part of the evolutionary cycle
of technology. Traditional, evolutionary models of technical change, in essence extensions of
Kuhnian (Kuhn 1970) notions of scientific trajectories, have been quite deterministic. They posit
that following a technological discontinuity, variation and selection take place in an era of
ferment, with selection leading to the retention of a dominant design, followed by a period of
incremental technical change, and ultimately disruption by another technological discontinuity as
the cycle repeats itself (Anderson and Tushman 1990). In line with the organizational learning
literature, once a dominant design has emerged, technological progress is guided by a path
dependent learning process in which a firm’s adaptation is limited to what can be achieved
through local search (Levinthal and March 1993; Levitt and March 1988/1996). Firms engage
in local search, building upon historical problem solving routines and procedures associated with
the dominant design (Nelson and Winter 1977; Nelson and Winter 1982). For instance, Dosi
(1982: 152) defines a technological trajectory “as the pattern of ‘normal’ problem solving activity
(i.e. of ‘progress’) on the ground of a technological paradigm,” and Rosenberg (1969) describes
technical change as meant to progress in one “painfully obvious” direction.

As technology moves towards incremental improvements, it is viewed as having natural
limits that are defined either by the essence of the technology (Foster 1986; Freeman and Soete
1997) or problems of scale and complexity over time (Sahal 1981). When a technology has
reached its limits, discontinuous technology is likely to invade an industry, sparking a new
period of ferment. Much of this literature is predicated on the Schumpeterian view that
 technological discontinuities are exogenously given and can be known as they occur: a
breakthrough technology creates the discontinuous change (Dosi 1982). While Schumpeter
notes that discontinuities are innovations that “command a decisive cost or quality advantage”
(Schumpeter 1942: 84), the inherent uncertainty surrounding new technology makes it difficult
to identify such advantages prospectively. The specific nature of a discontinuity, the dimensions along which it will have impact and the appropriate path of action are very rarely obvious in the moment. These factors, “known” ex post, are unknown ex ante.

Research on firm response to discontinuity is rife with stories of firm failure or radical dislocation. Firms have to contend with changes in the environment (relevance of different competitors, technologies, market boundaries), changes in performance dimensions (technical choices, economic formulae) and changes in internal dynamics (salience of different capabilities). As Knight (1921/1965) suggested, it is not these changes per se that make discontinuities so difficult for firms to manage but rather the inability to anticipate, even probabilistically, the future. In periods of relatively slow change, firms can develop quasi-stable sets of heuristics that help guide strategic choices about investment and direction. Discontinuities, on the other hand, place firms in a setting of particularly intense Knightian uncertainty in which these routines break down. These settings can be thought of in Giddens’ sense of “critical situations...circumstances of radical disjuncture of an unpredictable kind which affect substantial numbers of individuals, situations that threaten or destroy the certitudes of institutionalized routines” (1984: 61) where “the frame of reference [has] lost its salience...” (1979: 125). As one of my informants in my field study said about the crash in the telecommunications market, “Because of what has happened in the market, we now have a crisis of confidence about looking into the future.”

Given these ambiguities, actors thus need to “make sense” of their situation in an era of technological ferment before they can act (Weick 1990; Weick 1995), opening the door to the possibility that cognition may play a significant role in shaping their responses, and suggesting that these very interpretations and actions can, in a co-evolutionary manner, shape the direction of the technical change itself. Indeed, these sensemaking efforts are most manifest precisely when established interpretations and practices break down (Louis 1980; Weick 1995; Winograd and Flores 1986). Yet, while managerial cognition is receiving increasing attention as a field in management research (Huff 1990b; Huff, Huff, and Barr 2000; Walsh 1995), the floodlights

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1 An informant in EQUIPCO, the site of my field study. This study will be covered in Chapters 4 and 5.
have not yet been pointed fully on this particular setting where, ironically, frames may be most likely to matter.

2.1.2 Cognitive frames

Cognition means many different things to many people, and even in the context of managerial research, the views cover a broad spectrum. At its heart, cognition is about the way individuals perceive, filter and conceptualize information (Tenbrunsel, Galvin, Neale, and Bazerman 1996; Weick 1990) in a way that forms the foundation of decisions and action (Hambrick and Mason 1984). These perceptions are represented as frames (Goffman 1974), mental models (Johnson-Laird and Shafir 1993; Senge 1990), cognitive maps (Axelrod 1976), or one of more than 70 different terms used in organization studies (Walsh 1995).

The examination of cognition in the managerial arena goes back at least to March and Simon (1958) who argued that everyone in a firm brings a certain cognitive foundation, a set of “givens” to any management decision – assumptions about the future, knowledge about alternatives and a view of the consequences of pursuing each alternative. This cognitive foundation forms the basis of simplified representations of the information environment. These simplified representations must be made because of cognitive limits in the face of an information environment that cannot be known in all of its complexities, a notion they call “bounded rationality.”

This concept of bounded rationality has led to a rapidly growing literature in the strategic management field in which scholars argue that cognition is the basis of strategic action directed by management (Huff 1990a; Kiesler and Sproull 1982; Porac, Thomas, and Baden-Fuller 1989; Prahalad and Bettis 1986). While cognition has its origin in the cognitive psychology of the individual, management scholars have found it useful to conceptualize cognitive frames as the property of both individuals and collectives (Carroll 1993; Kogut and Zander 1992) such as groups or coalitions (Peteraf and Shanley 1997; Reger and Huff 1993), firms (Prahalad and Bettis 1986) and industries (Porac et al. 1989). Bringing in cognition as the filter of information and shaper of strategic choice is intuitively appealing for studies of technical change, which by its very nature requires new information from the environment, new interpretations of the nature the technical change, new definitions of success, new strategies, and different kinds of decisions than have been made in the past.
Scholars of managerial cognition have tended to draw on purely psychological notions of cognition (being solely in the mind of individual actors) or even of the firm (often reifying the firm as a cognizer). But, cognition exclusively viewed in psychological terms may not capture the dynamics that shape organizational outcomes. In this research, I find it useful to expand beyond the psychological notion of bounded rationality to a more sociological conception. Specifically, I draw on Goffman’s (1974) notion of “frames” or schemata of interpretation because of its foundation in theories of interactions among actors and its use as a means to link micro and macro changes. Importantly, Goffman emphasizes the situational nature of frames: meanings are linked to the context in which they arise. These contexts include the specific interaction (the individuals involved, the setting), the occasion (the reason for the interaction, in the case of my research, this would be the project and associated decision) and the social dynamics (the broader social setting including relationships among people and among occasions). Frames are the property of individuals yet can become collective or shared through a process of negotiating meaning.

Frames have their impact as they function in the interpretive system of the organization. Daft and Weick (1984) and subsequent models of the same ilk (Foster and Kaplan 2001; James 2000; Ocasio 1997) argue that there is an organizational interpretive process that involves both individual and collective engagement in environmental scanning and noticing, interpreting, decision making and acting. The first stage – scanning – is fundamentally about data collection which involves both what is looked at and what is noticed or attended to. Because the environmental inputs are potentially infinite, the (implicit or explicit) choices about what data to collect are critical. What is the relevant competitive set? Which customers should we pay attention to? What measures should we use to benchmark performance? Which technologies should we monitor? These decisions will be critical for defining what information gets in to the interpretive system.

The second stage – interpretation – is where meaning is attributed to these data. Here, diagnoses about the relevance and impact of the information are made: Is this new technology a threat or opportunity? Will it be competence enhancing or competence destroying? Is it radical or incremental? Do these new regulations help or hurt? Does this new entrant pose a credible challenge? This analysis happens at the individual level but also involves a process for
achieving a collective, if not consensual, view about the solution that will ultimately lead to a
decision and action (the third stage). Part of the third stage is the definition of the choice set
itself: Can we really consider breaking out a division to pursue this new technology? Could we
reduce investment in a major program by an order of magnitude? Could we consider an
earnings-diluting acquisition? At each stage, the frames held individually and collectively in the
producer or user organization define the possibilities and constraints.

Management teams can be seen as systems of distributed meaning formation that can
have very different kinds of interpretations and decisions than those implied by individual
cognitive properties depending on how the decision making process is organized within the
group (Hutchins 1995). Organization theorists that subscribe to this tradition argue that
knowledge is not just held at individual level but embedded in social context (Kogut and Zander
1992). The attempt in this thesis is not to reify the organization as a cognizer itself but rather to
show how a collective frame and ultimately a collective decision might emerge through the
interactions of individuals (Spender 1998; Weick and Roberts 1993) in particular under
conditions of uncertainty.

2.1.3 Firm response to discontinuities – emerging cognitive explanations

A large body of literature has documented the difficulties that established firms face in
adapting to radically new technologies (Klepper 1996; Tushman and Nadler 1986). Within this
literature, there is an important debate about the degree to which incumbents or new entrants will
thrive. In a vast array of industries, including watches (Landes 1969), disk drives (Christensen
and Rosenbloom 1995), photolithography (Henderson and Clark 1990), calculators (Majumdar
1982) pens, semiconductors and locomotives (Cooper and Schendel 1976), new entrants
displaced incumbents as market leaders when radically new technology invaded the market, yet
other work has shown that incumbents can often survive these events and even thrive
(Christensen, Suarez, and Utterback 1998; Tripsas 1997). For the most part, existing
explanations for established firm responses are rooted in economic and behavioral explanations
for firm actions.

By adding a cognitive lens to existing theories, we can enhance our understanding of
these outcomes. Making decisions about new technologies involves high levels of ambiguity.
Typically a broad range of competing technologies is under consideration. Uncertainty exists
about the performance trajectory of the technologies, the cost of developing them, their ultimate
uses, and the size of the potential market, among other things. Firms often fail to notice a new
technology, notice it but fail to understand its importance, or make investment decisions that are
not adequate to the task. This suggests that managerial sensemaking would likely influence
activities associated with firm response to technical change: search processes, interpretation and
appropriation of value. Few studies of firm response to technical change have addressed
cognitive frames head on as an explanatory variable. Indeed, in their recent review of schools of
strategy research, Mintzberg and Lampel (1999) noted that the cognitive perspective was
underdeveloped as an explanatory variable. On the other hand, a broader body of literature
makes arguments that are consistent with or hint at the role of cognition.

There is considerable empirical evidence to suggest that firm search processes affect their
response to technical change. Existing explanations for firm failure in this context often focus on
the inertial forces that constrain firm behavior. At the extreme, firms are characterized as highly
inert systems incapable of fundamental change (Hannan and Freeman 1977). Others have argued
that firms can adapt, but are constrained by existing organizational routines (Nelson and Winter
1982) where a given stock of firm capabilities changes only incrementally since learning is based
on local search processes (Levinthal and March 1993; Levitt and March 1988/1996; March and
Simon 1958). Existing information processing routines and communication patterns limit the
range of exploration in which firms engage (March 1994). When looking at new technologies in
particular, firms don’t stray too far from what is familiar: using patent classifications and
citations as a measure of “localness,” established firms have been shown to search more closely
to their existing areas of technological expertise (Podolny and Stuart 1995).

These experience-based search choices, however, are inextricably linked to cognitive
choices, each influencing the evolution of the other (Gavetti and Levinthal 2000). Cognitive
frames can therefore have a significant influence on how firms search in a new technological
domain. For instance, engineers make a series of choices as they move down the design
hierarchy in developing a new product (Clark 1985). In doing so, the types of questions asked
and definition of the problem space are based on the questions and problems of the past.
Codified in a firm’s architectural knowledge, these heuristics are difficult to change. In
implementing new photolithographic technology, established firms were therefore more likely to
utilize architectural concepts from a previous generation of technology than were new entrants, resulting in inferior performance for the incumbents (Henderson and Clark 1990).

Similarly, incumbent firms in the disk drive industry did not invest in new generations of technology. Using resource dependence theory (Pfeffer and Salancik 1978), Christensen and Bower (1996) explain this behavior by arguing that when a firm is dependent upon a dominant set of customers for its current profits, those customers exert undue influence on firm action. If a new technology is perceived to be of value to those customers, then a firm will invest heavily in it. If, however, as in the case of disk drives, existing customers do not value the capabilities of a new technology, then established firms are less likely to invest, bypassing potentially attractive opportunities. Although not explicitly discussed by Christensen and Bower, there are also elements of a cognitive explanation present in this story. Based on prior frames, established firms pay more attention to existing customers and are not necessarily aware of emerging customer segments. New entrants, unencumbered by prior history, have a different framing and are much more open to new customers.

Cognition also has a significant influence on these search processes by making the nature of what is “local” a firm-specific variable. In forming judgments about new technological domains, management teams utilize a set of beliefs about the firm: beliefs about the firm’s capabilities and how the firm makes money. These beliefs influence strategic behavior. For instance, Polaroid was able to learn about fundamentally new scientific disciplines in digital imaging because management believed that exploring radically new technologies was one of the firm’s strongest capabilities (Tripsas and Gavetti 2000). Management thus had a frame that included radically different technologies in a “local” search process. One can thus conceive of local search as socially constructed within a firm and not predetermined by characteristics of technologies.

Management frames about the firm also affect the interpretation of the technology and environment. For instance, those pharmaceutical firm top management teams that interpreted the biotechnology revolution as more important to their core pharmaceutical business were more likely to make significant technical investments, in the form of patents and scientific publications (Kaplan et al. 2003). In another case, when executives perceived their firm to have a greater emphasis on technology, they placed greater value on opportunities related to potential
technology alliances and less on the alliances’ associated risks (Tyler and Steensma 1995). How a firm responds to a new technology is also influenced by whether that technology is perceived as a threat or opportunity (Dutton and Jackson 1987). In his study of newspapers’ response to the Internet, Gilbert (2002) found that if firms perceived the new technology as a threat they were more likely to invest in it, however, the investment was “rigid,” and based on existing models of the industry. As a result, newspapers missed out on many of the potential new categories of revenue on the Internet, instead replicating their hardcopy business models in an online environment.

At the same time, firms (and more specifically their scientists) are influenced by social forces in their evaluation of new technical areas. While individuals may begin with their own set of frames and evaluation routines related to an emerging technology, the materialization of commonly accepted industry frames and evaluation routines can force a new understanding of reality (Garud and Rappa 1994). For instance in photolithography, Henderson (1995) found that industry forecasts about the limits of the technology were based upon a set of shared assumptions – assumptions that were eventually found to be incorrect. The aggressive pursuit of incremental progress had led to embedded, tacit, and taken for granted knowledge about component performance, and only unexpected changes in semiconductor manufacturer’s requirements broke this perceived constraint. Garud and Karnoe (2001) propose that through a “mindful” process, entrepreneurs may intentionally depart from the existing understanding of the technology trajectory in order to create new opportunities in the future, even though these actions may be suboptimal in the present context. In this way they enact new realities. Using the familiar case of 3M’s Post It Notes, they suggest that this innovation was not a chance act but rather a deliberate attempt on the part of the inventor to generate new possibilities by mixing molecules in new ways.

Another factor affecting a firm’s ability to succeed in a new generation of technology is its ability to appropriate the value of its innovative activity. Existing work has shown the importance of complementary assets such as a brand, distribution channels, or complementary products, in appropriating value (Mitchell 1991; Teece 1986; Tripsas 1997). Commercialization choices can also be constrained by cognitive frames. Over time, top management teams develop a set of shared beliefs about how a firm makes money. In implementing a new technology,
managers base their expectations of commercial success on these shared frames. Even if these frames are inappropriate in a new environment, managers may find it difficult to change them. In a longitudinal comparison of two railway companies, for instance, Barr, Stimpert and Huff (1992) found that while management teams in both firms were cognizant of new environmental conditions, the more successful firm was able to link those changes in the environment to corporate strategy. Similarly, Tripsas and Gavetti (2000) found that the Polaroid top management team experienced difficulty overcoming its belief in the efficacy of a particular business model for commercializing digital imaging technologies.

While not addressing technical change per se, several studies in the broader managerial cognition field have connected organizational strategic change with management belief systems. Meyer (1982) found that differences in responses of hospitals to a physician’s strike could be attributed to differences in frames within the organizations. Dutton and Dukerich’s (1991) study of the New York Port Authority showed that their response to increasing numbers of homeless people in their facilities was hampered by management’s beliefs about the organizations role in the community. Bartunek (1984) found that organizational restructuring in a nun’s religious order could be attributed to changes in their interpretive schemes about their mission. And, Barr and colleagues (Barr et al. 1992) found in a comparison of two railroad companies that differences in changes to corporate strategy after a major environmental change could be attributed to differences in ability to notice new conditions and to connect them to strategic action.

2.1.4 The strong alternative hypothesis – interests explain outcomes

The existing research on cognition and strategy has failed to take into account the strong alternative hypothesis of managers’ interests, both within and across firms. This gap is particularly noticeable in the context of firm response to technical change because much of the management of technology literature has attributed heterogeneous response to differential incentives to invest in new technologies.

At the firm level of analysis, scholars have argued that incumbents tend to lose out during discontinuities because they (rationally) underinvest in new technological areas. In this line of thinking, the incentive to invest is driven by the economic value of the effort and thus response to technical change is just another investment decision. Schmookler’s (1972) analysis suggested

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that innovation in trains was driven by increasing territory in the US and thus changes in demand predicted patenting in trains. These scholars have made important distinctions between the incentives of entrants and incumbents, suggesting that under conditions of uncertainty, incumbents will invest less than entrants due to fear of cannibalization of rents of existing products, at least under some conditions (Arrow 1962; Gilbert and Newbery 1982; Reinganum 1983). Similarly, Klepper and Simons (2000) found that the largest firms in the market (likely the incumbents) do the most R&D because cost can be amortized over a larger base. Henderson (1993) refined this insight to suggest that, as neoclassical theory predicts, established firms invested more than entrants in incremental innovation, but that in agreement with organizational theory, the research efforts of incumbents seeking to exploit radical innovation were significantly less productive than those of entrants. And, Gans and Stern (2000) argue that incumbents have strategic incentives to invest in R&D because it increases their bargaining power in licensing technology from entrants, but that they will invest less in research than entrants.

Within the firm, when the value of ideas is uncertain (as in periods of technical change) it is difficult to establish a relationship between effort and value (due to unobserved effort and the stochastic outcome for the supply of ideas). To cope with this problem economists have developed the field of information economics to study markets for incomplete goods both within and across firms (many scholars treat the firm as a subeconomy) (Aghion and Tirole 1994; Holmstrom and Roberts 1989). In this light, cognitive frames are simply representations of individual actors’ interests. The frame matters less than the interests it represents. As such, even if they do have differential information or interpretations, actors throughout the organization may not have incentives to share information that they have. These differences in interests can lead to opportunistic behavior within the firm in which actors may distort or obfuscate information in order to pursue their own interests (Williamson 1985). Hence, incongruent interests within the firm can further complicate the acquisition and communication of the information necessary to make a decision (Aghion and Tirole 1997). Differences in interests lead to different information sharing both in amount and in kind. Career concerns, for example, influence the amount of effort put into work (Holmstrom 1982/1999), and different incentives lead to different kinds of knowledge transfer (Osterloh and Frey 2000).
Few, if any, researchers on cognition have addressed interests explicitly in their models. However, two of the underpinnings of the incentives literature could be enriched by a cognitive turn. First, Williamson’s notion of interests is that all individuals are essentially the same, and that beyond some basic requirements for material subsistence, their major interest is in achieving esteem or status. But, as Douglas (1990) points out, Williamson and others do not address how this status is collectively negotiated in the organization. This conceptualization of interests does not take into account that the interests themselves might be subject to interpretation. In particular, in more dynamic, ambiguous information situations, it may not be clear what the interests are or what the incentives should be. Second, the typical solution proposed to resolve the incongruence of interests with information is to achieve incentive alignment (Holmstrom 1979; Kerr 1975). The better aligned incentives are, these scholars argue, the better the outcomes. By definition, this makes conflict dysfunctional. While some research into strategic decision making suggests that it might be the case that conflict has negative effects (Eisenhardt and Bourgeois 1988), other analysis suggests that conflict and politics can actually produce ‘better’ decisions, especially under highly turbulent situations (Jehn 1995; Morrill 1995).

While cognitive perspectives have begun to expand our understanding of firm response to technical change, there have been limited attempts to examine the interrelationship between cognitive and interest-based explanations. Thomas’ (1994) and Pettigrew’s (1985) case studies of the dynamics of organizational change are noted exceptions. They consider “worldviews” and power simultaneously, but they treat power as an exogenous factor rather than something endogenous to the framing process and do not consider mechanisms for frames to change over time. And, as I will explore in greater depth in Chapter 5, theories of framing in the social movements literature (Benford and Snow 2000) also provide some initial handholds for understanding the interactions between frame-based and interest-based action. I argue that it is essential when examining the role that frames play in firm response to technical change to take into account interest-based explanations, not simply to test this strong alternative hypothesis, but rather to understand how frames and interests might be interrelated.

2.1.5 Unanswered questions

The research on firm response to technical change has for the most part neglected to examine explicitly the role of frames in shaping outcomes, though a broader set of studies does
suggest that it might be a meaningful explanatory variable. Where research has looked at
cognition head on, the work has gaps in both theory and evidence. This research has not focused
adequately on the patterns and consequences of frames for strategic action nor on the
mechanisms that connect them.

First, the research has mainly been descriptive: it describes the frames but does not
always connect them to strategic choice and action. Where these connections are made, it has
been mainly through case studies and therefore has not been able either to establish the effects of
frames on outcomes across a range of companies nor to control for important alternative
explanations (such as interests).

Second, this research has not adequately examined the mechanisms that connect frames
to strategic choice and action. While these studies have described many sorts of frames, there
has been less attention to the actual process of framing. There has been little focus either on the
conflict and negotiated process for producing the collective frames in an organization nor on the
precise ways that these frames shape choice. Research in managerial cognition has attributed
organizational inertia to individual cognitive inertia (or group cognitive inertia to the extent that
frames are shared), but there has been less attention to the dynamics that might produce that
inertia. In addition, there is little consideration of the factors that might enable new frames to
emerge. The work has largely neglected human agency, having reified the firms as cognizers
and focusing little on the individual actors. Yet, it is not firms that actually interpret and act but
the actors within the firms. The research suggests that stresses to existing frames can emerge
only if other actors can plausibly challenge the shared cognition, but there is little explanation for
what might make these actions plausible.

Third, from the standpoint of methods, research on managerial cognition has often been
cross-sectional or covering short time periods and thus does not contribute to an understanding
for how managers and firms cope with change over time. In addition, the studies that have been
conducted are often case studies without any grounding in a more general understanding of the
consequences of frames for outcomes. As such, they are also unable to control for important
alternative explanations of firm action. Also, this work has also taken an ex post view. Yet,
when firms are making choices about investments and strategic direction, they do not have the
benefit of knowing the ex post outcomes. They must act in the ex ante conditions of Knightian
uncertainty. Therefore, frames must be examined prospectively, capturing the perspectives of actors in the moment as they are making strategic choices.

In order to make progress on understanding the role of frames in firm response to discontinuity, I focus in on the dynamics that produce strategic choice and action. Using choice and action as a focal point of understanding management and strategy goes back at least to Barnard (1938). In the context of strategy, Allison (1971) famously used the decision as the unit of analysis to understand government policy in the Cuban Missile Crisis, and there has been some traction in studying decisions in the management literature as well (cf., Bourgeois and Eisenhardt 1988; Papadakis, Lioukas, and Chambers 1998). Research in managerial cognition has suggested that the focus on strategic choice and action is appropriate for understanding strategic change (Day and Lord 1992; Duhaime and Schwenk 1985; Lowstedt 1993; Thomas, Clark, and Gioia 1993).

Using the optic of strategic choice and action as a way of viewing the role of framing in organizational outcomes, my research is thus aimed at answering the following research questions:

- Can we understand frames to have a systematic effect on strategic action that is distinct from alternatives such as interests across firms and over time?
- What are the dimensions of the frames constructed to make sense of ambiguous information during periods of discontinuity?
- How are they enacted by multiple actors over time to produce strategic choices and action? How do these processes relate to interests?

The research reported in this dissertation is a multi-method study of firm response to the fiber-optic revolution. I conducted a large-sample, quantitative analysis examining the connection of top management frames to strategic outcomes in 72 firms over 20 years and a qualitative field study of one incumbent firm in the communications technology industry examining the day-to-day practices by which frames shape strategic choices. In the next section, I briefly describe the evolution of fiber-optics in the communications technology industry and account for why it is an appropriate setting for this multi-method examination. In the subsequent section, I describe the research approach and methods for accomplishing the study.
2.2 Research setting – the fiber-optic revolution

The fiber-optic revolution provides a number of advantages for the exploration of research questions about firm response to technical change. In order to respond to the questions about patterns, consequences and mechanisms, it was essential to identify an industry setting with the following characteristics. The number of firms had to be substantial enough to be amenable to a large-sample, quantitative analysis. The discontinuity had to have taken place over a long enough time period that historical, longitudinal analysis would be possible. In addition, there had to be ongoing flux in the industry during 2002 when I would conduct field research. Finally, there had to be evidence of the impact of a discontinuous technical change: radically changed performance dimensions and substantial entry and exit of firms. In this section, I will demonstrate that the impact of the fiber-optic revolution on the communications technology industry meets each of these criteria.

2.2.1 A brief history of the fiber-optic revolution in communications

Communications technology involves all of the components and equipment required to install a network. There are four essential segments of this network: the backbone or core of the network connecting major cities together (including submarine applications), the metro (regional) core which involves transport between network hubs such as central offices, local (“last mile” or “first mile”, depending on the perspective) access to business or home premises and the local area network inside the premises. Communications technology firms cover several stages of a long supply chain in the communications industry (Table 2-1).

This industry encompasses those firms making products, either components or systems, for the communications industry. Component and subcomponent suppliers provide, for example, semiconductors, lasers, cabling including optical fiber, detectors, add/drop modules, multiplexers, attenuators and/or filters. Their customers are primarily the equipment suppliers. Equipment suppliers provide systems that are built from the components and modules. They develop the architectures and platforms of the networks. Their customers are typically service providers (for long haul and metro applications) and enterprises (for local area network applications). Test and measurement firms serve both component and equipment companies.
Table 2-1: Stages of the communications supply chain

<table>
<thead>
<tr>
<th>Materials and process equipment</th>
<th>Test and measurement</th>
<th>Sub-components (semiconductors)</th>
<th>Components</th>
<th>Equipment, systems</th>
<th>Network owners</th>
<th>Service providers</th>
<th>Content</th>
<th>End users</th>
</tr>
</thead>
</table>

This system has arisen through a series of revolutions in telecommunications over its 130 or more year history: from the introduction of the telegraph (1830) and the telephone (1876), the switch from analog to digital signal technologies (in the 1970’s), and now more recently the emergence of optical technologies (1980’s and 1990’s).

Interest in the potential of optics extends nearly to the beginning of the telecommunications industry. Bell patented an optical phone in 1880 but at the time electrical had more potential.² Fiber optics only began to get traction in the 1970’s with technical breakthroughs in the development of fiber. In the early days of the development of fiber-optic systems, researchers involved in the field claimed, “The driving force for putting fibers into long-distance systems is low transmission loss and attractive bandwidths [which leads to] much lower repeater costs than for wire-pair and coaxial systems that the system economics for light wave is very attractive based on voice traffic alone, and wide-band services would increase the attractiveness” (Miller 1980: 1173). Before a single system had been tested, researchers such as

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² Photophone, Patent number 235,199, 1880 by Alexander Graham Bell
Bernard DeLoach Jr. of Bell Labs argued that "What we’re talking about here is a complete new Bell System."³

Why were and are optical technologies attractive for communications? The answer comes down to the cost-effectiveness and speed of transmission of information. Telephone and data communication systems were initially based (and in parts of most systems, continue to be based on) copper wire. Yet, copper wire is limited to 1 megahertz in frequency (1 million cycles per second, which translates into a few dozen voice channels). Coaxial cables can carry up to 10 gigahertz (10 billion cycles). They were introduced for trunk lines between major cities but were too expensive for other types of connections. Beyond these limits, electrical resistance in the wire increased substantially leading to inferior performance. Optical fiber on the other hand has theoretical limits well beyond that of other technologies. Fiber has other technical and economic benefits. It has the ability to deliver not only more information but information at a greater fidelity (lower signal loss) than either copper wire or coaxial cable. Fiber is immune to environmental interference such as lightning, proximity to high voltage electrical equipment and power lines, corrosion from chemicals or other outdoor atmospheric conditions. These features mean that fiber can easily be buried in the ground or lashed to existing telephone poles or electrical cables. While it is expensive to dig new trenches to lay fiber, there are other aspects of handling fiber that make it attractive. Because it doesn’t conduct electricity, there is no danger of electrical shock to personnel repairing broken fibers. And, fiber optic cable is smaller and lighter per carrying capacity than copper and coax. The appendix to this chapter provides an overview of the workings of fiber optics in a communications system.

Multiple scientific and technical paths as well as social and economic events shaped the evolution of optical communication technologies. As I have proposed elsewhere in the context of another discontinuity, that of biotechnology (Murray and Kaplan 2001), a discontinuity only becomes a discontinuity when technological change is translated into economic change. The origin of a discontinuity arises as a result of the interplay of economic and technological forces that act upon a technological breakthrough. Discontinuities are characterized by significant interpretive flexibility not only in the technological domain but also in the economic domain.

which is characterized by uncertainty. The variation in interpretation of the discontinuity that characterizes its early contours (era of ferment) arises as the result of firms taking entrepreneurial action in the face of interpretive flexibility, experimenting with different interpretations of the technology in the economic domain and taking action to construct the economic from the technological. The selection mechanisms that are crucial to the gradual “weeding out” of these interpretations of the discontinuity are driven by the legitimizing effect of evidence that reshapes firm action and resolves and closes interpretive flexibility along different dimensions of uncertainty (and at times reopens uncertainty). Thus, a discontinuity can best be understood as not just purely having a technical logic, but also and unavoidably, an economic logic shaped by economic actors. The dynamics that played out in the emergence of the fiber-optic revolution follow these contours.

The fiber-optic revolution, while having its technical and scientific roots in developments throughout the 20th century (and before), began to influence the direction of the communications industry in the 1980’s. Coupled with the arrival of the Internet and World Wide Web (indeed, the development of these technologies have been mutually reinforcing), fiber-optics have changed the way we communicate and have reshaped the communications industry. One can describe the fiber-optic revolution in five phases of development to date: early development of optical technologies (pre 1985), first applications (1986-1991), rapid growth (1992-1996), the communications bubble (1997-2001), and the crash and its aftermath (2001-present). These periods coincide with important technical and industry changes.

Early development of optical technologies (pre-1985). While the fiber-optic system only developed in the 1970’s and 1980’s, nearly a century earlier, experts in communications theorized about the possibility of communication by light. In 1891, John J. Carty wrote an anonymous “Profets Column” in the Electrical Review in which he speculated about future technologies. In his evaluation of the potential of light to transmit communications, he commented, “Ether is the Africa of Science, and not all of the gold and ivory of the Dark Continent would equal the rewards which await is successful explorers.”

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4 Carty, Prophets Column. Electrical Review, April 11, 1891, 18 (7), 98 cited in (as cited in Pool 1983: 34). Note that in the late 19th century, Africa was the great unexplored continent that transfixed the imaginations of nations seeking wealth.
Early scientific and technical development of optical technologies occurred primarily in two parallel streams of discoveries in the area of optical glass and lasers. In the first stream, the development of fiber optics rests on scientific and technical breakthroughs that extend back to the late 18th century when inventors and scientists made demonstrations of refracting light through jets of water and glass rods. Development in the late 19th century and early 20th century came mainly in the form of “Fairy Fountains” and other illuminated jets of water as well as in use of glass rods for illumination (e.g., for surgery). In the 1930’s, Owens Corning and others make progress in producing glass fibers (both non-optical and those intended for transmission of images). In the mid-1950’s, a race between Harold Horace Hopkins in the UK and Abraham C. S. Van Heel in Holland led to breakthroughs in the development of clad fibers and fiber bundles to transmit light and images. Researchers at American Optical capitalized on these developments and eventually left the company in 1958 to form the first fiber-optics company, Mosaic Fabrications (in Southbridge, Massachusetts). In the same year, Alex Reeves of Standard Telecommunication Laboratories began investigating the potential for optics in communications. The early 1960’s saw a series of progressive improvements in fiber quality until, in 1966, Charles Kao and George Hockman at Standard Communications Labs in the UK demonstrated theoretically the potential for optical fiber with acceptable levels of light loss (less than 20 db per km).

Another contributing stream was the development of lasers that could pump light. Insights from physics started with Max Planck’s initiation of the field of quantum physics in which he demonstrated mathematically that matter radiates energy in quanta (discrete bundles) in 1900. In 1905, Albert Einstein built on this theory to explain the photoelectric effect by showing that light is made of packets (later known as photons) (earning him the Nobel Prize in 1921). In 1913, Niels Bohr developed a model of the atom in which electrons occupy specific energy states which quickly led to Einstein’s identification of stimulated emission as a phenomenon in 1917. Charles Townes at the Columbia University Radiation Laboratory harnessed stimulated emission

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5 Some timelines extend the history to 2500 B.C.E. when the first known glass was developed and to Roman times when the first glass fibers were drawn (Hecht 1999).

6 For example, in 1887: Royal Jubilee Exhibition in Manchester has illuminated "Fairy Fountains" designed by W. and J. Galloway and Sons; in 1888: illuminated fountains at Glasgow and Barcelona fairs; in 1889: Universal Exhibition in Paris shows refined illuminated fountains designed by G. Bechmann (Hecht 1999).
to develop the Maser (microwave amplification by stimulated emission of radiation) in 1951 and by 1958, working with Arthur Schawlow of Bell Labs, published a theory for Lasers (light amplification by stimulated emission of radiation). After that time, laser development proceeded rapidly to the point in 1970 that Morton Panish and Isuo Hayashi (Bell Labs researchers) demonstrated semiconductor lasers that could operate continuously at room temperature. Through the early 1980’s, there were still important questions about which would be the best fiber-guide transmission technology. Lasers (of which there were multiple options) looked better for longer distance systems. LED’s (light emitting diodes) seemed better for short distances (Miller 1980).

Laser development suggested a means to speed up transmission of voice and data. But, the question remained how to transmit light signals. Unlike long wavelength radio signals which are unobstructed by fog or rain, short wavelength laser light can be scattered or redirected by particulate in the atmosphere. One potential approach was glass fiber—though in the mid-1960’s “it was by no means certain that the answer lay in this direction and other possibilities were seriously considered” (Conlan and Heppenheimer 1996: 6).

Nevertheless, by the late 1970’s, Corning’s progress in manufacturing high quality optical fiber made their use in communications possible. While optical fiber had been produced in the late 1970’s by Corning, it was only introduced in the first commercial systems in 1982-85 when AT&T installed fiber in the Boston-Washington route, MCI put in fiber in the Washington-New York corridor and British Telecom laid the first submarine fiber to the Isle of Wight. The use of fiber expanded rapidly in the late 1980’s but it was not without its limits. In particular, because of attenuation, the signal needed to be boosted with amplifiers at regular intervals (a few kilometers). Amplification was very expensive because it required the conversion of the light signal into an electrical signal and then back to a light signal (known as optical-electrical-optical

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7 Actually, while Corning made the initial strides, other firms were not far behind. In addition, during this period of exploration on the production of fiber cables, there were many competing process technologies. Corning used an outside vapor phase oxidation (OVPO). Bell Labs developed the modified chemical vapor deposition (MCVD) technique. Nippon Telegraph developed the vapor phase axial deposition (VAD) approach. All of these used vapor deposition of materials. Yet, British Post attempted to develop an approach that would allow the glass fiber to be drawn from a crucible (as all other kinds of glass had been drawn prior to the development of optical fibers) (Miller 1980).
or O-E-O conversion). This was done with relatively costly electronics in large boxes. Separate amplifiers were required for each wavelength of light.

The business press began covering the potential of optics for communications in the late 1970’s, mainly suggesting the potential for radical changes in telecom (c.f., “Fiber Optics—Exciting New Technology for Everyone,” U.S. News & World Report, April 28, 1978 or “A ‘light’ phone with optical fibers,” Business Week, December 4, 1978) though not everyone was in sync. The New York Times noted in 1985 that “most analysts have become cautious about the prospect for fiber-optics networks for long-distance communications. But analysts note that there are many other applications for fiber. The regional Bell phone companies, for example, are using fiber to modernize local phone networks, businesses are using the glass for private communications networks, and the military continues to use fiber for its communications.”

Of course, in retrospect, it has become clear that the long haul market was the main source of growth of optics in the 1980’s and 1990’s.

At this time, a small number of large equipment firms dominated the communications technology market. This was particularly true because most countries had single monopolies providing telephone services. And, in the case of the U.S., AT&T was both the major consumer as well as provider of communications technologies. MCI was a critical driver of an effort to end this monopoly through suits that led to multi-billion dollar awards and eventually pressure to change the corporate structure. Other suppliers, such as Northern Telecom (now Nortel) agitated for a change as well.

This era ended with the breakup of AT&T. The Justice Department and AT&T agreed to an antitrust settlement in 1982 (based on an original antitrust suite brought in 1974 under the Ford Administration) that broke the corporation up into 8 pieces. AT&T retained long distance services, manufacturing and Bell Labs. The seven other Regional Bell Operating Companies (RBOC’s) became independent companies (later named Ameritech, Bell Atlantic, BellSouth, Nynex, Pacific Telesis, SBC and US West). Despite the fact that President Reagan and many of his cabinet members were opposed to the breakup, AT&T “lost the antitrust battle...to a fourth level government official (William Baxter, head of the Antitrust Division) and an information

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coalition that included MCI, the FCC, Judge Harold Greene, most foreign and domestic equipment suppliers, the telecom managers of some large corporations, and a few disgruntled academics. “Devolution,” as it was called, changed the landscape for equipment suppliers. Business press at the time claimed that “the breakup of American Telephone & Telegraph Co. not only created seven giant regional telephone companies, but it also has opened a vast and growing market for telephone equipment, more dramatically than industry executives could have imagined.” Companies such as Northern Telecom and other Canadian suppliers expanded rapidly into the US by putting sales and R&D operations in Dallas, Research Triangle Park, Boston and elsewhere.

The break up of AT&T triggered dramatically increased demand for optical technologies. MCI and others were allowed to compete with Ma Bell for long distance service provision. Anticipating at least 80-90% growth in their business, MCI needed to invest in very high capacity systems that would accommodate the volume. The major focus of their investments was in an optical fiber system ($500 million to build a 4,200 mile system in the eastern US). AT&T, which had invested $125 million to install one of the earliest systems, was forced to upgrade its technologies in order to keep up with MCI. As Northern Telecom said in their Annual Report in 1982 (when the AT&T breakup decision was made),

*The Bell System is undergoing a restructuring which will result in the divestiture of the BOCs in early 1984. This restructuring is expected to have profound effects on the U.S. market, although we do not expect to realize any major benefits until 1984. The restructuring will create exciting and possibly substantial new opportunities for Northern Telecom and other telecommunications equipment suppliers to serve the needs of the divested operating companies. It will also bring about some significant changes in the, already hotly competitive environment, attracting aggressive international companies and new competitors from other industries. Northern Telecom is in the best position of any North American company to benefit from these changes. (Walter Light, CEO and Edmund Fitzgerald, President, Northern Telecom Letter to Shareholders, 1982)*

Other suppliers spoke of a “newly competitive market” that would stimulate new orders (ITT Annual Report, 1982) and create “business opportunities” (NEC Annual Report 1985).

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First applications (1986-1991). The late 1980's was initially a growth period for the installation of fiber. The first submarine fiber systems were installed (starting with the first fiber-optic cable across the English Channel in 1986). The first trans-Atlantic cable was laid in 1988. Early experiments in fiber-to-the-home took place such as 1,500 homes in Biarritz, France being connected using a fiber system in the summer of 1986. Fiber was installed by all types of communications carriers. In the United States, Interexchange carriers (AT&T, MCI, Sprint, Williams, etc.) had already installed 41,000 system miles by 1986 and this grew by 16.4% p.a. through 1991. Local operating companies (Ameritech, Bell Atlantic, Bell South, SBC, etc.) had 34,000 sheath miles in place in 1986 and this grew at 36.4% p.a. through 1991. Fiber installations of competitive access providers (RCN, Kansas City Fiber Network, Metromedia, McLeod USA, etc.) were only tracked by the FCC since 1990, and they grew 52% from 1990-1991 from a base of 50,000.12 In addition, there was some interest in the use of fiber in enterprises for local area networks. Initial strong enthusiasm did not pan out as anticipated due to some technical shortcomings. Demand remained “stunted,” making up only a very small portion of network vendors’ sales, but fiber did make some headway in these types of installations.13

The breakup of AT&T created a new set of customers for communications technology firms in the form of the Baby Bells and released them from the grip of the AT&T equipment technology. This created fertile ground for entry of new suppliers: 75 new communications technology firms held IPO’s in US exchanges. Many of these firms, however, were not focused on optical technologies. Some, such as Optek and LanOptics had photonic technologies at the core of their businesses. Many of the others were capitalizing on the growth in communications (both telecom and data) more generally. It should be noted that the number of new entrants in this early entry period pales next to the slew of entry that came later, once the communications revolution took hold. IPO’s of communications technology firms occurred at a rate of about 15 per year in this early period. In later periods, it was much faster (46 per year 1992-1996, 35 per year 1997-2001).

Despite this growth in fiber deployment, there were many limits to the usefulness or cost effectiveness of these early fiber systems. In the late 1980's, scientists began to search for solutions to the limited capacity (relative to cost) of the existing fiber-based systems. One alternative was amplification in the fiber itself which would avoid the O-E-O conversion and dramatically reduce the cost of amplification. The technology that gained the most traction was erbium doped fiber amplifiers (EDFA's). EDFA's are optical repeaters that boost the intensity of an optical signal in a fiber. The fiber is doped with erbium (a rare earth element) so that it can absorb light at one frequency (980 or 1480 nm) and emit it at another frequency (1530 or 1620 nm). A semiconductor laser couples light into the fiber at the lower frequency. Signals arrive at the higher frequency and pump (stimulate) the already excited erbium atoms which then emit photons at the higher wavelength. Before EDFA's light signals in fiber optic systems had to be converted back into electronic signals at each point of amplification and then reconverted to photons for further transmission. The EDFA allows the signal to be retained as photons, thus eliminating the conversion/reconversion steps from the process. This had a dramatic cost impact for the system. For example, while an O-E-O box could cost $50,000-100,000 (in today's dollars), an EDFA might run $11,000.

The breakthroughs in EDFA development came in 1986-87. In 1986, D.N. Payne obtained single-mode operation in an erbium doped optical fiber.\textsuperscript{14} The following years saw the first experimental demonstrations of a high-gain EDFA both by Payne's group in the UK and by researchers in Japan.\textsuperscript{15} But practical and commercializable devices were slow in development due to the high optical pump powers required. The major problems were increasing pump source capacity and optimizing the waveguide structure to raise the pump density to enable single-mode operation (as described by Yu, Jutamulia, and Yin 2001).

In the 1980's, the EDFA was not the only potential solution to the amplification problem.\textsuperscript{16} There was a lot of uncertainty around the evolution of optical amplifiers. First, at the

\begin{itemize}
  \item \textsuperscript{16} And, conversely, it was not clear that the most obvious application for optical amplification was communications. "Telecommunications are not an obvious application [for optical amplifiers], since optical fibres work better if left
\end{itemize}
time, many thought that developing a light-powered device such as an optical amplifier was a "crazy idea." The more likely solutions to the existing limits to fiber were to increase the speed of signals down the existing fibers or simply to add more fiber. Second, even within the explorations of optical amplifiers, alternatives such as Raman amplification were extensively studied in 1970’s and 1980’s but were eclipsed by the advent of EDFA’s. At that time, Raman amplifiers, for example, were further from practical application (they lacked practical pumping devices at right wavelengths) though ultimately it has been argued that they are a better technical solution. Another alternative to erbium (Er) was to use praseodymium (Pr) doping instead, but this technology failed to develop the same traction as Erbium.

Simultaneously, research focused on finding ways to send multiple colors of light down the same fiber at the same time in order to increase the capacity of each fiber (a technique known as wave division multiplexing or WDM). While the concept of multiplexing had been around for a century, its application in optical communications was suggested by scientists in the late 1970’s and early 1980’s. WDM is a way of pulling together many channels onto one fiber.

in the infrared. There are many other possibilities, though. The laser light comes out in blue, green and two shades of red: the primary colours. That leads to thoughts of television. No need for vacuum tubes and coloured phosphor dots – lasers could do it instead. The infrared lasers in CD players could also benefit from a wavelength boost. Because visible light has a shorter wavelength, it can 'see' smaller objects, which means that more data can be stored on a disk – about four times more, if blue light is used. And though undersea cables will not benefit, other denizens of the deep might. Blue beams cut nicely through water, which could help submarines keep in touch with the shore.” “Getting the blues,” The Economist, July 6, 1991 p. 88.

17 Source: personal interview with Alan Graves, Nortel Networks scientist who invented SONET technologies.

18 As the limits of EDFA’s begin to be reached, Raman gained attention again because it was adapted to work with 1400 nm pumping laser diodes. EDFA limits are related to lumped amplification rather than distributed (which leads to a higher noise figure for the same integrated gain). Also, EDFA’s are limited to certain bandwidths. EDFA’s have the effect of shifting most optical transmission from 1310 nm (where optical fiber has zero dispersion) to 1530 nm where erbium exhibits the strongest stimulated emission. Thus, Raman technologies, while less feasible in the short term, might be a better solution in the long term. Raman amplifiers, unlike EDFA’s or the alternative praseodymium doped amplifiers, do not involve modifying the fiber with a rare earth element such as erbium. Instead, this approach uses a more intense laser and the atoms in the glass fiber itself to achieve amplification. Raman provides a much greater range of wavelengths but requires much more energy as well. The key for Raman amplification was to come up with this high energy laser technology.

19 In fact, Alexander Graham Bell’s invention of the telephone was the product of efforts to increase the capacity of copper wires for telegraphing. Experiments to use different frequencies for different signals led to the production of sounds which them implied the possibility of transmitting voice rather than just dots and dashes.

The alternative means for increasing bandwidth would have been to lay more fiber, which was a more expensive alternative. The easier way, once technologies were available, was to increase data rates on existing fibers. As one early researcher noted in 1978 in reference to the potential of WDM, experimental systems in fiber optics made good use of fiber’s low-loss, wide-bandwidth, light weight, immunity to environmental hazards and small size, however “they are presently only substitutions of conventional transmission systems. For the full development of the potentialities of optical fibers, it is of prime importance to find and use other new features of optical fibers, and these new ones would make the optical fibers more attractive”.21 There were (and are today) competing approaches for the multiplexers themselves: thin film filters, arrayed waveguides (AWG’s) and more recently fiber Bragg gratings are among the main alternatives.

Multiplexing had been prohibitively expensive because it required separate amplification for each wavelength at each amplification point. It could only be useful to the extent that the amplification problem could be solved. EDFA’s were not initially developed with WDM in mind (the primary aim had been to reduce the costs of amplification for submarine fiber applications), and it was only apparent later that they could be useful in making WDM systems economical.22 Now, they are an essential enabling component of multiplexing. Neither EDFA’s nor WDM technologies had been ready for prime time in the 1980’s. They existed in the lab, but practical applications in actual communication systems had not been attempted in the 1980’s. Without EDFA and WDM technologies, sales of optical fiber itself stalled later in this time period.

Rapid growth (1992-1996). While EDFA’s and WDM had only been promises in the 1980’s, they soon became practical realities in the 1990’s. In 1990 a significant influx of technical papers on EDFA products appeared at the Optical Fiber Conference (the major industry

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conference for previewing new technologies), and by 1992, EDFA products were launched onto the market. This technology made multiplexing more attractive because it reduced amplification costs.

The first applications of EDFA’s were as transmitter power amplifiers and receiver preamplifiers in submarine applications to extend the reach of nonregenerated spans without the use of underwater O-E-O conversion. In 1992-1993, the use of EDFA’s as repeaters was still a future, next generation application. Researchers were still writing papers advocating the application of EDFA’s in terrestrial long-haul networks. For example, Tingye Li, one of the leading Bell Labs innovators in optical technologies argued in 1993 that “optical amplifiers will change the traditional paradigm by allowing WDM technology and architecture to be utilized in a very cost-effective manner. First, the distance between repeater huts can be increased considerably, from about 30-50 km in current networks to about 90-150 km for amplified systems...Second, each amplifier can support many WDM channels, with an ultimate total capacity limited by the nonlinear effects of the transmission fiber...Third, capacity upgrades are easily implemented at the nodes, by adding channels that use available equipment such as that developed for SONET or SDH...Fourth, the ease and flexibility of capacity enhancement through multichannel operation presents a cost-effective means to provide route redundancy for network restoration.”

He also noted that WDM technologies were not advanced enough to take advantage of this: “Although various technologies for building a terrestrial amplified WDM...
transmission system are available for experimental demonstrations, further work is needed to develop practical systems for commercial application."25

The general sense during this period was that these technologies had revolutionary potential. Again, according to Li, "the widespread use of optical amplifiers with WDM will hasten the realization of the full potential of optical fiber communications, transforming the field from a replacement phase to a revolutionary era of ubiquitous broadband communications services."26 Firms began to see the potential for applying EDFA technology in combination with multiplexing to increase the capacity of existing fibers. These technologies transformed the optical networks themselves. In the mid 1990’s, carriers installed WDM systems at 4 and later 8 wavelengths per channel. The first commercial dense wavelength division multiplexed (DWDM) network (16 wavelengths per channel) went into operation in 1995 (which quickly grew to 80 channels and more by the end of the decade).27 As a result, WDM transmission rates increase by orders of magnitude (see Figure 2-1). The introduction of this technology coincided with and co-evolved with the emergence of the Internet in a way that created tremendous growth in the industry as demand for optical technologies grew rapidly in the late 1990’s.

This period closed with the US Telecommunications Act of 1996 which was the first major update of US communications since 1934. This Act significantly deregulated telecommunications with the goal “to let anyone enter any communications business – to let any communications business compete in any market against any other.”28 It paved the way for the entry of many CLEC’ s (Competitive Local Exchange Carriers) that competed directly with the traditional phone service providers. These CLEC’s were not burdened with legacy equipment and therefore were more likely to be interested in investing in optical technologies. This increased the demand for optics throughout the industry and entry of new communications technology firms spiked as players with different new technologies tried to get in on the game. A flagship example is Ciena, a company founded in 1992 to develop DWDM systems. It

25 Ibid., p. 1576.
26 Ibid., p. 1577.
28 From FCC website describing the Telecommunications Act: http://www.fcc.gov/telecom.html
launched its first commercial 16-channel system in 1996. Many of the incumbents (such as Nortel, Alcatel, NEC, Fujitsu, Hitachi, Ericsson, and Pirelli) as well as AT&T spinoff, Lucent, quickly followed.

**Figure 2-1: Capacity per fiber by types of network technology, both experimental and commercial**

![Graph showing capacity per fiber by types of network technology.](image)


**Communications bubble (1997-2001).** The late 1990's saw the communications and Internet revolution boom. Carriers had embarked on a major program to lay new fiber in the ground to keep up with rapidly increasing demand for bandwidth. As demonstrated in Figure 2-1 above, improvements in DWDM technologies increased the already rapid rate of improvement in fiber performance. At the same time, WDM and EDFA technologies were increasing the capacity of each of those fibers. The fiber build-out started at the core of the network (for long haul point-to-point transmission of communications), though as more suppliers entered, the focus on metro and access markets increased. The concern during this period of the industry was
"fiber exhaust" and the main focus of technology development was "resolving the capacity crisis." At this point, there was little debate about the value of optics overall but within all optical devices, there remained major debates about which technology would win. Agilent was testing bubble technology. Corning was pursuing liquid crystals. Bell Labs, Analog Devices and many others were going after MEMS (micro-electro-mechanical systems or micromirrors). Other technologies considered viable were thermo-optics (silica and polymer), electro-optics (indium phosphide, semiconductor optical amplifier) and acousto-optics. In 2000, Nanovation pledged $90 million to MIT to help fund the development of new photonic technologies, including the holy grail of the photonic integrated chip.

Entry of new firms continued unabated in the late 1990’s, and was perhaps spurred by the growth strategies of some of the larger players such as Cisco, Lucent and Nortel. Cisco pioneered the model of rapid growth through continuous acquisition of small technology companies and others followed suit. For example, Nortel made $8 billion of acquisitions for companies such as Xros (which at the time had no product sales and was at least a year away from having a commercial optical switch), Coretek and Qtera within a few short weeks of each other in 2000. The reason they gave was to put together as rapidly as possible the technologies for the "all-optical internet." Every major equipment supplier was racing to develop capabilities in all optical cross connects and switches. Cisco bought ArrowPoint Communications for $5.7 billion, Pirelli Optical Systems for $2.2 billion and Monterey Networks for $500 million. Ciena acquired Lightera Networks for $552 million. Similarly, new start ups with the same aspirations were having money thrown at them by venture capital firms. Corvis, for example, raised $300 million in 1997.  

There were many remaining uncertainties about technologies. For example, there were several competing technologies for next generation products such as filters (thin film vs. fiber Bragg grating vs. arrayed wave guides), optical switches (MEMS, bubble, liquid crystal and others), and platforms (e.g., silicon, indium phosphide, lithium niobate, or gallium arsenide). The third generation push was to explore all optical technologies, e.g., O-O-O rather than O-E-O, but

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29 International Engineering Consortium Web ProForum Tutorial on DWDM and fiber-optic transmission in 1997, www.iec.org. The motivation of this tutorial was entirely on solving the problem of "fiber exhaust."

it is not clear which would be the superior technology. There was a major debate about the value of optical switching. Proponents argued that optical switching (no O-E-O conversion for switching) would have advantages by scaling with increasing wavelength capacity and was bit rate independent relative to the disadvantages of O-E-O switching which adds delay during the conversion process, has expensive components and total volume limitations. Proponents of O-E-O switching argued that this approach offered performance monitoring, greater control in signal grooming and could perform wavelength translation and conversion relative to the disadvantages of optical switching which made it difficult to monitor the signal and could not achieve granularity any finer than one wavelength. There was also a good deal of uncertainty around the kinds of technologies that would best meet the needs of the increasingly important metro (regional) and access ("last mile") market segments that had lagged behind long haul in moving from analog to digital to optical. And, few in the industry shared an understanding of the nature of the "killer apps" for driving demand growth in the future.

**Crash and aftermath (2001-present).** The trends of increased entry and increased performance of optical technologies collided creating a tremendous bandwidth glut in the long haul segment of the market. At that point, the product market collapsed. Many of the CLEC’s went out of business. Many technology providers exited. Entry came to a halt. While there were many contributors to the telecoms crash of 2001 (overbuilding, the dotcom explosion and implosion after Y2K spending declined, greedy CEO’s and managers), most argue that the fiber explosion of 1997-2001 was the primary culprit. And, in many ways, the crash has been extended by how slowly the realization of a meltdown occurred. In fact, in early 2000, the fiber market began to collapse in Europe as CLEC’s overbuilt and overspent in laying down fiber (to the tune of $15 billion). But, buoyed by a record of fast growth, equipment companies failed to take stock of this situation and continued to expand development.32

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32 Kalba, Kas. 2002. "Telecom in the time of crash." Program on Information Resources Policy, Center for Information Policy Research, Harvard University, Cambridge, MA. One example of this is the view on free-space optics (FSO), a wireless technology that uses lasers to connect buildings to fiber at high data rates, was the basis of big reports and forecasts from several analysts up until mid 2002. At that point, it was clear the market opportunity for FSO had gone down the drain with many CLECs, which were supposed to be the key buyers. Among the bullish were IGI Group Inc., Merrill Lynch & Co. Inc., and The Strategis Group. "As an analyst, I take some of the blame for this," admitted IGI senior analyst Tony Carmona. "But sometimes we all get caught up in what looks like really
As that market tapped out, it was natural for suppliers to consider expansion into the Metro (regional) market. While communications technology firms thought of this as a great, unexploited territory, the economics of the systems were quite different. Where long haul systems required relatively little switching, in the regional market, expensive switches were required at quite close intervals. Thus, the business case for Metro optical systems was not as strong as for long haul systems. Similarly, suppliers also fantasized about bringing fiber to the home (FTTH) so that everyone could be connected at very high speeds. The economics turned out to be prohibitive in all but Greenfield sites (due to the need to dig trenches to lay the fiber, a very expensive proposition). The result was that avenues for continued rapid growth were more constrained than suppliers had anticipated.

The net impact was a decline in market capitalization of 80-90% over the course of a few months. Light Reading, an on line magazine and research service developed in the late 1990's to focus on optical telecommunications, began publishing the market value of what they called the “Light Reading Index” of companies in January 2000. From an index of 1,000 at that time, the index rose to nearly 1,400 over the course of the first half of the year 2000. As the crash emerged, the index fell to below 700 by January 2001, and hit a bottom just under 100 in late 2002. While the index has recuperated to 200 in 2003-2004, it is a far cry from the peaks reached just a few years ago (see Figure 2-2).

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cool technology. But I’ve come to realize that a lot of this stuff is baloney. Carriers just aren’t buying it.” (Lightreading, “2002 Top 10: Forecasting Follies,” December 26, 2002).

While the bursting of the telecommunications bubble in 2001 brought service provider investment in infrastructure to a relative standstill, there was ample evidence that the pace of technological change had not slowed. New research continued in areas as diverse as increased photonic integration to reduce packaging problems, to quantum cryptography, to further breakthroughs in low attenuation and plastic fibers, to quantum-dash lasers and semiconductor optical amplifiers. Therefore, the uncertainties were both economic and technical. Remaining firms were extraordinarily financially constrained and yet had to keep up technology development.

2.2.2 The fiber-optic revolution as discontinuity

While the literature has put forth various definitions of discontinuities or radical innovations, the emergence of optical technologies coupled with the arrival of the Internet would qualify as discontinuous technical change under nearly any criterion. Scholars have variously defined discontinuities along either technical, economic (business model), or organizational (and related industry structure) dimensions. Theories of technology s-curves suggest that discontinuities are movements from one technology to another. The new technology has inherently higher limits to performance (Christensen 1992; Foster 1986), the older technology is

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34 See “Optical innovators keep up the pace,” by Tami Freeman, Fibers.org, February 13, 2003 and “Optical innovators maintain the momentum,” by Jacqueline Hewett and Tami Freeman, Fibers.org, January 29, 2003
not a viable substitute for the newer one (Arrow 1974), and the definition of the specific problem and knowledge required to solve it are different (Dosi 1982). In the case of communications technologies, fiber optics transmit data at dramatically higher rates (see Figure 2-3), radically shifting the price performance curve. Multiplexing technologies for copper wire increased copper wire transmission to near its theoretical limits. The first introduction of a fiber optic communication system well exceeded those limits. And, even after optical technologies were introduced, they continued to make rapid (logarithmic) increases in performance based on the introduction of new technologies.

Figure 2-3: Relative information capacity, optical vs. non-optical systems

An extension of the technical definition is one that focuses on the creation of new business models (economic formulae) based on serving new customers with initially inferior technologies (Christensen and Bower 1996). In the case of communications technologies, the emergence of optical technologies was driven largely by the creation of a broad set of new customers through the breakup of AT&T. Many of the existing technology firms, such as Northern Telecom, actively engaged in lobbying efforts in favor of the breakup. The decoupling
of long distance service brought competition to both. And, it was during this time that AT&T and upstart competitor MCI began implementing their first fiber optic networks. This story is somewhat different from that told about disk drives (where new entrants outcompeted incumbents by initially selling to different classes of customers). While it is true that MCI, as a new service provider, was able to incorporate new technologies more rapidly because it did not have legacy systems to contend with, in the communications industry, the suppliers acted purposefully to create these new customers to sell to.

This crash was largely unanticipated. And, even as the bad news poured in, it took those in the industry a long time to adjust their conceptions of industry dynamics. For example, RHK, the major industry analyst firm, changed its forecasts of sales in the optical transport market over and over as each new forecast cycle came along. In each case the estimates for future growth were radically reduced as the direness of the situation became felt (Figure 2-4).

Figure 2-4: Changes in RHK predictions for North American optical transport market as the telecoms crash evolved (by date of forecast)

Other scholars have suggested that discontinuities have both technical and organizational dimensions (Henderson 1993) in which radical technical changes can have either competence enhancing or competence destroying effects on organizations (Tushman and Anderson 1986). Utterback argues that to be a discontinuity, it must be a change that "sweeps away much of a
firm's existing investment in technical skills and knowledge, designs, production technique, plant, and equipment" (Utterback 1994: 200). In Schumpeter's words, discontinuities are innovations that "command a decisive cost or quality advantage and that strike not at the margins of the profits and the outputs of the existing firms, but and their foundations and their very lives" (Schumpeter 1942: 84). The net result is Schumpeter's "waves of creative destruction" in which entrants overtake incumbents and the industry structure changes in often dramatic ways.

The emergence of fiber optics coincided with a tremendous amount of dynamism in the communications technology industry. Of the 617 total publicly traded communications technology firms in the population I studied, 415 (or 67%) entered\(^\text{35}\) after 1985 (88 in the early period, 186 in the late period, 141 during the bubble). In addition, 257 firms (42%) exited between 1986 and 2001. Of these, 157 (24% of the total firms) both entered and exited between 1986 and 2001 (see Figure 2-5).

\textbf{Figure 2-5: Entry and exit of publicly traded firms in the communications technology industry, 1985-2001}

\begin{figure}
\centering
\includegraphics[width=\textwidth]{figure2-5.png}
\caption{Entry and exit of publicly traded firms in the communications technology industry, 1985-2001}
\end{figure}

\(^{35}\) In this case, "entry" is counted as the point at which the firm holds an initial public offering.
These technical changes and entry/exit patterns were accompanied by an industry boom and then bust (see Figure 2-6).

**Figure 2-6: US telecoms capital expenditures ($ billions) and percent annual change**

Of course, each of these definitions of discontinuity can only be applied to an industry or technology *ex post*, once the nature of the impact is known. For example, Christensen (1996) assumes disruptive technologies as given, and Henderson and Clark (1990) claim that a radical innovation is "obviously radical" at its inception (p. 18). Yet, the specific nature of the discontinuity nor the dimensions along which it will have impact are not necessarily obvious in the moment.36 Thus, what a discontinuity means for a manager, a firm and an industry *ex ante* is simply that there are uncertainties along the technical, economic and organizational dimensions. Does this new technology have the potential to make existing ones obsolete? Does it create the

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36 For example, Vincenti’s (1994) case of the evolution of aircraft showed that the retractable landing gear for airplanes was not immediately recognized by many in the industry as a discontinuity for the existing “pants-type” fixed landing gear. Cusumano et al.’s (Cusumano, Mylonadis, and Rosenbloom 1992) case of VHS vs. Beta video technologies demonstrated that it was not clear *ex ante* which performance dimensions would be most critical.
opportunity for different economic formulae? Do existing firms have the right competences to develop the technology? Throughout the past few decades, the ongoing flux in communications technologies increased the uncertainty of decision making about such strategic issues as technology investments, product design, market segment targets and business models. These uncertainties are precisely what make the setting in a time of discontinuity interesting for research on managerial interpretation and strategic choice. In this “high velocity environment” (Bourgeois and Eisenhardt 1988), managerial interpretation will certainly matter for strategic choice and action.

2.3 Research methods – multi-method, multi-level exploration

I use the fiber-optic revolution as a “critical situation” within which to examine the role of cognitive frames in firm response to discontinuity. To understand the patterns and consequences of cognitive frames on action and the underlying mechanisms that connect them, I conducted a multi-method study. I carried out a large-sample, quantitative analysis examining the connection of top management frames to strategic outcomes in 72 firms over 20 years and a qualitative field study of one incumbent firm in the communications technology industry examining the day-to-day practices by which cognitive frames shape strategic choices. Both studies share an emphasis on longitudinal analysis and on understanding managerial cognitive frames prospectively. In this section, I describe the basic principles that guided the methodological choices I made for this dissertation: (1) grounded theory building, (2) multi-method, (3) multi-level, and (4) prospective, longitudinal approach. The specific methodological details associated with each of the two studies will be discussed in more detail in the appropriate empirical chapters (Chapter 3 for the quantitative, large-sample study, Chapter 4 for the qualitative, field study).

2.3.1 Grounded theory building

The philosophy that has guided the research design and execution has been that of grounded theory building (Dougherty 2002; Glaser and Strauss 1967). This approach focuses on building, not testing or verifying, theory. This seems a particularly appropriate way to respond to the research questions I have proposed because of the gaps in existing theory and evidence in the arena. Grounded theory building has at its core the idea that social life is inherently complex and that outcomes are produced by ongoing interactions among people in a particular context
(Strauss 1987). As Dougherty argues about research on technology in general, grounded theory building “reaches into the ‘infinite profusion (Weber, see Giddens, 1971) of social action in organizations in order to tease out, identify, name, and explicate themes that capture the underlying dynamics and patterns in the blooming, buzzing confusion that is technology development and management. [Grounded theory building] tries to understand why and how structures, conditions, or actions might arise, to ferret out generative mechanisms, to explore conditions under which these effects might vary or not, and to qualify their temporary and emergent aspects” (Dougherty 2002: 851). I make the same claims about this research project on cognitive frames and strategic choice.

I argue that the overarching approach to the dissertation is one of grounded theory even though the quantitative, large-sample study itself is designed in a more deductive way (it tests whether or not a systematic relationship between management cognitive frames and strategic outcomes can be established). It is traditional to see micro, qualitative studies as exploratory: they are often intended to generate hypotheses that can then be tested in a larger sample in a quantitative study. In the research project for this dissertation, I take the opposite approach. I start with the quantitative study to identify some patterns of the association between cognitive frames and action. I then use the micro, field study to explore the mechanisms that might explain the connection. It is in this larger sense that the entire project is one of grounded theory building. I share Giddens’ notion that “all so-called ‘quantitative’ data, when scrutinized, turn out to be composites of ‘qualitative’ – i.e., contextually located and indexical – interpretations produced by situated [actors]” (Giddens 1984: 333). By combining these different optics on the optical technology discontinuity, I hope to generate a process theory of the mid-range that highlights the critical events in strategy-making and outlines the processes that connect them.

2.3.2 Multi-method

The goal of my methods is to bridge field study and quantitative research traditions. Coupling a quantitative study of a large set of firms with a qualitative study within one firm helps extend the case from its specific context. As Dougherty suggests, “These [quantitative] studies contribute by “verifying” that these complex processes of knowing and knowledge transfer are important, and by sorting out some contextual factors. They cannot deepen our understanding of these processes, except by ungrounded inference. By the same token,
[grounded theory building] cannot verify that a process exists across diverse settings, nor properly estimate relative importance for some outcome. Both kinds of research do different things” (Dougherty 2002: 855).

I explore the macro perspective through a quantitative, statistical analysis using a panel dataset of 72 firms in the communication equipment industry. This study examines the role of managerial interpretations of technological change in the firms’ strategic responses from the early days of fiber optics through the internet bubble and crash (1982-2001). The companies studied are a stratified random sample of 72 of the 617 public firms in the industry. Drawing on an approach I used in previous research (Kaplan et al. 2003), the analysis proceeds through an estimation and interpretation of a reduced form equation: \( Y_{jt} = f(X_{jt-n}, Z_{jt-n}, e) \) where \( Y_{jt} \), the dependent variable, is a measure of the extent to which firm \( j \) has responded to optical technologies in time \( t \). The key explanatory variable \( X_{jt-n} \) is a measure of the importance that the top management of a particular firm places on optical technologies in a prior year and \( Z_{jt-n} \) is a vector of control variables, also lagged. Using a measure of senior managers’ frames about the importance of optical technologies derived from each firm’s “Letter to Shareholders” and optical patents and publications as measures of strategic response, I hypothesize that top managers’ view of the importance of new optical technologies is systematically associated with strategic action, even when controlling for firm fixed effects, time trends, previous activity and a number of important alternative explanations.

I develop the micro perspective through an in-depth, qualitative exploration of one firm using ethnographic techniques to uncover the everyday practices of making technology strategy when pre-established routines are challenged by rapid change. This project examines cognition “in the wild” (Hutchins 1995) of strategy-making by following several strategic projects over a period of months to understand not just the decisions themselves but how they are produced in the course of situated action (Suchman 1987). Studying specific practices within a single firm makes sense for these purposes because of the desire to uncover the micromechanisms associated with strategy-making (Pettigrew 1987). My study was conducted in the Advanced Technology Group (ATG) of EQUIPCO, an important, multidivisional equipment manufacturer in the

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37 The identity of the firm, the projects examined and the individual informants are all disguised.
communications industry. This firm was selected as broadly representative of large incumbent firms in the industry. I selected five projects that were representative of the more than 65 total projects being pursued in the group, each reflecting a different interpretation of and response to the current state of the optical technology revolution. My unit of observation is the project while the unit of analysis is the decision itself.

My multi-method approach is analogical to the one suggested by Barley and Kunda (2001) for organization theory: the idea being that “bringing work back in” to strategy should shed light on more proximal reasons for variation by linking micro processes to macro changes. By triangulating across two different studies or perspectives on the same phenomenon, I hope to draw stronger inferences about the underlying dynamics (Denzin 1978; Jick 1979). This is an interactive research design because I am not only looking to compare and integrate the outputs of the different studies, but also, by conducting the studies nearly simultaneously, I allow the projects to mutually influence the approaches, questions and analytical choices (Maxwell and Loomis 2003).

2.3.3 Multi-level

The dissertation encompasses micro-level strategy practices (Johnson et al. 2000; Whittington 1996) of the individuals and groups as they perceive, react to and shape macro-level environmental change (Barley and Kunda 2001; Vaughan 1999). The overall project cuts across levels. The large-sample study focuses on the firm as the unit of analysis, though more specifically it is on the cognitive frames of top management in relationship to organizational outcomes. The field study focuses inside the firm on projects and individual actors, the interactions of whom produce strategic choices. In integrating across these two perspectives, my analysis resides in the “mesomain” (Hall 1995) where situated activity, history and structure converge. This approach has two effects related to the environment and to the firm. First, it has the effect of endogenizing environmental forces (Smircich and Stubbart 1985). I study the environment as it is perceived by individuals and firms (as proxied by top management views). In the quantitative study, I do control for some environmental factors that we know ex post (e.g., market demand, trends in the media, competitive patenting patterns, etc.), but the focus is on how these were interpreted by management (in terms of how much importance top management assigned to optical technologies).
Second, it has the effect of both putting the firm in context and using it as context. Organizations embody structures located between micro-level interactions and environmental contingencies. Because “organizations can complicate and manipulate the entire knowledge-production process: configuring people, objects, technologies and work practices; transcending intra- and inter-organizational boundaries by creating an alternate reality of signs and symbols; limiting knowing in some directions while encouraging it in others; valuing some kinds of information and discounting others, depending on the goal; constructing alternate arenas where discourse takes place that define the kinds of exchange that are admissible; requiring classification systems and standardized documents that regiment, restrict and reduce experience and understanding into easy digestible and communicable abstractions from more complex, dynamic interactions and situational logics” (Vaughan 1999: 931), it is important to account for them appropriately in the analyses. In the quantitative study, this takes the form of specifying firm fixed effects models. I want to make sure that the findings help us understand the effect of changes within firms not across them. In the qualitative study, the organization is the context that bounds the scope of interpretation and generalization. At the same time, the organization is subject to interpretation by the informants in the field study, becoming part of the frames enacted and disputed by different individuals.

2.3.4 **Longitudinal and prospective**

Two essential guiding principles of both of the studies is the emphasis on longitudinal data and an prospective perspective. First, a longitudinal approach is essential for any study looking to develop or test theories of organizational change (Huber and Van de Ven 1995). The quantitative large-sample study looks at firm response to the fiber optic revolution over a period of 20 years. Not only does this provide the opportunity to establish more clearly the direction of causality but it also allows me to examine the association between managerial cognitive frames and strategic action across different stages of development of the industry. Second, both studies are concerned with managers’ frames as they are constructed prospectively, that is to say, before the outcomes are known. The goal is to avoid any form of retrospective bias in accounts of what was known at the time strategic choices were being made. Some strategy scholars, recognizing the problem of retrospective bias, have attempted to accommodate the problem by suggesting ways to minimize it (through types of informants selected, framing of questions, or interview
methods) (Huber and Power 1985). However, my approach is aimed at avoiding the problem altogether. In the quantitative study, the Letters to Shareholders are superior to ex post interviews because they capture the views of management at a moment in time. In the field study, I focused on observations and interviews of people about what was going on in the present. To the extent that informants discussed events that took place in the past, I also gathered archival materials (e.g., emails and presentations) to determine to what degree the current interpretation was consistent with that of the past.

These four principles – grounded theory building, multi-method, multi-level, and a prospective, longitudinal approach – have guided the overall research design of the dissertation project as well as the specific choices in each of the two studies.

* * *

In this chapter, I have argued for the potential of a cognitive explanation of firm response to discontinuity. In particular, I proposed several research questions focused on understanding the relationships between frames and strategic action the specific mechanisms that connect them. I suggested that an examination of communication technology firm response to the fiber-optic revolution would be an ideal setting to examine these dynamics. I outlined a quantitative, large-sample macro study and qualitative, micro field study that I conducted to provide empirical evidence in response to the research questions. In Chapter 3, I report on the results of the macro, quantitative study. In Chapters 4 and 5, I describe the results of the qualitative field study. In Chapter 6, I integrate the two studies to produce a structurational model of framing that can help explain firm response to technical change.
Appendix to Chapter Two – How fiber optics work

Fiber optics is the science and technology of transmitting information in the form of light through a glass fiber. Optical fibers (also known as waveguides) are strands of glass about the diameter of human hair (Figure 2-7). They come in two types: multi-mode fibers have large cores (62.5 microns in diameter) and transmit infrared light (850-1,300 nm) from light emitting diodes (LEDs). Single-mode fibers have small cores (9 microns in diameter) and transmit infrared light (1,300-1,550 nm) from lasers. Transmission of light in a glass fiber works because of the cladding (mirror-lined walls) around the core of the fiber. Even if the fiber bends, light can continue to travel down the core because it simply bounces off the walls. This is called total internal reflection. Despite the total internal reflection, the signal will degrade over longer distances due primarily to impurities in the glass and to the wavelength being transmitted. The fiber is then covered in a buffer coating that protects it from the elements.

Figure 2-7: Schematic of an optical fiber

A fiber-optic communication system requires many other optically-specific technologies than just the fiber itself (Figure 2-8). A transmitter converts an electrical signal (either analog or digital) to an optical signal (a lambda, λ). The source can either be an LED or a laser diode. The receiver converts the optical signal back to the original electrical signal using a photodiode detector. Amplifiers (regenerators) are boosting the signal along the path of transmission. The
optical network system is currently in its third generation. The first generation was SONET (synchronous optical network) which was a single channel, time division multiplexing based system. The second generation was WDM and DWDM (dense wavelength division multiplexing) which was a multi-channel solution to fiber exhaust. The third generation currently emerging is intelligent optical networking (software platforms that take advantage of optical capabilities).

Figure 2-8: Basic point-to-point fiber optic transmission system

Amplifiers have historically required optical-electrical-optical (O-E-O) conversion meaning that the signal had to be converted back to electrical, boosted and then converted into an optical signal again. More recent technologies such as the erbium doped fiber amplifier (EDFA) allow regeneration to take place entirely optically. EDFA’s are optical fibers that have been “doped” (coated) with erbium which become lasers themselves when pumped with a laser at another wavelength. When the degraded signal enters to doped area, they draw energy from the laser pumping and are able to emit a new, stronger signal with the same features as the degraded signal that entered the amplifier. EDFA’s only do reamplification and don’t perform the other functions of an O-E-O switch (e.g., retiming and reshaping of the signal). Therefore, they do not completely replace O-E-O boxes, but just make it possible to place them less frequently in the system.

More advanced systems have permitted multiple signals to travel down the same fiber. This is called wavelength division multiplexing (WDM) (Figure 2-9). This system adds optical multiplexers (gather together multiple optical signals) and demultiplexers (separate them back out) to the system. Multiplexing technology had been around for more than 100 years having
been initially developed for increasing the flow of telegraph signals. In an optical system, multiplexing was prohibitively expensive without optical regeneration (e.g., EDFA’s) because each individual signal had to go through the O-E-O conversion separately at each amplification stage. This required a massive amount of expensive equipment. But, with the invention and development of EDFA’s, multiplexing became feasible as the amplification could take place without demultiplexing and multiplexing at each stage.

Figure 2-9: Wavelength division multiplexing

The WDM system is comprised of several key technologies: the EDFA, the (de)multiplexers and various cross connects (Table 2-2).
Table 2-2: Key technologies in WDM system

<table>
<thead>
<tr>
<th>Device</th>
<th>Function</th>
<th>Technologies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Erbium-doped fiber amplifier</td>
<td>Provides flat gain spectrum to WDM channels</td>
<td>Silica-based or fluoride-based fibers, laser pumps</td>
</tr>
<tr>
<td>(EDFA)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Multiplexer/demultiplexer</td>
<td>Combines/separates multiple wavelength channels onto/from a single fiber</td>
<td>Waveguide arrays, zigzag filters, interference filters, diffraction gratings, fiber gratings, fuse couplers</td>
</tr>
<tr>
<td>Wavelength add/drop multiplexer</td>
<td>Adds or drops one or more wavelength channels without terminating the entire layer</td>
<td>Fuse couplers, interference filters, circulators and fiber Bragg gratings, Mach-Zehnder interferometers</td>
</tr>
<tr>
<td>Wavelength interchange</td>
<td>Crossconnects signals with allowance for wavelength interchange</td>
<td>Optoelectronic regeneration, cross-gain modulation, optical nonlinearity, mechanical</td>
</tr>
<tr>
<td>crossconnect</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wavelength-selective</td>
<td>Crossconnects individual wavelengths without wavelength interchange</td>
<td>Fused couplers, interference filters, circulators and fiber Bragg gratings, Mach-Zehnder interferometers</td>
</tr>
<tr>
<td>crossconnect</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Optical crossconnect</td>
<td>Optical signal switching</td>
<td>Electromechanical, electrooptic</td>
</tr>
</tbody>
</table>

Wavelength division multiplexing has evolved in its capabilities since the late 1980's. Increases in channel density (the spacing between wavelengths being sent through the fiber) have radically increased the carrying capacity of the fiber, and this rate of improvement has increased exponentially (Figure 2-10).

Figure 2-10: Evolution of DWDM technology

![Figure 2-10: Evolution of DWDM technology]

Source: Adapted from “Fundamentals of DWDM Technology,” Chapter 2
Chapter Three

At the heart of a revolution: communications firm responses to the emergence of optical technologies

3.1 Introduction

3.2 Setting – the optical technology revolution 1982-2001

3.3 Analytical approach
   3.3.1 Sample construction
   3.3.2 Construction of variables and sources of data
   3.3.3 Dependent variable – measure of strategic action
   3.3.4 Independent variable – measure of cognitive frames about optical technologies
   3.3.5 Controls/alternative explanations
   3.3.6 Estimation

3.4 Preliminary results and analysis
   3.4.1 Qualitative evidence and descriptive statistics
   3.4.2 Results from regressions

3.5 Discussion and conclusion

Appendix to Chapter Three: count model regression using optical patent counts

Appendix to Chapter Three: using optical publications as dependent variable

3.1 Introduction

Telecommunications is the "killer app" driving the Internet revolution. This is good news for a company like Nortel Networks that understands both telecommunications and the Internet. It puts your company at the heart of the revolution – the coming together of public and private networks with the Internet. High-performance optical technology is powering the Internet revolution that's changing the way the world communicates. Seventy-five percent of Internet traffic in North America is carried on Nortel Networks high-performance optical networks... Together, the Internet and the World Wide Web are having a major impact on the volume and kinds of traffic carried on the world's networks. They're helping to change the way we think about networks and the very nature of what networks do... Your company has always succeeded by taking a leadership position, embracing discontinuities and capitalizing on change to fuel new growth and improve competitiveness. Nortel Networks rose to the challenges of leadership with digital, wireless, and fiber-optic systems. (Nortel Networks Letter to Shareholders, Donald Schuenke Chairman of the Board, John Roth, Vice-Chairman and Chief Executive Officer 1998 Annual Report)
This excerpt of the Letter to Shareholders written by Nortel Networks' senior executives indicates the central importance they assigned to optical technologies. This quote is an example of top managers' interpretations of the nature of technical change. In this chapter, I will use this kind of evidence to explore the association between the managers' frames of the importance of optical technologies and technical outcomes in the form of patenting over the course of the fiber-optic revolution.

As I discussed in Chapter 2, this study is part of a stream of research in the management of technology field that has been occupied with resolving essential questions about firm fate in periods of discontinuity. Why do different companies respond differently during discontinuities? What factors determine their fates? There is general agreement that discontinuities create problems for established firms, but there is no consensus as to why discontinuities should be so difficult to manage (Christensen and Rosenbloom 1995; Cooper and Schendel 1976; Henderson and Clark 1990; Tushman and Anderson 1986; Utterback 1994). Scholars have suggested such culprits as rigidities in organizational capabilities, inability to manage changes in value networks, and failures of incentives; but, with some important exceptions, this stream of the literature has not focused attention on management's cognitive processes (those explanations which link management noticing and interpreting the nature of the technological change and translating those perspectives into strategic choice and action). However, as I demonstrate in this chapter, top management's interpretations of the nature of technical change in the communications technology industry were salient factors in shaping strategic action.

In this study, I focus on the cognitive frames of top managers in particular. The idea that senior managers play an important role in setting strategy has, of course, a long and distinguished pedigree, dating back to Andrews (1971) and Selznick (1957). While some argue that top managers do not have a substantive impact on performance (Pfeffer 1981), there is also a rich body of work providing support for managerial discretion in eras of ferment. Tushman and his collaborators, for example have found that those firms that successfully navigate major discontinuities have more variance in team tenure and background or tend to replace their senior management teams at critical moments, suggesting that senior management teams play an important role in shaping firm response (Tushman and Rosenkopf 1996; Virany, Tushman, and Romanelli 1992). Similarly, Eisenhardt and Bourgeois (1988) show that managers have
significant discretion in what they term “high velocity environments,” a conjecture that is certainly consistent with the hypothesis that the ability to change cognitive frames may be a critical skill in the face of discontinuity. In the case of discontinuities which can become “life or death” issues for organizations (or, at a minimum, define potentially extreme differences in performance), the upper echelon of the organization is an important focal level of analysis (Hambrick and Mason 1984). Scholars have suggested that in such “weak situations” (Mischel 1968) where the characteristics are not clear enough to dictate action, “the decision-maker’s … frame of reference, not the objective characteristics of the situation become the basis for action” (Finkelstein and Hambrick 1988, p. 20).

In this chapter, I report on the results of a macro, quantitative study designed to examine the relationship between managers’ cognitive frames about the importance of optical technologies and strategic outcomes as measured by patenting in the optical arena. This study aims to redress a gap in the managerial cognition literature in which empirical work on managerial frames in discontinuous situations has been primarily limited to case studies. Barr, Stimpert and Huff (1992) examined changing cognitive frames in two railways that differed in their response to changes in the industry over time. Tripsas and Gavetti (2000) studied Polaroid’s paradoxical response to the transition from analog to digital imaging technologies in which belief structures were inappropriate for the digital world. Garud and Rappa (1994) studied the development of cochlear implants in which beliefs among scientists about what is technically possible interacted with the actual technologies themselves to shape the trajectory of the technology.

While these results are provocative, they beg the question about observability in larger samples in which it would be possible to control for alternative explanations of firm response. Given the wide variety of explanations that have been advanced for firm response to technical change, adding controls for these alternatives would seem essential for establishing cognitive frames as a truly separate explanatory factor. Kaplan, Murray and Henderson (2003) quantitative study of 15 large, incumbent pharmaceutical firms’ responses to the emergence of biotechnology and Sharma’s (2000) study of 99 oil and gas firms’ responses to environmental issues are initial indications that more quantitative explorations could yield insight about the relationship between frames and action. Other larger “n” studies on managerial cognition (Baum...
and Lant 1995; Baum and Lant 2003; Porac, Thomas, Wilson, Paton, and Kanfer 1995; Thomas et al. 1993) generally focus on relatively stable settings or have not examined a changing environment over time.

In this vein, this study was designed as a longitudinal and quantitative exploration of the relationship between frames and action. Using a panel dataset of 72 firms in the communications technology industry, I examine the role of managerial interpretations of evolving technological change in shaping firms’ strategic responses. The study expands on the approach developed in Kaplan, Murray and Henderson (2003) in several ways. As a great deal of research in the management of technology field argues that incumbents and entrants respond differently to technical change (some suggesting incumbents can be more successful, others argue that it is the entrants38), this study includes both kinds of firms (and samples entrants from different time periods over the evolution of fiber-optics). The literature also argues that large and small firms have differential abilities to act (though, again, the predications are equivocal about the direction of the effect39), so this study includes firms of widely varying size in the sample. Over the past 20 years, communication technology companies have had to respond to the emergence of fiber-optics in what they themselves have called “the communications revolution,” “the Internet revolution,” “the networking revolution,” or “the broadband revolution.”40 The study covers two decades from the early introduction of fiber optics through the Internet bubble and crash (1982-2001).

The analysis proceeds through the estimation and interpretation of reduced form equation in which the dependent variable is a measure of the extent to which a firm has responded to

38 For example, early Schumpeter (1934) suggested that entrants would do better than incumbents. Later Schumpeter (1942) suggested that larger, incumbent firms would benefit from complementary assets and scale. The population ecologists support this view in arguing that there is a liability of newness for entrants (Freeman, Carroll, and Hannan 1983). Other scholars have suggested that incumbents and entrants may behave differently in different contexts, either depending on the type of innovation (Henderson 1993) or the skills of leaders (Chandler and Hikino 1990).

39 Some scholars have argued that large firms are more inertial than small firms (Cooper and Schendel 1976). Others have suggested that there are economies of scale in adoption of new technologies and therefore large firms are potentially less inertial (Klepper and Simons 1997), e.g., in the case of pharmaceutical firm adoption of biotechnology (Zucker and Darby 1997).

40 All of these quotes are from Letters to Shareholders from firms in the dataset I used for this study. They are different ways that management articulated the nature of the fiber-optic revolution.
optical technologies (through investment in patenting in optics) and the key explanatory variable is a measure of the importance that the top managers of a particular firm place on optical technologies in a prior year. I also include a series of control variables. In an effort to address alternative explanations for heterogeneous firm action, the study covers 72 firms, both large and small, both entrants and incumbents, with a wide range of capabilities and timing of entry. Using a measure of managerial cognitive frames constructed from word counts in the Letter to Shareholders from Annual Reports, I test for an association between cognitive frames and strategic choices about investment as represented by patent counts, an extension of the approach used in previous research examining incumbent pharmaceutical firm response to the emergence of biotechnology (Kaplan et al. 2003). I use several controls for alternative explanations to begin to understand the relationship between these factors and strategic outcomes during periods of technical change. The results are consistent with the idea that senior manager’s frames of the technology help explain firm response to technical change during periods of discontinuity.

This chapter proceeds by first describing the setting and phenomenon. The next section discusses the analytical approach and the construction of key measures. The following section reports results from descriptive and regression analyses, and the final section concludes with a discussion of implications.

3.2 Setting – the optical technology revolution 1982-2001

As described in Chapter 2, the communications industry is as an old one that has experienced a number of revolutions in its history, from the introduction of the telegraph and the telephone, to the switch from analog to digital signal technologies and now more recently the emergence of optical technologies. The fiber-optic revolution, while having its technical and scientific roots in developments throughout the 20th century (and before), began to influence the direction of the communications industry in the 1980’s. Coupled with the arrival of the Internet and World Wide Web, fiber-optics have changed the way we communicate and have reshaped the communications industry. Fiber dramatically changed the cost/performance equation for communications (as described in Chapter 2). The switch from copper to fiber dropped the cost of voice and data transmission. As more fiber was laid in the ground, it enabled vastly larger quantities of information to be transmitted. This opened up new potential applications, including the World Wide Web, because a click on a hyperlink could travel to the intended server at the
speed of light and return a response equally quickly. Optical technologies have been enabling technologies for a host of related revolutions: the Internet, the World Wide Web, the convergence of data and voice, Napster, etc. Fiber optics are in this sense what Bresnahan and Trajtenberg called “general purpose technology” which is “characterized by a potential for use in a wide range of sectors and by their technological dynamism...[and] play a role of ‘enabling technologies,’ opening up new opportunities rather than offering complete, final solutions” (Bresnahan and Trajtenberg 1995: 84). The revolutionary developments in fiber optics gave rise to a whole host of complementary technical changes. This setting is particularly suited to my research because it has been a “high velocity environment” (Bourgeois and Eisenhardt 1988).

For the purposes of this study, I categorize the fiber-optic revolution into 4 periods: early development of fiber (pre 1985), first applications (1986-1991), rapid growth (1992-1996) and the communications bubble (1997-2001). These periods coincide both with important technical and industry changes. And, because these periods provided a very different environment for firm entry, my sampling approach included both incumbents and firms that entered in each different stage of industry development. Descriptive results suggest that these firms were qualitatively different in the relationship between frames and strategic action. While I described the industry evolution in Chapter 2, here I provide a brief reprise to set the context for this specific analysis.

Early development of fiber (pre-1985). While optical fiber had been produced in the late 1970’s by Corning, it was only introduced in the first commercial systems in 1982-85 when MCI put in fiber in the Washington-New York corridor, AT&T installed fiber in the Boston-Washington route and British Telecom laid the first submarine fiber to the Isle of Wight. The use of fiber expanded rapidly in the late 1980’s but it was not without its limits. In particular, because of attenuation, the signal needed to be boosted with amplifiers at regular intervals (a number of kilometers). Amplification was very expensive because it required the conversion of the light signal into an electrical signal and then back to a light signal (known as optical-electrical-optical or O-E-O conversion). This was done with relatively costly electronics in large boxes. In addition, separate amplifiers were required for each wavelength of light. At this time, a small number of large equipment firms dominated the communications technology market. This was particularly true because most countries had single monopolies providing telephone services and communications technologies. And, these firms were often both the major
consumer as well as provider of communications technologies (as in the case of AT&T in the US, British Telecom in the UK, etc.).

First applications (1986-1991). In the late 1980’s, scientists began to make breakthroughs in fiber-based amplification that would avoid the O-E-O conversion and dramatically reduce the cost of amplification (mainly in the form of erbium doped fiber amplifiers, or, EDFA’s). Simultaneously, research focused on finding ways to send multiple colors of light down the same fiber at the same time in order to increase the capacity of each fiber (a technique known as wave division multiplexing or WDM). Multiplexing was at first prohibitively expensive because it required separate amplification for each wavelength at each amplification point. Sales of optical fiber itself slowed dramatically at the end of this time period. However, the breakup of AT&T created a new set of customers in the form of the Baby Bells and released them from the grip of the AT&T equipment technology. This created fertile ground for later entry of new suppliers.

Rapid growth (1992-1996). By 1992, EDFA products were launched onto the market. This technology made multiplexing more attractive because it reduced amplification costs. Their first application was in reducing amplification costs in submarine applications where small, watertight amplifiers could be placed every 50 miles or so. Later, firms began to see the potential for applying EDFA technology in combination with multiplexing to increase the capacity of existing fibers. The first commercial dense wavelength division multiplexed network went into operation in 1995. The introduction of this technology coincided with and co-evolved with the emergence of the Internet in a way that created tremendous growth in the industry as demand for optical technologies grew rapidly in the late 1990’s. This period closed with the US Telecommunications Act of 1996 which was the first major update of US communications since 1934. This Act significantly deregulated telecommunications with the goal “to let anyone enter any communications business – to let any communications business compete in any market against any other.” It paved the way for the entry of many CLEC’s (Competitive Local

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41 As discussed in more detail in Chapter 2.

42 European countries and Japan maintained their single monopolies for the most part, but the changes in the larger US market along was enough to trigger entry of suppliers.

43 From FCC website describing the Telecommunications Act: http://www.fcc.gov/telecom.html
Exchange Carriers) that competed directly with the traditional phone service providers. These CLEC’s were not burdened with legacy equipment and therefore were more likely to be interested in investing in optical technologies. This increased the demand for optics throughout the industry and entry of new communications technology firms spiked as players with different new technologies tried to get in on the game.

**Communications bubble (1997-2001).** The late 1990’s saw the communications and Internet revolution boom and bust. Carriers had embarked on a major program to lay new fiber in the ground to keep up with rapidly increasing forecasted demand for bandwidth. At the same time, WDM and EDFA technologies were increasing the capacity of each of those fibers. Entry continued unabated in the late 1990’s, but these two trends collided creating a tremendous bandwidth glut in the long haul segment of the market. At that point, the product market collapsed. Many of the CLEC’s went out of business. Many technology providers exited. Entry came to a halt.

During the evolution of fiber optics, entrants and incumbents had differential (perceived) abilities to respond to the technical change posed by the optical revolution. For example, in their Annual Report, Alcatel (a large, foreign incumbent) spoke of their lack of technical leadership in certain areas and their attempt to use scale to make up for it: “Having purchased companies at the leading edge of technology, we have leapfrogged ahead of most competitors - including those who were involved in these fields before us. Today, Alcatel is at the intersection of Internet, optical networks and network intelligence. These three areas are important to preparing and implementing next-generation networks. Today, Alcatel is poised to take advantage of the Internet revolution” (Serge Tchuruk, Chairman, Letter to Shareholder, Alcatel, 1998). Nortel, a large, North American incumbent spoke often of their ability to “capitalize on the enormous opportunities generated by the Internet Revolution” (Frank Carlucci, Chairman, and John Roth, CEO, Letter to Shareholders, Nortel 1999).

On the other hand, Ciena, an equipment company that went public in 1997 declared their ability to shape the market even as a small player: “Ciena’s timely application of optical technology in products that enable service providers to deploy additional bandwidth – without disrupting existing traffic flows – made it possible for Ciena to enter and impact the
telecommunications equipment market in ways usually reserved for much larger and longer-established companies” (Patrick Nettles, CEO, Letter to Shareholder, Ciena, 1997).

3.3 Analytical approach

The analysis of communication firms’ responses to optical technologies proceeds through an estimation and interpretation of a reduced form equation,

\[ Y_{j,t} = f(X_{j,t-n}, Z_{j,t-n}, \mu) \]

where \( Y_{j,t} \), the dependent variable, is a measure of strategic action (the extent to which firm j has responded to optical technologies in time t). The key explanatory variable \( X_{j,t-n} \) is a measure of the importance that the top managers of a particular firm places on optical technologies in a prior year and \( Z_{j,t-n} \) is a vector of control variables, also lagged. Using a measure of senior managers’ cognitive frames about optical technologies derived from each firm’s “Letter to Shareholders” and measures of strategic response in the form of optical technology patents, I hypothesize that top managers’ frames about the importance of new optical technologies is systematically associated with strategic action, even when controlling for a number of important alternative explanations.

An obvious alternative explanation is that the structure of causality is reversed: individual scientists or middle managers make the decision to invest in optical technologies and that if these investments prove to be successful they lead to both patents and mention of optical technologies by senior managers in the Annual Report. It is highly likely that this alternative is an important dynamic in what is a highly complex system of management recognition of technologies and firm response. Some research has shown that organizational change can often come despite top management disregard of new technologies – as in the case of Intel’s exiting the DRAM business through the autonomous action of middle management (Burgelman 1994). In order to understand these dynamics, in this chapter, I test the relationship of frames and action “in reverse.”
3.3.1 Sample construction

The analysis covers 72 firms in the communications technology industry. These represent a stratified random sample from 617 firms traded on US stock exchanges, about 10% of which are non-US firms listed in the US. The original population was established by selecting all 1,752 firms in primary and secondary NAICS (previously known as SIC) codes covering communications equipment firms. I then collected short (one paragraph) descriptions of each firm. Based on these descriptions, three different coders determined separately whether the firm had a significant business in communications technologies. Interrater reliability was .75. Where there were disagreements, we discussed the differences and reached a consensus about the categorization. The remaining 617 firms that were categorized as having a significant communications business were divided into 4 age cohorts – incumbent (entry 1985 or before), early entrant (1986-1991), mid entrant (1992-1996) and bubble entrant (1997-2001). They were also categorized in 3 size cohorts – large (greater than $1 billion in average inflation adjusted sales over the time period in the dataset), medium ($100 million to $1 billion) and small (less than $100 million).

Where possible, 5 firms were randomly selected from each of the 12 strata of firms (4 age cohorts times 3 size cohorts). Where there were fewer than 5 firms, all of the firms were selected. I also oversampled the population of large incumbents, selecting all 20 firms in order to have a larger sample for incumbent-entrant comparisons. Ten firms exit the dataset by being acquired, going bankrupt or being taken private. AT&T was removed from the dataset after its divestiture of Lucent Technologies because it was no longer a supplier of communications technologies. Table 3-1 provides the sampling weights by stratum.

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44 The companies covered in the analysis are equipment, component, test and measurement, and subcomponent (semiconductor) companies in communications. For brevity, I refer to them as communications technology companies.

45 NAICS codes (North American Industrial Classification System, previously known as SIC codes) that cover communications equipment and components companies included: 334119, 334210, 334220, 334413, 334418, 334415, 335921, 541512.
Table 3-1: Sampling weights for stratified random sample of 72 firms in the communications equipment industry

Random sample of five firms (where possible) taken from each of 12 subsets (combining 4 age cohorts and 3 size cohorts). Oversampling of all 20 firms that were large incumbents (1,1). Only 4 firms in the population 2,1 and only 3 firms in 3,1 (large entrants in the 2nd and 3rd age cohorts).

<table>
<thead>
<tr>
<th>Entry</th>
<th>Average size</th>
<th>Stratum</th>
<th>Population</th>
<th>Sample</th>
<th>% of population</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incumbent</td>
<td>Large</td>
<td>11</td>
<td>20</td>
<td>20</td>
<td>100%</td>
</tr>
<tr>
<td></td>
<td>Medium</td>
<td>12</td>
<td>66</td>
<td>5</td>
<td>8%</td>
</tr>
<tr>
<td></td>
<td>Small</td>
<td>13</td>
<td>116</td>
<td>5</td>
<td>4%</td>
</tr>
<tr>
<td>Early entrant</td>
<td>Large</td>
<td>21</td>
<td>4</td>
<td>4</td>
<td>100%</td>
</tr>
<tr>
<td></td>
<td>Medium</td>
<td>22</td>
<td>25</td>
<td>5</td>
<td>20%</td>
</tr>
<tr>
<td></td>
<td>Small</td>
<td>23</td>
<td>59</td>
<td>5</td>
<td>8%</td>
</tr>
<tr>
<td>Mid entrant</td>
<td>Large</td>
<td>31</td>
<td>3</td>
<td>3</td>
<td>100%</td>
</tr>
<tr>
<td></td>
<td>Medium</td>
<td>32</td>
<td>53</td>
<td>5</td>
<td>9%</td>
</tr>
<tr>
<td></td>
<td>Small</td>
<td>33</td>
<td>130</td>
<td>5</td>
<td>4%</td>
</tr>
<tr>
<td>Bubble entrant</td>
<td>Large</td>
<td>41</td>
<td>13</td>
<td>5</td>
<td>38%</td>
</tr>
<tr>
<td></td>
<td>Medium</td>
<td>42</td>
<td>23</td>
<td>5</td>
<td>22%</td>
</tr>
<tr>
<td></td>
<td>Small</td>
<td>43</td>
<td>105</td>
<td>5</td>
<td>5%</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td>617</td>
<td>72</td>
<td>12%</td>
</tr>
</tbody>
</table>

Timing of entry has also been argued to be critical for determining firm success or failure in the face of a new technology. The evidence is mixed though it leans to the notion that incumbents will (rationally) under invest in new technological areas (Cockburn and Henderson 1994; Gilbert and Newbery 1982; Reinganum 1983). Christensen, Suarez and Utterback (1998) suggest that entry just before the emergence of a dominant design leads to better performance while Klepper and Simons (1997; 2000) find that early entry (leading to scale economies) is most effective. Here, I use the age cohort to characterize entry timing. Incumbents (cohort 1) covers incumbent firms before the emergence of anything but the most rudimentary fiber optics. Early entrants (cohort 2: entry between 1986-1991) cover those firms that entered when new optical technologies such as erbium doped fiber amplifiers and wavelength division multiplexing were under development but there were no commercially viable options. Mid entrants (cohort 3: entry during 1992-1996) cover firms that entered as these new optical technologies became commercially viable. “Bubble” entrants (cohort 4) are firms that entered 1997-2001 during the bubble when optical technologies combined with the internet created a major boom in the
industry. In the analyses that follow, I examine how the relationship between management frames and strategic action differs for each of these cohorts.46

Table 3-2: Stratified random sample of 72 firms in the communications technology industry

<table>
<thead>
<tr>
<th>Company Name</th>
<th>Non-US</th>
<th>Left censor</th>
<th>Right censor</th>
<th>Entry cohort</th>
<th>Size cohort</th>
<th>Type of entrant</th>
</tr>
</thead>
<tbody>
<tr>
<td>3Com Corp.</td>
<td>1982</td>
<td>2001</td>
<td>1</td>
<td>1</td>
<td>Incumbent</td>
<td></td>
</tr>
<tr>
<td>Agilent Technologies Inc.</td>
<td>1999</td>
<td>2001</td>
<td>4</td>
<td>1</td>
<td>De novo</td>
<td></td>
</tr>
<tr>
<td>Alcatel -ADS</td>
<td>Yes</td>
<td>1982</td>
<td>2001</td>
<td>1</td>
<td>1</td>
<td>Incumbent</td>
</tr>
<tr>
<td>Anadigics Inc.</td>
<td>1995</td>
<td>2001</td>
<td>3</td>
<td>3</td>
<td>De novo</td>
<td></td>
</tr>
<tr>
<td>Andrea Electronics Corp.</td>
<td>1982</td>
<td>2001</td>
<td>1</td>
<td>3</td>
<td>Incumbent</td>
<td></td>
</tr>
<tr>
<td>AT&amp;T Corp.</td>
<td>1982</td>
<td>1996</td>
<td>1</td>
<td>1</td>
<td>Incumbent</td>
<td></td>
</tr>
<tr>
<td>Atmel Corp.</td>
<td>1991</td>
<td>2001</td>
<td>2</td>
<td>2</td>
<td>De novo</td>
<td></td>
</tr>
<tr>
<td>Bay Networks Inc.</td>
<td>1991</td>
<td>1998</td>
<td>2</td>
<td>1</td>
<td>De novo</td>
<td></td>
</tr>
<tr>
<td>Bookham Technology PLC -ADR</td>
<td>Yes</td>
<td>2000</td>
<td>2001</td>
<td>4</td>
<td>3</td>
<td>De novo</td>
</tr>
<tr>
<td>Brocade Communications Sys.</td>
<td>1999</td>
<td>2001</td>
<td>4</td>
<td>2</td>
<td>De novo</td>
<td></td>
</tr>
<tr>
<td>Brooktrout Inc.</td>
<td>1992</td>
<td>2001</td>
<td>3</td>
<td>3</td>
<td>De novo</td>
<td></td>
</tr>
<tr>
<td>California Micro Devices Corp.</td>
<td>1987</td>
<td>2001</td>
<td>2</td>
<td>3</td>
<td>De novo</td>
<td></td>
</tr>
<tr>
<td>Ciena Corp.</td>
<td>1996</td>
<td>2001</td>
<td>3</td>
<td>2</td>
<td>De novo</td>
<td></td>
</tr>
<tr>
<td>Cisco Systems Inc.</td>
<td>1990</td>
<td>2001</td>
<td>2</td>
<td>1</td>
<td>De novo</td>
<td></td>
</tr>
<tr>
<td>Converse Technology Inc.</td>
<td>1985</td>
<td>2001</td>
<td>1</td>
<td>2</td>
<td>Incumbent</td>
<td></td>
</tr>
<tr>
<td>Conexant Systems Inc.</td>
<td>1999</td>
<td>2001</td>
<td>4</td>
<td>1</td>
<td>De novo</td>
<td></td>
</tr>
<tr>
<td>Corning Inc.</td>
<td>1982</td>
<td>2001</td>
<td>1</td>
<td>1</td>
<td>Incumbent</td>
<td></td>
</tr>
<tr>
<td>Corvis Corp.</td>
<td>2000</td>
<td>2001</td>
<td>4</td>
<td>2</td>
<td>De novo</td>
<td></td>
</tr>
<tr>
<td>DMC Stratex Networks Inc.</td>
<td>1987</td>
<td>2001</td>
<td>2</td>
<td>2</td>
<td>De novo</td>
<td></td>
</tr>
<tr>
<td>ECI Telecommunications -Orç</td>
<td>Yes</td>
<td>1982</td>
<td>2001</td>
<td>1</td>
<td>2</td>
<td>Incumbent</td>
</tr>
<tr>
<td>Epcom AG -ADR</td>
<td>Yes</td>
<td>1999</td>
<td>2001</td>
<td>4</td>
<td>1</td>
<td>De novo</td>
</tr>
<tr>
<td>Ericsson (L M) Tel - ADR</td>
<td>Yes</td>
<td>1982</td>
<td>2001</td>
<td>1</td>
<td>1</td>
<td>Incumbent</td>
</tr>
<tr>
<td>Fibercore Inc.</td>
<td>1995</td>
<td>2001</td>
<td>3</td>
<td>3</td>
<td>De novo</td>
<td></td>
</tr>
<tr>
<td>Finisar Corp.</td>
<td>2000</td>
<td>2001</td>
<td>4</td>
<td>3</td>
<td>De novo</td>
<td></td>
</tr>
<tr>
<td>Franklin Telecommunications</td>
<td>1987</td>
<td>2001</td>
<td>2</td>
<td>3</td>
<td>De novo</td>
<td></td>
</tr>
<tr>
<td>Fujitsu Ltd. - ADR</td>
<td>Yes</td>
<td>1982</td>
<td>2001</td>
<td>1</td>
<td>1</td>
<td>Incumbent</td>
</tr>
<tr>
<td>General Datacomm Inds</td>
<td>1982</td>
<td>2000</td>
<td>1</td>
<td>2</td>
<td>Incumbent</td>
<td></td>
</tr>
<tr>
<td>General Instrument Corp.</td>
<td>1982</td>
<td>1998</td>
<td>1</td>
<td>1</td>
<td>Incumbent</td>
<td></td>
</tr>
<tr>
<td>Harris Corp.</td>
<td>1982</td>
<td>2001</td>
<td>1</td>
<td>1</td>
<td>Incumbent</td>
<td></td>
</tr>
<tr>
<td>Hubbell Inc.</td>
<td>1982</td>
<td>2001</td>
<td>1</td>
<td>1</td>
<td>Incumbent</td>
<td></td>
</tr>
<tr>
<td>Infineon Techniqies AG -ADR</td>
<td>Yes</td>
<td>2000</td>
<td>2001</td>
<td>4</td>
<td>1</td>
<td>De ako</td>
</tr>
<tr>
<td>Interdigital Commun Corp.</td>
<td>1982</td>
<td>2001</td>
<td>1</td>
<td>3</td>
<td>Incumbent</td>
<td></td>
</tr>
<tr>
<td>Intersil Corp.</td>
<td>2000</td>
<td>2001</td>
<td>4</td>
<td>2</td>
<td>De novo</td>
<td></td>
</tr>
<tr>
<td>ITT Industries Inc.</td>
<td>1982</td>
<td>2001</td>
<td>1</td>
<td>1</td>
<td>Incumbent</td>
<td></td>
</tr>
<tr>
<td>JDS Uniphase Corp.</td>
<td>1993</td>
<td>2001</td>
<td>3</td>
<td>2</td>
<td>De novo</td>
<td></td>
</tr>
<tr>
<td>Kyocera Corp. -ADR</td>
<td>Yes</td>
<td>1982</td>
<td>2001</td>
<td>1</td>
<td>1</td>
<td>Incumbent</td>
</tr>
<tr>
<td>Lucent Technologies Inc.</td>
<td>1996</td>
<td>2001</td>
<td>3</td>
<td>1</td>
<td>De ako</td>
<td></td>
</tr>
<tr>
<td>Madge Networks NV</td>
<td>Yes</td>
<td>1993</td>
<td>2001</td>
<td>3</td>
<td>2</td>
<td>De novo</td>
</tr>
</tbody>
</table>

46 In the regression analysis, results do not converge for any of entrant cohort subsample (nor for the entire group of entrants), so results are only reported for the incumbent subsample.
<table>
<thead>
<tr>
<th>Company Name</th>
<th>Non-US</th>
<th>Left censor(^a)</th>
<th>Right censor(^a)</th>
<th>Entry cohort(^b)</th>
<th>Size cohort(^c)</th>
<th>Type of entrant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maxim Integrated Products</td>
<td>1988</td>
<td>2001</td>
<td>2</td>
<td>2</td>
<td>De novo</td>
<td></td>
</tr>
<tr>
<td>MCK Communications Inc.</td>
<td>1999</td>
<td>2001</td>
<td>4</td>
<td>3</td>
<td>De novo</td>
<td></td>
</tr>
<tr>
<td>Metalink Ltd.</td>
<td>Yes</td>
<td>1999</td>
<td>4</td>
<td>3</td>
<td>De novo</td>
<td></td>
</tr>
<tr>
<td>Microlink International Inc.</td>
<td>1986</td>
<td>2001</td>
<td>2</td>
<td>3</td>
<td>De novo</td>
<td></td>
</tr>
<tr>
<td>Microwave Filter Co Inc.</td>
<td>1983</td>
<td>2001</td>
<td>1</td>
<td>3</td>
<td>Incumbent</td>
<td></td>
</tr>
<tr>
<td>Motorola Inc.</td>
<td>1982</td>
<td>2001</td>
<td>1</td>
<td>1</td>
<td>Incumbent</td>
<td></td>
</tr>
<tr>
<td>National Semiconductor Corp.</td>
<td>1982</td>
<td>2001</td>
<td>1</td>
<td>1</td>
<td>Incumbent</td>
<td></td>
</tr>
<tr>
<td>NEC Corp. - ADR</td>
<td>Yes</td>
<td>1982</td>
<td>1</td>
<td>1</td>
<td>Incumbent</td>
<td></td>
</tr>
<tr>
<td>Newbridge Networks Corp.</td>
<td>Yes</td>
<td>1989</td>
<td>1998</td>
<td>2</td>
<td>2</td>
<td>De novo</td>
</tr>
<tr>
<td>Nokia Corp. - ADR</td>
<td>Yes</td>
<td>1984</td>
<td>2001</td>
<td>1</td>
<td>1</td>
<td>Incumbent</td>
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<td>Nortel Networks Corp.</td>
<td>Yes</td>
<td>1982</td>
<td>2001</td>
<td>1</td>
<td>1</td>
<td>Incumbent</td>
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<tr>
<td>ON Semiconductor Corp.</td>
<td>2000</td>
<td>2001</td>
<td>4</td>
<td>1</td>
<td>De alio</td>
<td></td>
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<tr>
<td>Openroute Networks Inc.</td>
<td>1990</td>
<td>1996</td>
<td>2</td>
<td>3</td>
<td>De novo</td>
<td></td>
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<tr>
<td>Optek Technology Inc.</td>
<td>1987</td>
<td>1998</td>
<td>2</td>
<td>3</td>
<td>De novo</td>
<td></td>
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<tr>
<td>Optical Cable Corp.</td>
<td>1996</td>
<td>2001</td>
<td>3</td>
<td>3</td>
<td>De novo</td>
<td></td>
</tr>
<tr>
<td>Paradyne Corp.</td>
<td>1982</td>
<td>1987</td>
<td>2</td>
<td>3</td>
<td>De novo</td>
<td></td>
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<tr>
<td>PerkinElmer Inc.</td>
<td>1982</td>
<td>2001</td>
<td>1</td>
<td>1</td>
<td>Incumbent</td>
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<tr>
<td>Porta Systems Corp.</td>
<td>1982</td>
<td>2001</td>
<td>1</td>
<td>3</td>
<td>Incumbent</td>
<td></td>
</tr>
<tr>
<td>Qualcomm Inc.</td>
<td>1991</td>
<td>2001</td>
<td>2</td>
<td>1</td>
<td>De novo</td>
<td></td>
</tr>
<tr>
<td>Raychem Corp.</td>
<td>1982</td>
<td>1998</td>
<td>1</td>
<td>1</td>
<td>Incumbent</td>
<td></td>
</tr>
<tr>
<td>Reliance Electric Co.</td>
<td>1987</td>
<td>1993</td>
<td>2</td>
<td>1</td>
<td>De novo</td>
<td></td>
</tr>
<tr>
<td>Remec Inc.</td>
<td>1996</td>
<td>2001</td>
<td>3</td>
<td>2</td>
<td>De novo</td>
<td></td>
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<tr>
<td>Research In Motion</td>
<td>Yes</td>
<td>1997</td>
<td>2001</td>
<td>4</td>
<td>2</td>
<td>De novo</td>
</tr>
<tr>
<td>SBS Technologies Inc.</td>
<td>1992</td>
<td>2001</td>
<td>3</td>
<td>3</td>
<td>De novo</td>
<td></td>
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<tr>
<td>Siemens AG - ADR</td>
<td>Yes</td>
<td>1982</td>
<td>2001</td>
<td>1</td>
<td>1</td>
<td>Incumbent</td>
</tr>
<tr>
<td>STMicron Electronics NV</td>
<td>Yes</td>
<td>1994</td>
<td>2001</td>
<td>3</td>
<td>1</td>
<td>De novo</td>
</tr>
<tr>
<td>Stratacom Inc.</td>
<td>1992</td>
<td>1995</td>
<td>3</td>
<td>2</td>
<td>De alio</td>
<td></td>
</tr>
<tr>
<td>Superior Telecom Inc.</td>
<td>1996</td>
<td>2001</td>
<td>3</td>
<td>1</td>
<td>De novo</td>
<td></td>
</tr>
<tr>
<td>Tebyte Inc.</td>
<td>1983</td>
<td>2001</td>
<td>1</td>
<td>3</td>
<td>Incumbent</td>
<td></td>
</tr>
<tr>
<td>Terayon Commun Systems Inc.</td>
<td>1998</td>
<td>2001</td>
<td>3</td>
<td>2</td>
<td>De novo</td>
<td></td>
</tr>
<tr>
<td>Texas Instruments Inc.</td>
<td>1982</td>
<td>2001</td>
<td>1</td>
<td>1</td>
<td>Incumbent</td>
<td></td>
</tr>
<tr>
<td>Triangle Industries Inc.</td>
<td>1982</td>
<td>1987</td>
<td>2</td>
<td>1</td>
<td>De novo</td>
<td></td>
</tr>
<tr>
<td>Turnstone Systems Inc.</td>
<td>1999</td>
<td>2001</td>
<td>4</td>
<td>3</td>
<td>De novo</td>
<td></td>
</tr>
<tr>
<td>Vitesse Semiconductor Corp.</td>
<td>1991</td>
<td>2001</td>
<td>2</td>
<td>2</td>
<td>De novo</td>
<td></td>
</tr>
</tbody>
</table>

\(^a\) = Left censored at 1982 (earliest sampling date) or the date that the firm initially began trading on a US stock exchange

\(^b\) = Right censored at 2001 (latest sampling date) or the date that the firm stopped trading on a US stock exchange (usually due acquisition) or in the case of AT&T, when the communications equipment business was spun off (Lucent).


\(^d\) = Size cohort. 1 = average inflation adjusted sales for period in dataset is greater than $1 billion ("large"). 2 = average is between $100 million and $1 billion ("medium"). 3 = average is less than $100 million ("small").

Note: random sample of five firms (where possible) taken from each of 12 subsets (combining 4 age cohorts and 3 size cohorts). Oversampling of all 20 firms that were large incumbents (1,1). Only 4 firms in the population 2,1 and only 3 firms in 3,1 (large entrants in the 2nd and 3rd age cohorts).

Table 3-2 lists the companies and further details on the sampling strategy. It also indicates which firms are de novo vs. de alio entrants (spinouts) to the industry. De alio entrants
were all large firms whereas de novo entrants ranged in size. The firms in the sample cluster into several subsamples, by timing of entry, by stage in the value chain and by types of customers served. In this analysis, I examine the extent to which managers’ frame about the importance of optical technologies and its association with strategic action may differ across these clusters.

I also run regressions on other subsamples of firms. Firms in the sample cut across three stages of the communications value chain: semiconductor, components and systems companies. Some of the firms operated in more than one of the stages. While there is no research that I am aware of that compares differences in cognitive frames across different stages of the value chain, one might imagine that those firms that were closer to the end user would be more likely to recognize the importance of optics to improve service. It is less clear if the relationship between cognitive frames and strategic choice should be stronger or weaker than for firms at earlier stages in the value chain. Firms in the sample also served two major classes of customers. Companies with voice-related products primarily served carriers (such as Verizon, British Telecom or Bell Canada) and were focused on dimensions of merit such as reduced connection time and elimination of echo where “carrier grade” technologies required the highest level of technical achievement. Companies with data-related products primarily served enterprises and were focused on dimensions of merit such as “best effort” connections. Some companies served both types of customers. Again, it seems likely that firms serving carriers, with their higher quality requirements, would be more likely to pursue optical technologies. To construct these measures, I used three industry experts to code the companies according to their stage in the value chain and the major customer types served. In addition to running regressions on the whole sample, I run regressions on each of these subsamples to identify any differences in the relationship between cognitive frames and strategic outcomes.

3.3.2 Construction of variables and sources of data

Data were collected for 1982 to 2001. Table 3-3 describes each of the variables and the data sources. Below, I describe each in turn.

47 Coder 1 is in the advanced technologies and business development group of a major equipment company. Coder 2 is a former industry analyst and current Program Manager of the MIT Microphotonics Industry Consortium. Coder 3 is an MIT Professor active in the communications industry. All three have a wide range of industry knowledge and contacts. Average interrater reliability was .72. Any differences in coding were resolved by the author in a thorough review of company information including SEC filings and analyst reports.
Table 3-3: Construction of variables

<table>
<thead>
<tr>
<th>Construct</th>
<th>Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dependent variable:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Optical patents percent of total</td>
<td>Count of patents with primary optical patent classes (356, 359, 372 and 385), divided by total patents for each firm year</td>
<td>US Patent and Trademark Office</td>
</tr>
<tr>
<td><strong>Independent variables:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Optical words</td>
<td>Count of optical words in Letter to Shareholder normalized by total number of words in the letter</td>
<td>Company Annual Reports</td>
</tr>
<tr>
<td>Economies of scale</td>
<td>Log of sales</td>
<td>Compustat</td>
</tr>
<tr>
<td></td>
<td>Log of R&amp;D</td>
<td>Compustat</td>
</tr>
<tr>
<td>Resources (operating income)</td>
<td>Operating income as a percent of sales</td>
<td>Compustat</td>
</tr>
<tr>
<td>Absorptive capacity</td>
<td>Log of stock of optical patents (depreciated by 20%)</td>
<td>US Patent and Trademark Office</td>
</tr>
<tr>
<td>Optical product capabilities</td>
<td>Presence in one or more of 5 different optical product lines</td>
<td>CorpTech</td>
</tr>
<tr>
<td>CEO tech background</td>
<td>CEO technical background (dummy = 1 if predominant experience in R&amp;D)</td>
<td>Multiple sources, including company press releases, Who's Who, news coverage, SEC filings, company web sites, Moody's industry directories, CorpTech directory, and phone/e-mail requests directly to the companies</td>
</tr>
<tr>
<td>CEO job tenure</td>
<td>CEO tenure in job (years as CEO)</td>
<td></td>
</tr>
<tr>
<td>CEO firm tenure</td>
<td>CEO tenure at the focal firm</td>
<td></td>
</tr>
<tr>
<td>CEO outside experience</td>
<td>CEO outside experience (dummy =1 if worked in another firm)</td>
<td></td>
</tr>
<tr>
<td>Demand: telco capex</td>
<td>Communications capital expenditures for top US carriers</td>
<td>ValueLine Investment Survey</td>
</tr>
<tr>
<td>Competitor optical patents</td>
<td>All optical patents for each year, less focal firm optical patents</td>
<td>US Patent and Trademark Office</td>
</tr>
<tr>
<td>Media coverage</td>
<td>Count of all articles covering optical technologies in the Wall Street Journal for each year</td>
<td>Factiva</td>
</tr>
</tbody>
</table>

3.3.3 **Dependent variable – measure of strategic action**

The study assesses the effect of managers' cognitive frames about the importance of optical technologies on related strategic action. I focus on strategic action in the form of investment in optical technology development. The preferred way to measure investment in technology development would be to use R&D expenditures for optical technologies, but this program-specific information is not available from firms. As an alternative, I use patents as
measures of strategic action. Patent data are most often used in strategic analysis as a measure of the degree of innovative output (Griliches 1990), however, other scholars have argued that patents can be a measure of innovative input (or action) as well (Schmookler 1972).

Qualitative evidence from my field study and interviews with other industry innovators indicate that in the context of the communications technology industry, patent data can reasonably be thought of as an indicator of strategic action, if measured correctly. Interviewees suggest that, while innovators do not feel pressure to patent only in areas that have been officially sanctioned by management, patenting can be seen as a strategic action. Innovators will not usually make a formal internal disclosure of inventions that are clearly out of the strategic realm of the company. They will not put in as much effort in developing supporting documentation in the disclosure for projects that are not a main focus. Internal firm peer review will reject disclosures that are not in the strategic direction or worth the resources to file the patent. And, patent ideas come out of project work, so they are more likely to emerge from officially sanctioned areas (i.e., funded projects). It appears in this engineering intensive industry that patents are therefore a reasonably good proxy for strategic action (better than as a proxy of inventive activity overall).

Their use as a measure of innovative effort (strategic action) in the communications technology industry may also be appropriate since it is an area of heavy patenting (the patent classes covering communications technologies represent 4 percent of all patents from the US Patent Office during 1982-2001, the time period of this study). Patents are frequently mentioned in the Letters to Shareholders of the communications firm covered in my study. The following quote from Ericsson’s senior managers is a typical view of the strategic importance of patents.

*During the last two decades patents have become increasingly more important for manufacturers within the telecom and IT industries. A strong, well balanced patent portfolio covering present and future technologies and products is now a prerequisite for success within these industries. Such an intangible asset, although not directly traceable in the balance sheet of a company, gives the patent holder strategic as well as other business advantages, for example possibilities to get access to technology through cross-licensing with other companies. At the same time, this focus on patents within the converging technologies also means an increased exposure to allegations of infringement of patents of others. Since the beginning of the 1990’s, Ericsson has safeguarded its investments in Research & Development and met the intense competition by developing a worldclass patent portfolio to support its business. (Board of Directors, Letter to Shareholders, Ericsson, Annual Report 2000)*
However, in order to use patent data as a measure of strategic action, typical measures, such as citation weighted counts, are not necessarily appropriate. Citation weights in particular are useful when examining degree of successful organizational outcomes (Jaffe and Trajtenberg 2002). Because the dependent variable in this analysis should represent strategic action, I measure optical patents as a percent of total patents granted to the firm in order to represent the emphasis placed on optics. Because raw counts are a more typical means for using patents in strategic analysis, in the appendix, I report on the results of negative binomial regressions on counts of optical patents. The results are largely consistent with the findings using normalized patent counts, though the associations between words and action are weaker. I use a count of all optically related patents (based on primary patent class) in the application year (not granting year\textsuperscript{48}) of the patent and normalize it using a count of total patents granted. The patent data come from the USPTO (US Patent Office) web site. Patent counts were derived using the main alternative names for the company and its patenting entities (including alternative spellings and misspellings). Optical patent 3-digit classes are: 356, 359, 372 and 385. Patents were counted if one of these codes was the primary patent class. As with all patent classes, there is considerable ambiguity about the classification of particular patents to communications applications (Griliches 1990). However, because I only count patents by firms in communications technologies, this eliminates much of the problem. A review of the individual patent titles indicates that they are consistent with optical technologies for communications.

Publication counts have also been construed in studies on the pharmaceutical industry to be an important indicator of the thrust of research activity (Cockburn, Henderson, and Stern 2000; Kaplan et al. 2003). However, there are important differences between the science-intensive pharmaceutical industry and the engineering-intensive communications technology

\textsuperscript{48} There is always a delay between the application and the granting of a patent by the USPTO. The average delay for optical patents is 2 years, though there are certainly cases when the delay was more than 10 years. Therefore, the application date is the better representative of the strategic action taken by the firm. However, the application dates are only available for patents that ultimately get granted. While the USPTO does list some patent applications, the full set of applications (including those that do not get granted) is not available for the entire time period studied. As a result, there may be under counting of total patent applications. The patent search was most recently updated in October 2003. Given that the gap between application and grant may be more than 2 years, and that patents are only posted once they have been granted, the patent counts in the latter years of the dataset may under represent the actual numbers. This has resulted in some truncation of patent counts for 2001. However, given that the dependent variable is normalized by total patents per firm, the effects of the undercounting of applications and of the truncation is minimized.
industry. Interviews with engineers and patent lawyers in some of these firms indicate that publication was not a focal activity of people in the R&D organization. While patenting is often highly rewarded (through bonuses, plaques and awards ceremonies, as I will describe in Chapter 4 that reports on my field study), scientific publication does not appear to be have the same emphasis in the communications technology industry. The one major exception to this rule is Bell Labs which has historically operated more like a research institution than a traditional R&D organization for a firm.\textsuperscript{49} As a result, in this industry context, there is reason to believe that patents are a better measure of strategic action as directed by top management than are publications. However, because publications have been shown to be at least marginally significantly associated with prior management frames about the importance of an emerging technology (Kaplan et al. 2003), in the appendix, I report on the results of analyses using optical publications. The results are consistent with the view that there should be little connection between top managers' cognitive frames and publishing in optics.

Table 3-4 gives the values of the dependent variable over time. Optical patents grew slowly in the 1980's and early 1990's and then had a major upswing from 1996 through the bubble. Note that the coefficient of variation generally increases over time indicating that there has been little convergence in the industry at least through 2001. These results differ from those in the pharmaceutical industry in which patenting coefficients of variation (and those of biotech patenting specifically) decrease over time as the industry converged on a particular approach (Cockburn et al. 2000; Kaplan et al. 2003). In optical communications, there is less evidence convergence in pure counts but some evidence in the case of optical patenting emphasis (percent of total).

\textsuperscript{49} Findings from my interviews with engineers in the industry have suggested that individuals cannot publish their ideas until a patent has been applied for. In the US there is a one year grace period for protecting intellectual property between a publication and the ability to file a patent; however, in Europe, there is no grace period. Thus, since many of the firms in the communications industry follow an international patenting strategy, publication is not directly encouraged and all publications are typically reviewed by a firm's patent lawyers. To the extent that an individual does publish in a scientific journal, it seems to come more from personal desire to participate in the scientific community than as a response to the intentions of management This is consistent with a "scientists pay to be scientists" (Stern 1999) viewpoint as the individuals are not compensated or rewarded by the firm for publication as they are for patents.
Table 3-4: Means and coefficients of variation for dependent variable: optical patents, count and percent of total patents

<table>
<thead>
<tr>
<th>Year</th>
<th>Optical patents</th>
<th>Optical patents % total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>CV</td>
</tr>
<tr>
<td>1982</td>
<td>3.192</td>
<td>1.842</td>
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<tr>
<td>1983</td>
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<td>2.312</td>
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<td>1984</td>
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<tr>
<td>1985</td>
<td>5.034</td>
<td>1.850</td>
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<tr>
<td>1986</td>
<td>5.000</td>
<td>1.988</td>
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<td>1987</td>
<td>4.171</td>
<td>2.346</td>
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<td>1988</td>
<td>4.824</td>
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<td>6.477</td>
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<td>7.500</td>
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<td>2.310</td>
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<tr>
<td>2001</td>
<td>7.197</td>
<td>2.355</td>
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</table>

3.3.4 Independent variable – measure of cognitive frames about optical technologies

The major empirical challenge was to construct a reasonable quantitative measure of top managers’ cognitive frames that can be entered into regression models. To date this has been accomplished primarily using demographic measures as proxies (Ancona and Nadler 1989; Hambrick and Mason 1984; Norburn and Birley 1988; Virany and Tushman 1986; Wiersema and Bantel 1992). More recent research has suggested that demographic measures are, at best, weak approximations of cognition and therefore more direct measures of frames should be considered (Markoczy 1997). In this study, I use normalized word counts derived from the Letters to Shareholders from the Annual Reports of each sample company as the primary measure of management frames.50 This measure of frequency is a proxy for importance to

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50 I use the following words (in all forms except as they appear in company names) to cover mentions of optics and optically related technologies: EDFA, erbium doped fiber amplifier, fiber, fiber-optic, laser, light, multiplex, optic,
management (Abrahamson and Park 1994; Wade, Porac, and Pollock 1997). I have been able to locate 750 of the 855 potential Letters. The other 105 Letters could not be located and likely not published (they are neither available directly from the company, through libraries nor from the Securities and Exchange Commission), and therefore these firm-year observations are not included in the analysis.

In my analysis, I normalize optical words by the total number of words in the Letter to Shareholder to adjust for letters of different lengths. In effect, this produces a measure of the emphasis of optics relative to other themes in the document. This thematic rather than relational approach to textual analysis seems the simplest and most appropriate given the need to generate quantitative measures over a large number of texts (Roberts 1997). This measure is an admittedly rather distant proxy for managerial cognitive frames, but its strength is its objectivity and replicability. Annual Reports in general, and the Letters to Shareholders in particular, have been used in a number of studies of managerial cognition (Barr et al. 1992; Narayanan and Fahey 1990; Osborne, Stubbart, and Ramaprasad 2001) and offer several advantages. Because they are documents produced in the moment, their use avoids the problem of retrospective bias. They provide a prospective rather than retrospective accounting of managerial frames. They are also directly comparable across firms and over time.

Other potential sources such as press releases or speeches, in contrast, are not consistently available across the sample, and internal sources such as minutes from Board meetings are extremely difficult to obtain. Moreover substantial qualitative evidence suggests that the Letter is written or closely reviewed by the Chairman and/or CEO, and that it is distributed to the executive team for comments and revisions. In addition, for fiduciary reasons, it is unlikely that a company would suppress discussions of important issues in the Letter to Shareholders, even if they did not reflect entirely favorably on the company. Annual reports

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opto-, photonic, SONET, SDH, lightwave, waveguide. These words were selected after first reviewing a concordance of the entire list of more than 26,000 separate words that appear in the Letters to Shareholders coded. All words that were related to optical communications were chosen.

51 Firms are not required by the SEC to publish an Annual Report nor write a Letter to Shareholders; however, they keep them on file if provided by the firm. The only annual document required by the SEC is the 10K which does not usually include a Letter to Shareholders. The search for the Letters to Shareholders included all of the major holdings of Annual Reports in the US and UK, the SEC itself and individual calls and letters to each of the firms.
have been shown to be consistent at least at a thematic level with internal planning documents (Fiol 1995).

The major drawback of the use of word counts as a measure of managerial cognitive frames is that while they are likely to measure the strategic importance of the issue in the eyes of senior managers, they do not speak to the interpretation that senior managers are using. It is conceivable, for example, that the CEO could devote a lot of time to the discussion of optical technologies in the context of explaining why he/she believes that they are not central to the future of the firm. However, having read the Letters in the sample in detail, I found that discussions of optical technologies do reflect a view of their centrality to the firm’s future strategic success. Several examples show that when CEO’s and other top executives talked about optical technologies in the Letter to Shareholders, it was to emphasize their importance:

**Alcatel.** “We have also invested heavily in research and development, mainly in optical networks and in data products for operators. In a fast-growing business segment, these developments will enable Alcatel to place new products on the market that fully anticipate its customers needs.” (Serge Tchuruk, CEO, Letter to Shareholders, Alcatel 1999)

**Raychem.** “Raychem’s strategy for growth depends upon our ability to develop and commercialize proprietary materials science technologies. Accordingly, we maintained research and development activity at planned levels during the year, despite lower-than-planned sales. R&D expense in fiscal 1989 amounted to nearly $120 million or 11.1% of sales, compared to $84 million and 7.7% in fiscal 1988...We continued to invest significant resources in our Raynet subsidiary, as it prepared to launch customer trials of its fiber-optic distribution system for the telecommunications subscriber loop—a potentially huge market. In fiscal 1989, our investment in the Raynet project had a negative impact of $55 million on Raychem’s pre-tax profit.” (Paul M. Cook Chairman and CEO, Robert M. Halperin President and COO, Letter to Shareholders, Raychem, 1988)

**FiberCore.** “FiberCore’s technology is evolving rapidly as well, and is expected to result in several new and very important patents for the Company. FiberCore has already developed an EconoGrade single-mode optical fiber which will be significantly more cost effective than the products currently available. Although we are not certain at this stage, this product is expected to play an important role in Fiber to The Home ("FTTH") applications in the future. FiberCore is also planning To introduce an EconoGrade multimode optical, fiber for the data communication market, again at a significantly lower manufacturing cost than other products. This invention may very well revolutionize the development of multimode fiber in Fiber To The Desk ("FTTD"), local area networks ("LANS"), and perhaps even FTTH applications. Again, the future is never certain, however, we at FiberCore, are quite excited about our future technology, profitability, and our position in the industry, and we intend to live up to our slogan “Fiber Optics for the Next Generation.” (Dr. Mohd. A. Aslami, Chairman, President and CEO, Letter to Shareholders, FiberCore, 1996)

**Kyocera.** “Kyocera will concentrate on supplying ceramic components for use in mobile telecommunications equipment and fiber-optic networks. Explosive demand for Internet and other telecommunications services has created a boom in both areas, which together form the backbone of global communications. We will strive to expand market share and margins by
focusing on high-value-added products. (Kazuo Inamori Chairman Emeritus, Kensuke Itoh Chairman, Yasuo Nishiguchi President, Letter to Shareholders, Kyocera 2000)

**Ciena.** "But we can't stop there. We've already begun to push DWDM technology beyond bandwidth expanding applications and into true optical networking applications and we'll continue that push. From added intelligence in management systems to aid in fault diagnostics and service quality monitoring to the broader requirements emerging for bandwidth management in the new network architectures, we have challenging work and rewarding opportunities to pursue in the next few years... Ciena is competing in one of the most exciting new market spaces to emerge in decades. The Internet is driving a change in telecommunications networks that can only be compared to the shift from mainframe computers to PCs. With business-to-business activity, e-commerce and innovative entertainment applications growing nearly unabated, traditional telecommunications network architectures are struggling to scale effectively and to keep pace with growing customer demands. Optical networking can meet the challenge of the new interconnected world, and Ciena is leading the way toward efficient, intelligent optical communications. My thanks to our customers, our shareholders and our suppliers for their continued belief in Ciena's vision of simpler, smarter optical networks. And to our employees, my thanks for making that vision a reality." (Patrick H. Nettles President and CEO, Letter to Shareholders, Ciena, 1998)

Of course, these Letters to Shareholders do not only speak of optical technologies. Letters to Shareholders in some firms, such as Bay Networks or Motorola, never mention optical technologies at all in any of the years. In other firms, the Letters include discussions of optics as well as other technologies, either within telecommunications or in other industry areas. Further, the Letters almost always include a discussion of financial performance, of any changes in senior management or membership in the Board of Directors, and other important events such as major acquisitions or mergers. Therefore, I suggest that the use of normalized word counts in the Letter to Shareholders is a fair representation of the relative importance attributed to optical technologies.

**3.3.5 Controls/alternative explanations**

Strategy and management of technology literature offer alternative explanations for heterogeneous firm response to technology. I enter measures for each of these alternatives, as well as for selected other controls, into the regressions.

**Scale.** There is some evidence from research on the pharmaceutical industry for the hypothesis that the adoption of new technologies was largely driven by economies of scope and scale (Zucker and Darby 1996; Zucker and Darby 1997), and Cockburn, Henderson and Stern (2000) note that, in strategic theories of the firm, scale is important in that it provides the resources to adopt new approaches that drive performance. I thus include the log of total firm
sales to control for potential economies of scale in the adoption of optical technologies. While ideally one would measure scale as a function of communications sales, these data are typically not reported for the entire period or consistently across firms. However, since I selected only firms with a substantial proportion of sales in communications technologies, I believe that this introduces only minimal error into my analysis.

An alternative is to look at the scale of resources invested. I thus include log of total R&D spending to control for potential economies of scale in the adoption of optical technologies. As with sales, this would ideally be measured as a function of communications R&D only, but these data are not available. Sales and R&D are highly correlated (.92) and independently are significantly associated with optical patenting. In regressions, the effects are cancelled out when they are entered simultaneously. Therefore, as the dependent variable is a measure of technical strategic action, I use R&D as the control for scale in a reduced model. An additional explanation could be that economies of scope in R&D across multiple different technical areas could condition decisions to adopt optical technologies (as an example, some firms such as NEC actively positioned themselves across multiple technologies). I do not include this control variable in the analysis.

**Resources.** I include firm operating income as a percent of sales to measure the extent of financial well-being. The literature provides ambiguous predictions as to the effect of this variable. On the one hand, higher returns could represent the availability of firm-wide resources for investment in a new technological field; on the other hand, it could be that firms with higher returns might be more complacent (or perhaps that firms with lower returns would be more risk seeking) with regard to the adoption of new techniques (Bowman 1982). Again, as with the measures of scale, this variable is measured with error since it includes all firm profits and sales and not just those associated with the communications business.

**Competencies.** I introduce several measures that capture prior related competence. As one measure of each firm’s innovative competence, I include the stock of prior optical patents (depreciated by 20%) to assess the scientific understanding accumulated in the firm. I hypothesize that firms that have previous cumulative experience patenting in the field might be more likely to patent in optics later (Cohen and Levinthal 1990). The stock of prior patents is often included in analyses where patent counts are the dependent variable as a means to control
for the strong serial correlation always presenting in patenting patterns. However, in this analysis, the dependent variable is a measure of emphasis in optical patenting (a percent rather than a count) and therefore, the stock of optical patents is more appropriately considered one of prior related competence than of the lagged dependent variable.

Another measure of capabilities is based on the product lines sold. Firms in optically related product lines would more likely assign importance of optical technologies and invest further to reinforce their position. In this case, I used the CorpTech company guide which lists key product lines based on survey responses by participating firms. The data are based on survey responses by firms who indicated their presence or absence in a series of product categories. I selected the 5 optical product lines and calculated a dummy to indicate presence in at least one in a given year. CorpTech data are only available from 1986, so they are entered in a reduced dataset.

CEO demographics. Tushman and his collaborators, have suggested that team tenure and background are associated with the ability to navigate major discontinuities (Tushman and Rosenkopf 1996; Virany et al. 1992). Researchers have used demographic characteristics such as tenure and functional background to capture constructs such as receptivity to change and willingness to take risks (Wiersema and Bantel 1992). Thus, CEO’s with greater tenure have been found to be more likely to resist new technologies, and CEO’s with outside experience have been found to be more likely to be receptive to new ideas, new technologies. It is possible that CEO’s with technical backgrounds would more likely understand the value or be interested in new technical arenas and guide the firm in that direction. In this study, I collected several different demographic measures for the CEO of each firm: functional background (marketing, finance, R&D or other), tenure in the firm, tenure in the CEO position and whether or not the CEO has experience outside of the current firm. These data came from a wide variety of sources including SEC filings (10K and Annual Reports), Who’s Who, company web sites, press releases, Moody’s directories, the CorpTech directory, magazine and newspaper articles, and direct requests for information from the firms themselves. As mentioned above, CEO demographics have often been used as a proxy for cognition (Hambrick and Mason 1984;

52 Codes were: PHO-AO, PHO-FO, PHO-LA, PHO-OE, PHO-OP

Chapter 3: heart of the revolution
Wiersema and Bantel 1992), though others have suggested that this is a weak proxy at best (Markoczy 1997). Because this study includes separate measures of demographics and of cognitive frames, I have the opportunity to uncover some aspects of the relationship between these factors.

**Demand.** Some research in the management of technology field has suggested that demand is the critical driver of innovative output (Schmookler 1972). A measure of demand would ideally focus on telecommunications carriers' spending on optical technologies specifically. However, these data are not available for all of the years in the dataset. Indeed, most market and industry analysts only initiated coverage of the optical segment of the market in the mid 1990's. Therefore, for this study, demand is measured as telecommunication carriers' overall capital expenditures, both in the current year and as projected two years out. These data come from the Value Line Investment Survey which provides capital expenditures in each year and a projection for two years in the future. I include the first measure in the regressions but the results are similar for both.53

**Isomorphism.** Both economic and institutional arguments would suggest that strategic response might be driven by some form of isomorphism, either in response to competitors or to market trends overall (DiMaggio and Powell 1983). To control for the possibility of competitive isomorphism, I include competitive actions as measured by all optical patents for each year. These data also come from the USPTO. To control for overall market or industry trends, I include a count of articles in the Wall Street Journal that mentioned optical technologies. The Wall Street Journal is often cited as the newspaper of record in business and therefore a reasonable proxy for trends in the market. Media mentions have been argued to represent legitimacy of a new market segment (Sine, Haveman, and Tolbert 2003).

**Firm fixed effects.** I also use firm fixed effects in selected regressions to control for unmeasured heterogeneous firm competencies that may shape response to optical technologies. I control for firm fixed effects because there may be differences among firms in omitted variables

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53 Given that a number of communications technology firms serve enterprise rather than or in addition to telecommunications service providers, it could be appropriate to include a measure of enterprise demand for optical technologies. Unfortunately, no such data is available, and in this case, using total enterprise spending on communications technologies would not be a reasonable proxy. For enterprise customers, optical technologies were a relatively small proportion of spending. Therefore, in this analysis, no measure of enterprise demand is included.
(not measured by the controls) that are constant over time and may affect both independent and dependent variables (as a common cause). The interpretation of estimated coefficients with firm fixed effects would then be the amount that a change in the dependent variable within firm is attributable to a change in the predictor variables.

**Time trend.** A time trend deals with the statistical non-independence in independent variables measures. There are many unobserved effects that vary over time but are constant across firms, e.g., changes in the patent office operations, macro economic trends (e.g., changes in telecommunications regulation such as the Telecommunications Act of 1996), overall trends in the science. The measures of demand, isomorphism and competitive patents are all highly correlated with the time trend (correlations all over .8). Individually, each are significantly associated with the optical patenting in regressions, but collectively the effects cancel each other out. The time trend itself is linear while the other measures exhibit some lumpiness over time (with a flatter period of growth in the late 1980’s and early 1990’s and accelerated growth during the bubble period). Therefore, a time trend alone is not a good proxy for the effects of these other factors. In the reduced regressions, I enter the competitive optical patent count along with the time trend as a control for effects that affect all firms but vary over time. An alternative approach would be to use a year fixed effect. The results are robust to the use of this alternative measure. The regression results are similar whether this measure or any of the other time-varying industry measures are used (including a year fixed effect).

**Lagged dependent variable.** I include a lagged dependent variable in all models. From a substantive viewpoint, it is clear from qualitative knowledge of communications technology firms that research programs have a certain amount of momentum and will not fluctuate wildly from year to year. Previous activity in patenting rates will be an important predictor of activity in time \( t \). By including the lagged dependent variable, I am in effect focusing on growth (change) by adjusting indirectly my dependent variable for level. Given that I also include firm fixed effects, the analysis is estimating changes in growth rates. This makes sense for the kind of phenomenon I am examining. It is natural that patenting will grow over time in the growth stages of an industry (1982-2001 has been a growth stage in optical technologies), both in absolute numbers and in emphasis relative to other technologies. Therefore, I am interested in measuring the extent to which an increase in top managers’ frames of the importance of optics
increases the growth rate in counts of optical patents and the emphasis of optical patenting relative to other efforts.

**Other possible controls.** This study does not include other controls such as market share or balance of power that have been proven important in previous strategy research (Cockburn et al. 2000). Ideally, specific market share measures would be used for market position; however, these figures were not available for all of the product lines involved over the entire time period analyzed. I am also not able to establish a measure representing the balance of power within the firm related to optical technologies (i.e., if optical technologies represented a large proportion of sales in the firm, those managers heading up the optical areas of the business would likely have more power in influencing decisions about investment). Ideally, this would be measured by summing sales in optical technologies; however, while the CorpTech database indicates which product lines a company offers, it does not provide sales figures by these product lines. While Compustat does provide segment information, categorization of segments is neither consistent and nor fine-grained enough for use in this context.

Table 3-5 reports the correlations of all measures. Normalized optical word counts are significantly correlated with optical patents. The remaining variables are mainly correlated with the expected signs. The results for CEO demographics are mixed. Three of the demographic measures do not have the expected signs: CEO technical background and outside experience are negatively correlated with patents, and CEO firm tenure is positive correlated. This result reverses itself when controlling for other factors such as firm size or previous patenting behavior in the preliminary regressions. On the other hand, consistent with a complacency argument, CEO job tenure is negatively correlated with outcomes.
Table 3-5: Correlations of key variables

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<tr>
<td>1. Optical patents</td>
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<tr>
<td>2. Optical patents % total</td>
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<tr>
<td><strong>Independent variables</strong></td>
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<td>3. Normalized optical words</td>
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<tr>
<td>4. Log of sales</td>
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<td>-0.1023*</td>
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<td>5. Log of R&amp;D</td>
<td>0.4421*</td>
<td>0.1515*</td>
<td>-0.0825*</td>
<td>0.9178*</td>
<td>1.000</td>
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<td>6. Operating inc%</td>
<td>0.0425</td>
<td>0.0121</td>
<td>0.0087</td>
<td>0.2611*</td>
<td>0.1122*</td>
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<td>0.4247*</td>
<td>0.0982*</td>
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<td>0.1752*</td>
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<td>9. CEO technical background</td>
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<td>10. CEO job tenure</td>
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<td>-0.0593</td>
<td>-0.1665*</td>
<td>-0.1239*</td>
<td>-0.0465</td>
<td>-0.1984*</td>
<td>-0.1945*</td>
<td>0.1713*</td>
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<td>11. CEO firm tenure</td>
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<td>0.0506</td>
<td>-0.0832*</td>
<td>0.3662*</td>
<td>0.3234*</td>
<td>0.0386</td>
<td>0.4477*</td>
<td>0.1850*</td>
<td>0.2458*</td>
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<td>12. CEO outside experience</td>
<td>-0.2428*</td>
<td>-0.0110</td>
<td>0.0481</td>
<td>-0.2764*</td>
<td>-0.2620*</td>
<td>0.1011*</td>
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<td>0.1473*</td>
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<td>0.8773*</td>
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<td>0.1474*</td>
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<td>0.0805*</td>
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<td>16. Time</td>
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<td>0.1066*</td>
<td>0.1651*</td>
<td>0.0586</td>
<td>0.1006*</td>
<td>0.0778</td>
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<td>0.0016</td>
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<td>0.61</td>
<td>7.96</td>
<td>15.80</td>
<td>0.73</td>
<td>4.13</td>
<td>47.26</td>
<td>382.7</td>
<td>12.04</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>19.54</td>
<td>0.12</td>
<td>0.0040</td>
<td>2.82</td>
<td>2.88</td>
<td>1.33</td>
<td>1.84</td>
<td>0.48</td>
<td>0.49</td>
<td>6.54</td>
<td>12.54</td>
<td>0.45</td>
<td>1.22</td>
<td>25.58</td>
<td>388.8</td>
<td>5.63</td>
</tr>
</tbody>
</table>

* p<.05
3.3.6 Estimation

One important estimation issue when using optical patenting as a percent of total efforts is that some firms did not apply for an optical patent in at least one year. In this sample, 56% have no optical communications patents and 19% have no other communications patents (14% have no communications patents at all) for any year in the period studied. I use censored Tobit regression models to compensate for the censored or skewed nature of the dependent variables that do no meet the parametric assumptions required for ordinary least squares (OLS) (Greene 1990/2003; McDonald and Moffitt 1980). Use of the censored Tobit is appropriate if the independent variables would predict both the probability and the degree of patenting.

In this case, I can use the Tobit model to adjust for censoring at zero and 100%. The Tobit model can be best expressed as \( Y^* = \beta X + \varepsilon \) where \( Y = Y^* \) if \( Y^* > 0 \), and \( Y = 0 \) otherwise. \( Y^* \) is therefore a latent variable that is observed only when the value of the dependent variable is between 0 and 100 percent, and thus in some ranges the true value of \( Y^* \) is masked. In this study, \( Y^* \) represents the individual firm’s unobserved propensity to patent in the optical arena. To test for robustness across estimation techniques, in the Appendix to this chapter, I include the results from analysis of patent absolute counts (which requires a conditional firm fixed effects negative binomial count model). The results are robust to different estimations.

3.4 Preliminary results and analysis

The central goal of this chapter is to explore the relationship between managerial frames and strategic action in the case of significant discontinuity. I proceed with both descriptive and regression analyses of a relationship between managerial frames of optical technologies and strategic actions in the form of patenting. The analysis progresses through a series of questions: What have been top managers’ frames about the importance of optical technologies in the communications equipment industry? Is there any evidence that these interpretations shape (precede) investment in optical technologies (patenting)? Can I rule out the alternative explanation that the structure of causality is reversed?

3.4.1 Qualitative evidence and descriptive statistics

Figure 3-1 shows that optical patenting rates (in absolute numbers and relative to total patents) as well as mentions of optical technologies in the Letter to Shareholders on average
increased over time for the firms in the dataset. This is consistent with a growth story in which firms are recognizing and responding to new technologies. The downturn in average optical patents in 2001 appears to be due to right truncation resulting from the lag between patent applications and grants. The overall ratio of optical patents to total patents did not decrease. There is very substantial variation across firms in both the degree to which senior managers recognized the advent of the fiber-optic revolution and in the timing and extent of subsequent action.

Figure 3-1: Average optical patents (count and as % of total) and normalized optical words by year, average for sample of 72 firms.

Figures 3-2 through 3-4 include charts for selected firms in the dataset. Each chart maps a count of optical words in the Letter to Shareholders (normalized by the total number of words in the Letter to provide an indication of the importance of optical technologies relative to other issues discussed by management) against the number of optical patents in each year, and against the percent optical patents represent of total efforts. These charts demonstrate that each firm had very different patterns in the relation between managers’ frames of and response to optics.

Corning was the leader in developing optical fiber and this was an important focus of management discussion from the very early days: in their 1982 Letter of Shareholders, they spoke of the “increasing importance of...optical communications.” Patenting followed, though
at a gradually increasing pace (Figure 3-2). Nortel Networks (formerly Northern Telecom) recognized the importance of fiber optics in its early days and began reoriented R&D spending to develop systems that could take advantage of this new technology. By 1990, management had focused on business in optical switching and transmission. Patenting followed (Figure 3-3).

One major area of increased R&D spending was in fiber optics and transmission, which resulted in the October introduction of our new FiberWorld Family of products. FiberWorld makes Northern Telecom the first global telecommunications manufacturer to offer a family of switching and transmission products essential to the construction, operation, and services of a complete, end-to-end- fiber network (Edmund Fitzgerald, Chairman of the Board, Paul Stem, President and CEO, David Vice, Vice-Chairman, Products and Technology, Letter to Shareholders, Northern Telecom Annual Report 1990).

More recent entrants, such as Ciena were often founded explicitly to take advantage of the optical revolution. In their first Annual Report announcing their IPO, CEO Patrick Nettles claimed that the company’s specialization in optical technologies would allow it to leapfrog more entrenched incumbents.

Now service providers are faced with an entirely different challenge. Not only is network traffic growing far more rapidly than historic growth patterns would suggest – but the traffic fueling that growth is different, and it is stressing the networks built to carry telephone traffic in different ways. PCs “talk” faster than humans. Computers also transmit information in larger bursts. Faster traffic in greater bursts requires more network bandwidth. That’s where CIENA comes in! CIENA’s timely application of optical technology in products that enable service providers to deploy additional bandwidth – without disrupting existing traffic flows – made it possible for CIENA to enter and impact the telecommunications equipment market in a way usually reserved for much larger and longer-established companies. (Patrick Nettles, President and CEO, Letter to Shareholders, Annual Report 1997)

Their patenting grew rapidly and was almost exclusively in the optical arena (Figure 3-4).
Figure 3-2: Optical patents (counts and % total) and normalized optical words by year, for Corning

![Graph showing optical patents for Corning]

Figure 3-3: Optical patents (counts and % total) and normalized optical words by year, for Nortel

![Graph showing optical patents for Nortel]
On the other hand, not all of the firms focused on optics. Bay Networks, for example, entered the communications technology industry in a 1992 IPO (as Wellfleet Communications). In the years before they were acquired by Nortel Networks, optical technologies were never mentioned by senior managers in the Letter to Shareholders, and they never patented in the optical arena. As the following excerpt from the 1993 Letter to Shareholders indicates, Wellfleet/Bay was a router company entirely focused on LAN’s for enterprise customers.

Wellfleet’s progress in the year just ended demonstrates our ability to assess and respond to the needs of our rapidly growing and changing marketplace. The idea of linking all of an organization’s computers—regardless of type of hardware and software—to facilitate communications, transaction processing, data and design exchange, and idea sharing has been embraced by enterprises, universities, governments, and many individual users. The information internetworking market has grown from the initial development of local and wide area networks in the 1980’s to over a billion dollar market today. (Paul Severino, President, Letter to Shareholders, Annual Report 1993)

Management put emphasis on connecting computers within firms and not on extending the reach of Wellfleet/Bay technologies to the broader communications system. Therefore, the lack of presence in optical patenting is not surprising. Cisco’s case is not as extreme. While they also began life in an IPO in the early 1990’s with a focus on LAN equipment, their senior
management mentioned optical technologies in the Letter to Shareholders (though rarely) and patented in optics, though only sporadically and in very small numbers.

Not only are the relationships between optical words and optical patenting different across firms, but there are also strong differences across each of the age cohorts. Figure 3-5 shows a plot of the average optical words and patents by year by cohort. The overall emphasis on optical technologies in the Letters to Shareholders tended to be higher for the later (mid and “bubble”) entrants into the communications industry. These firms entered after 1991 just as the potential impact of optical technologies was clarified by the introduction of technologies such as EDFA’s and WDM.


In terms of emphasis on optical patenting, it is nearly non-existent for the early entrants but higher in all other categories (note that the late entrants may not have had enough time to gear up their patenting activities).
The relationship between management frames about the importance of optics and optical patenting (as a percent of total patents) is strongest for mid to late entrants and weakest for the early entrants. In fact, for this group of firms that entered before optics really took off, there seems to be nearly no correlation between words and outcomes: they mentioned optics in the Letters to Shareholders but they simply didn’t patent. On the other hand, the mid entrants (those that came in just as the critical EDFA and WDM technologies were being introduced) both emphasized optics in their Letters to Shareholders and patented heavily. There may be too little history to understand this relationship for the late entrants.

Similarly, there are strong differences in the relationship between optical words and patents for firms with different customer sets and those that play in different stages of the value chain. There is a strong association between words and patents for firms serving carriers, but almost none for firms serving enterprises (Figure 3-6). And, the firms serving carriers were more likely to emphasize optics in their Letters to Shareholders. There is a strong association between words and patents for component and to a lesser extent systems firms, but very little association for semiconductor firms in the simple correlation (Figure 3-7). Semiconductor firms mainly produce technologies that enable optics but do not necessarily include photonic elements. Therefore, while managers often talked about the importance of optics as a market opportunity, their actions would not take the form of patenting in optics per se. These firms did patent in other, non-optical arenas.

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54 The early entrant companies in the sample were: Atmel, Bay Networks, California Micro Devices, Cisco Systems, DMC Stratex Networks, Franklin Telecommunications, Maxim Integrated Products, Microtel International, Newbridge Networks, Openroute Networks, Optek Technology, Qualcomm, Reliance Electric, Vitesse Semiconductor. This sample includes all of the large companies who were early entrants (Bay, Cisco, Reliance and Qualcomm), 20% of the mid size early entrants and 8% of the small early entrants. Most of these firms were focused on enterprise networking or were electronics components suppliers. The one exception was Optek which focused on opto-electronics and fiber-optic components. A review of the full population indicates that these types of firms in the sample are highly representative of the population itself.
Figure 3-6: Scatterplot of average optical patent percent and average normalized optical words by year: firms serving carriers or enterprise

Figure 3-7: Scatterplot of average optical patent percent and average normalized optical words by year: firms at different stages of the value chain

Chapter 3: heart of the revolution
These descriptive analyses suggest that it will be important to examine these subsamples in the regression analyses.

### 3.4.2 Results from regressions

Despite this heterogeneity across the sample and the potential flaws in the measures, I find some systematic patterns of association between management frames about optical technologies and response to the fiber-optic revolution. In this section, I report on the results of regression analysis. I tested the effect of the normalized count of optical words in each Letter to Shareholders on optical patenting emphasis along with the various alternative explanations. Table 3-6 shows results for optical patents. These models are two-sided Tobits (censored at 0 and 100%) with firm fixed effects. Results for negative binomial count models are reported in the Appendix. The results presented here are largely robust to this alternative specification.

Model 1 examines the association of words to patents as a percent of total with only a limited set of controls (for time, for the lagged dependent variable and for firm fixed effects). Model 2 adds a reduced set of controls. Model 3 shows the full set of controls except the measure for presence in optical product lines. Model 4 includes the measure of presence in optical product lines in a reduced dataset. All independent variables are lagged 2 years.

The results for the measure of managers’ frames of optical technologies are positive for patents in all models. These results are somewhat robust to different lag structures, maintaining the strongly significant association between words and patenting for one year lags and positive, though not significant association for three and four year lags. They are also both statistically and economically significant. A standard deviation change in emphasis on optics in the Letter to Shareholders is associated with a 4 percentage point change in emphasis in optics in patenting (at the mean, this is an 80% change in emphasis in optical patenting). Measures of scale and resources (R&D and operating profit as a percent of sales) were positive and significant. The stock of optical patents does not behave as predicted (negatively significant). As predicted, CEO technical background is positively and significantly associated with patenting. Counter to predictions, CEO job tenure is positively associated with outcomes.

As suggested by the descriptive analysis, there are also differences across segments of firms. In Table 3-7, I report the results for several subsamples. I do not run these as interaction effects in the full sample because I use firm fixed effects in all regressions. Model 2 repeats the
results of the full model in Table 3-6. All of these regressions were run using the reduced number of controls. Model 2 reports the results for incumbent firms only and they are similar to those of the full sample. I could not report the results for entrants only (or even better for entrants by entry era) because these models do not converge. The results for firms that serve carriers (Model 3) are again similar to those of the full model. For firms that serve enterprise (Model 4), the coefficient on normalized optical words is much smaller and not significant. In terms of firms at various stages of the value chain, the coefficient on words for systems firms (Model 6) is higher than for the full sample and equally significant. However, for components firms (Model 5), it is much lower. I could not report the results for semiconductor firms because these models do not converge. These results suggest that those firms closer to the end user (the systems firms) and those serving customers for whom optics mattered the most (firms serving carriers rather than enterprise), the association between top managers’ frames about the importance of optical technologies and emphasis on patenting in optics is the strongest both statistically and economically.
Table 3-6: Frames as a determinant of response: optical words as a predictor of optical patent percent of total patents, controlling for selected alternative explanations, 1982-2001.

Two-sided TOBIT with firm fixed effects

<table>
<thead>
<tr>
<th>Measure of:</th>
<th>Dependent var: optical patents as a percent of total patents</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
<th>Model 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>602</td>
<td>602</td>
<td>602</td>
<td>525</td>
<td></td>
</tr>
<tr>
<td>Cognitive frames</td>
<td>Normalized optical words (t2)</td>
<td>10.231***</td>
<td>9.770***</td>
<td>10.202***</td>
<td>9.724***</td>
</tr>
<tr>
<td></td>
<td>(2.026)</td>
<td>(2.075)</td>
<td>(1.849)</td>
<td>(1.822)</td>
<td></td>
</tr>
<tr>
<td>Lagged dep. var.</td>
<td>Optical patents % of com. pats (t2)</td>
<td>0.368***</td>
<td>0.471***</td>
<td>0.437***</td>
<td>0.413***</td>
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<tr>
<td></td>
<td>(0.059)</td>
<td>(0.068)</td>
<td>(0.062)</td>
<td>(0.064)</td>
<td></td>
</tr>
<tr>
<td>Scale</td>
<td>Log of sales (t3)</td>
<td>0.043*</td>
<td>0.045*</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.019)</td>
<td>(0.021)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Log of R&amp;D (t2)</td>
<td>0.044***</td>
<td>0.011</td>
<td>0.012</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.012)</td>
<td>(0.015)</td>
<td>(0.016)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resources</td>
<td>Operating income percent (t2)</td>
<td>0.122*</td>
<td>0.085</td>
<td>0.077</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.062)</td>
<td>(0.056)</td>
<td>(0.092)</td>
<td></td>
<td></td>
</tr>
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<td>Capabilities</td>
<td>Log of stock of optical patents (t2)</td>
<td>-0.046***</td>
<td>-0.040***</td>
<td>-0.043***</td>
<td></td>
</tr>
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<td>(0.010)</td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dummy: stock of optical patents (t2)</td>
<td>-0.029</td>
<td>-0.017</td>
<td>-0.051*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.022)</td>
<td>(0.020)</td>
<td>(0.022)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Photonics products (t2)</td>
<td></td>
<td></td>
<td></td>
<td>-0.002</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(0.016)</td>
</tr>
<tr>
<td>CEO demographics</td>
<td>CEO tech background (t2)</td>
<td>0.037*</td>
<td>0.037*</td>
<td>0.029</td>
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</tr>
<tr>
<td></td>
<td>(0.016)</td>
<td>(0.015)</td>
<td>(0.016)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CEO job tenure (t2)</td>
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<td>0.002</td>
<td>0.001</td>
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</tr>
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<td>(0.001)</td>
<td>(0.001)</td>
<td>(0.001)</td>
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<tr>
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<td>CEO firm tenure (t3)</td>
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<td></td>
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<td>(0.001)</td>
<td>(0.001)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CEO outside experience (t2)</td>
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<td>-0.002</td>
<td>-0.002</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.016)</td>
<td>(0.016)</td>
<td>(0.019)</td>
<td></td>
<td></td>
</tr>
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<td>Competition</td>
<td>Competitor optical patents (t2)</td>
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<td>-0.028</td>
<td>-0.007</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.019)</td>
<td>(0.029)</td>
<td>(0.031)</td>
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<td>Demand</td>
<td>Carrier capex (t2)</td>
<td>0.002*</td>
<td>0.002</td>
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<td></td>
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<tr>
<td></td>
<td>(0.001)</td>
<td>(0.001)</td>
<td>(0.001)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Isomorphism</td>
<td>WSJ optical articles (t2)</td>
<td>-0.000*</td>
<td>0.000</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
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<td>(0.000)</td>
<td>(0.000)</td>
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<td>Time trend</td>
<td>Years</td>
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<td>0.006</td>
</tr>
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<td>(0.005)</td>
<td>(0.008)</td>
<td>(0.009)</td>
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<td>Constant</td>
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<td>-0.597***</td>
<td>-0.589***</td>
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<td></td>
<td>(0.033)</td>
<td>(0.085)</td>
<td>(0.117)</td>
<td>(0.125)</td>
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</tr>
<tr>
<td>Firm fixed effects</td>
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<td></td>
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<td>log likelihood</td>
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<td>242.144</td>
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<td>Pseudo $R^2$</td>
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<td>Chi squared (df)</td>
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<td>768.66</td>
<td>770.30</td>
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<td>P of Chi</td>
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<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
<td></td>
</tr>
</tbody>
</table>

Note: "N" is smaller in model 4 due to lack of data on product lines prior to 1986. Coefficients for firm dummies not shown. *p<.05, **p<.01, ***p<.001, ****p<.0001
Table 3-7: Frames as a determinant of response: normalized optical words as a predictor of optical patent percent of total patents, controlling for selected alternative explanations, 1982-2001. Comparison of sub samples.

Two-sided TOBIT with firm fixed effects

<table>
<thead>
<tr>
<th>Measure of:</th>
<th>Dependent var: optical patents as a percent of total patents</th>
<th>Model 1 Full sample</th>
<th>Model 2 Incumbents</th>
<th>Model 3 Carrier</th>
<th>Model 4 Enterprise.</th>
<th>Model 5 Components</th>
<th>Model 6 Systems</th>
</tr>
</thead>
<tbody>
<tr>
<td>n *</td>
<td>602</td>
<td>430</td>
<td>483</td>
<td>140</td>
<td>366</td>
<td>328</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(2.075)</td>
<td>(2.422)</td>
<td>(2.155)</td>
<td>(1.689)</td>
<td>(1.472)</td>
<td>(3.482)</td>
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<tr>
<td>Lagged dep. var.</td>
<td>Optical patents % of total pats (t2)</td>
<td>0.471***</td>
<td>0.443***</td>
<td>0.484***</td>
<td>0.046</td>
<td>0.357***</td>
<td>0.388***</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.068)</td>
<td>(0.062)</td>
<td>(0.072)</td>
<td>(0.149)</td>
<td>(0.089)</td>
<td>(0.068)</td>
</tr>
<tr>
<td>Scale</td>
<td>Log of R&amp;D (t2)</td>
<td>0.044***</td>
<td>0.047***</td>
<td>0.049***</td>
<td>0.046***</td>
<td>0.001</td>
<td>0.061***</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.012)</td>
<td>(0.013)</td>
<td>(0.013)</td>
<td>(0.014)</td>
<td>(0.009)</td>
<td>(0.015)</td>
</tr>
<tr>
<td>Resources</td>
<td>Operating income percent (t2)</td>
<td>0.121*</td>
<td>0.154**</td>
<td>0.161*</td>
<td>0.290</td>
<td>0.027</td>
<td>0.179**</td>
</tr>
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<td>(0.062)</td>
<td>(0.058)</td>
<td>(0.068)</td>
<td>(0.224)</td>
<td>(0.049)</td>
<td>(0.061)</td>
</tr>
<tr>
<td>Capabilities</td>
<td>Log of stock of optical patents (t2)</td>
<td>-0.046***</td>
<td>-0.034***</td>
<td>-0.047***</td>
<td>-0.033</td>
<td>0.003</td>
<td>-0.054***</td>
</tr>
<tr>
<td></td>
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<td>(0.011)</td>
<td>(0.01)</td>
<td>(0.013)</td>
<td>(0.019)</td>
<td>(0.009)</td>
<td>(0.014)</td>
</tr>
<tr>
<td>Dummy: stock of optical patents (t2)</td>
<td>-0.029</td>
<td>-0.016</td>
<td>-0.025</td>
<td>0.030</td>
<td>0.027</td>
<td>-0.023</td>
<td></td>
</tr>
<tr>
<td>CEO demographics</td>
<td>CEO tech background (t2)</td>
<td>0.037**</td>
<td>0.033*</td>
<td>0.039*</td>
<td>0.045*</td>
<td>0.047***</td>
<td>0.028</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.016)</td>
<td>(0.014)</td>
<td>(0.017)</td>
<td>(0.019)</td>
<td>(0.012)</td>
<td>(0.017)</td>
</tr>
<tr>
<td>CEO job tenure (t2)</td>
<td>0.002*</td>
<td>0.002*</td>
<td>0.002*</td>
<td>0.001</td>
<td>0.001</td>
<td>0.002</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.001)</td>
<td>(0.001)</td>
<td>(0.001)</td>
<td>(0.001)</td>
<td>(0.001)</td>
<td>(0.001)</td>
</tr>
<tr>
<td>Competition</td>
<td>Total optical patents, (t2)</td>
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<td>0.042*</td>
<td>0.033</td>
<td>-0.007</td>
<td>0.005</td>
<td>0.043*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.019)</td>
<td>(0.018)</td>
<td>(0.021)</td>
<td>(0.018)</td>
<td>(0.015)</td>
<td>(0.022)</td>
</tr>
<tr>
<td>Time trend</td>
<td>Years</td>
<td>-0.001</td>
<td>-0.006</td>
<td>-0.002</td>
<td>0.005</td>
<td>0.001</td>
<td>-0.005</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.005)</td>
<td>(0.005)</td>
<td>(0.005)</td>
<td>(0.005)</td>
<td>(0.004)</td>
<td>(0.006)</td>
</tr>
<tr>
<td>Constant</td>
<td>-0.493***</td>
<td>-0.485***</td>
<td>-0.528***</td>
<td>-0.435***</td>
<td>-0.135*</td>
<td>-0.597***</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.085)</td>
<td>(0.087)</td>
<td>(0.093)</td>
<td>(0.123)</td>
<td>(0.056)</td>
<td>(0.107)</td>
</tr>
<tr>
<td>Firm fixed effects</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>log likelihood</td>
<td>241.324</td>
<td>234.251</td>
<td>215.623</td>
<td>118.352</td>
<td>286.107</td>
<td>147.736</td>
<td></td>
</tr>
<tr>
<td>Chi squared(df)</td>
<td>768.66</td>
<td>422.60</td>
<td>642.30</td>
<td>207.06</td>
<td>673.25</td>
<td>352.04</td>
<td></td>
</tr>
<tr>
<td>P of chi</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
<td></td>
</tr>
</tbody>
</table>

Note: Coefficients for firm dummies not shown.

*p<=.05, **p<=.01, ***p=.001, ****p<.0001
One objection to these results showing a positive association between management frames and subsequent action could be that they simply indicate management coherence with organizational actions – management would just be reporting on what the organization had already accomplished. One might imagine, for example, that middle management instigates research projects that, if successful, lead to patents that senior executives then highlight in their Letter to Shareholders in the Annual Report. To address this concern, I tested the key variables “in reverse” by regressing the measure of frames against the measures of response with firm fixed effects and a time trend (Model 1 in Table 3-8).


Two sided Tobit regression with firm fixed effects.

<table>
<thead>
<tr>
<th></th>
<th>Model 1</th>
<th>Model 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>dependent var:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>normalized optical words</td>
<td>602</td>
<td>602</td>
</tr>
<tr>
<td>N</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Optical patents % of total coms patents (t2)</td>
<td>0.008*</td>
<td>0.007*</td>
</tr>
<tr>
<td></td>
<td>(0.003)</td>
<td>(0.003)</td>
</tr>
<tr>
<td>Previous normalized words (t2)</td>
<td>0.107</td>
<td>0.090</td>
</tr>
<tr>
<td>(lagged dv)</td>
<td>(0.092)</td>
<td>(0.090)</td>
</tr>
<tr>
<td>CEO tech background (t2)</td>
<td></td>
<td>0.004****</td>
</tr>
<tr>
<td></td>
<td>(0.001)</td>
<td></td>
</tr>
<tr>
<td>CEO job tenure (t2)</td>
<td></td>
<td>0.0001*</td>
</tr>
<tr>
<td></td>
<td>(0.000)</td>
<td></td>
</tr>
<tr>
<td>CEO firm tenure (t2)</td>
<td></td>
<td>-0.0001*</td>
</tr>
<tr>
<td></td>
<td>(0.000)</td>
<td></td>
</tr>
<tr>
<td>Time trend</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>(0.000)</td>
<td>(0.000)</td>
</tr>
<tr>
<td>Constant</td>
<td>-0.008**</td>
<td>-0.011****</td>
</tr>
<tr>
<td></td>
<td>(0.003)</td>
<td>(0.003)</td>
</tr>
<tr>
<td>Firm fixed effects</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>log likelihood</td>
<td>700.780</td>
<td>710.777</td>
</tr>
<tr>
<td>Pseudo R2</td>
<td>-0.356</td>
<td>-0.373</td>
</tr>
<tr>
<td>Chi squared(df)</td>
<td>368.12</td>
<td>386.51</td>
</tr>
<tr>
<td>P of chi</td>
<td>0.0000</td>
<td>0.0000</td>
</tr>
</tbody>
</table>

Note: Similar results achieved for lag of 1 year. No significant association found in lags of 3 and 4 years. Coefficients for firm dummies not shown.

*p<=.10, **p<=.05, ***p<=.01, ****p<=.001, *****p<=.0001

In the case of two year lags, I do find a positive and marginally significant association between optical patents as a percent of total and words in the Letter to Shareholders. This is also
the case for one year lags, however the relationship disappears for three and four year lags. Where there is a positive and significant association, it is weaker than for the association of prior optical words with subsequent strategic action in the form of patents. A standard deviation change in optical patents as a percent of total is associated with a 0.1 percentage point change in the emphasis in optics in the Letter to Shareholders (at the mean, this would be a 60% change in emphasis). This contrasts with a much more significant association in the hypothesized direction where, as mentioned above, a standard deviation change in normalized optical words is associated with an 80% change in emphasis on optics in patenting. Also, in the Appendix, I note that while a find a significant association between normalized optical words and subsequent counts of optical patents, I do not find this relationship “in reverse.”

A finding that there was no significant association when testing the hypothesized relationship “in reverse,” would have been stronger “proof” of the relationship between top managers’ frames about the importance of optics and subsequent strategic actions in the form of optical patenting. However, these results suggesting that there is some relationship in the reverse direction is not surprising. The process by which top management teams develops a viewpoint about technology is likely highly complex. The fact that prior technical activities have some marginal influence on the frames that come to predominate seems probable. In model 2 of Table 3-8, I show that CEO demographics are also significantly associated with the emphasis in optics in the Letter to Shareholders. Where the CEO has a technical background and longer job tenure, the Letter to Shareholders is likely to have a higher emphasis on optics (and where the firm tenure is longer, the emphasis is lower). This suggests that a number of factors shape the interpretations about the importance of optics arrived at by top managers. The fact that the association of prior patenting emphasis on subsequent words is both statistically and economically less significant than the hypothesized association between prior managerial frames and subsequent action is at least consistent with the hypothesis that managerial cognitive frames are not only a product of the firm’s prior experience.55

55 And, when using raw rather than normalized optical patent counts, there is no significant association between prior optical patenting and subsequent mentions of optics in the Letter to Shareholders.
3.5 Discussion and conclusion

The purpose of this study was to understand heterogeneous firm response to technical change and specifically the extent to which a systematic relationship exists between managers’ frames about technology and strategic outcomes. This analysis builds on the managerial cognition and management of technology literatures and focuses on the effect of changes in frames on changes in strategic outcomes. In particular, this was an attempt to extend beyond the current case study research to find a more systematic pattern connecting frames to action across a number of firms. In this macro, quantitative study of 72 firms in the communications industry, I find just such a pattern. Even when accounting for a host of alternative explanations, top managers’ frames about the importance of optical technologies was associated with strategic actions in the form of optical patenting.

The descriptive data show that interpretations of the importance of optical technologies as well as optical patenting rates varied widely in the communications technology industry, both across individual firms and classes of firms (i.e., types of entrants, firms with different types of customers and firms at different stages of the value chain). The regressions suggest that there is a significant association between the measure of managerial frames and optical patenting emphasis, though (as demonstrated in the Appendix) no such relationship is found for publications. The fact that, when testing this relationship in reverse, I find a marginally significant association between prior patenting behavior and managerial frames, suggests a highly complex and likely iterative process for the development of top managers’ interpretations. These results taken together provide some support for the notion that top managers’ interpretation of optical technologies is a driver of strategic action. This research highlights the role of managerial frames, lending weight to the concept that top management plays a crucial role in both interpreting the external environment and shaping the internal response to this environment, and reinforcing some of the qualitative studies making this link (e.g., Tripsas and Gavetti 2000).

The analysis in this chapter has focused on the association between top managers’ communication of frames and the subsequent patterns of scientific output. However, the descriptive data from the companies studied as well as interviews with executives and engineers in the field suggest that many types of exploration occur throughout organizations, in particular in periods of uncertainty when the optimal path is not clear. These explorations have
at their foundation different interpretations of both the environment and technology as well as the nature of the appropriate solution. The presence of these multiple paths of exploration may suggest that our understanding of cognition needs to be expanded in the context of technical change, moving beyond the unidimensional, social psychological sense of cognition as an aggregation of individual views to an interactive, dynamic process of meaning construction (Gamson 1992) in which multiple frames interact. The frames that are measured by words in the Letter to Shareholders are “snapshots” that can be interpreted as the adoption and legitimization of a particular set of interpretations by top managers (Oliver and Johnston 2000).

The purpose of this chapter has been to examine the effects of top managers’ cognitive frames on technical outcomes. However, many of the other strategic measures I use as controls could also be given cognitive interpretations. Management demographics have often been taken to be proxies for cognition (Hambrick and Mason 1984; Wiersema and Bantel 1992). The significant effect of the CEO technical background, for example, could be interpreted as representing a “technical frame” that the CEO would apply in interpreting the environment and technologies. Prior patenting activities could be interpreted as frames or heuristics within the research organization (Nelson and Winter 1977) suggesting there is a cognitive basis for a firm’s prior related knowledge (Cohen and Levinthal 1990). Measures of industry trends, such as the count of articles in the Wall Street Journal, have been interpreted as industry level cognition: media density has been construed as a sign of the cognitive legitimacy of a sector (or in the case of this study of an emerging technical opportunity) and reflects the development of knowledge in the industry (Sine et al. 2003). This suggests that multiple different “cognitions” influence organizational outcomes. In this chapter, I test the effect of top managers’ frames about the importance of a particular type of technology, and the results show a systematic relationship between these frames and strategic action. However, the results also make it clear that other frames are also salient in determining technical outcomes such as patenting.

This work contributes to managerial cognition research by extending to a larger number of firms a set of findings that had previously been established mainly in case study research. It also reinforces earlier research suggesting that the Letter to Shareholder is a reasonable “snapshot” of top management frames with regard to critical strategic issues.
This study contributes to the management of technology literature by suggesting that our explanations of how established firms respond to these periods of intense change and uncertainty should include managerial cognitive frames of discontinuities as an important feature. These explanations have traditionally been missing. Yet, if we take managerial frames as an explanatory factor seriously, it suggests an interesting midpoint between the inertial arguments of the population ecologists (Barnett and Carroll 1995; Hannan and Freeman 1989) and the incentive arguments of economists (Gans and Stern 2000; Gilbert and Newbery 1982; Henderson 1993; Reinganum 1983). The degree of firm inertia in the face of technical change may be affected by the degree to which management frames change and incentives are acted on based on how they are perceived. The forces for inertia and adaptation may both be present within a firm, and management frames could be a critical arbiter in shaping the direction the firm takes. The empirical evidence provides at least some preliminary indication that this may be the case. Managerial frames of the nature of discontinuities may play an important role in shaping their company’s actions.

These findings provide may also further dimensionalize the notion of dynamic managerial capabilities. Adner and Helfat (2003) suggest that these capabilities reside in managerial human capital, managerial social capital and managerial cognition. The research presented in this chapter highlights a specific kind of managerial cognition (that associated with understanding the importance of a particular technical change) that has an effect on heterogeneous firm action. It also suggests that, at least under conditions of industry discontinuity, the extent to which managers assign more importance to the technology, the more likely firms are to engage in strategic change.

* * *

This analysis of this large sample dataset of firms establishes the presence of a systematic pattern of association between managers’ frames and strategic action. By its very nature, this work that treats the firm essentially as a macro level whole cannot reveal the causal mechanisms that explain this relationship. And, the work raises the question about whether it might also be the case that interpretations differ within the firm given they differ so strongly across firms. In the next two chapters, I report on a qualitative field study aimed precisely at exploring these issues.
Appendix to Chapter Three: count model regression using optical patent counts

To test the robustness of the regression results, I also used optical patent counts as the dependent variable (instead of the percent measures using in the Tobit analyses reported in the body of the chapter). In the case of patent counts, standard linear OLS is not appropriate. The probability distribution that reflects the underlying process of aggregating events over time is the Poisson distribution. However, the Poisson regression model is based on the assumption that the variance of Y is equal to the mean. In all cases of the outcome measure I use, the data are overdispersed (the standard deviation is greater than the mean) due most likely to contagion and unobserved heterogeneity, and therefore the core assumption of the Poisson distribution is violated. In these cases, a negative binomial regression model (NBRM) is more appropriate because the Poisson regression model would be inefficient (standard errors biased downwards, leading to spuriously high significance levels). Overdispersion can be interpreted as indicating that there are unobserved variables determining the distribution of \( y_{it} \). Therefore, in the NBRM, the adjustment assumes that \( E(y_{it}) = \exp(\beta x_{it} + \epsilon_{it}) \) where \( \epsilon_{it} \) is gamma distributed. If \( \epsilon_{it} \) is not truly gamma, then the estimates of the coefficients will be inconsistent, but the gamma distribution seems an adequate assumption in this analysis.

Table 3-9 reports the results of negative binomial regressions for patents. Consistent with the findings in the Tobit regressions, normalized optical words are positively associated with subsequent optical patenting (though the effects are only marginally significant). When “testing in reverse,” there was no significant association between prior optical patenting and subsequent mentions of optics in the Letter to Shareholders.
Table 3-9: Frames as a determinant of response: normalized optical words as a predictor of optical patent counts, controlling for selected alternative explanations, 1982-2001.

Conditional firm fixed effects negative binomial regressions.

<table>
<thead>
<tr>
<th>Measure of:</th>
<th>Dependent var: count of optical publications</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
<th>Model 4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>378</td>
<td>378</td>
<td>378</td>
<td>318</td>
</tr>
<tr>
<td>Cognitive frames</td>
<td>Normalized optical words (t1)</td>
<td>21.201</td>
<td>27.886*</td>
<td>29.686*</td>
<td>25.902*</td>
</tr>
<tr>
<td>Lagged dep. var.</td>
<td>Log of stock of optical patents (t1)</td>
<td>0.210***</td>
<td>-0.022</td>
<td>-0.063</td>
<td>-0.375**</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.966)</td>
<td>(0.884)</td>
<td>(0.686)</td>
<td>(0.106)</td>
</tr>
<tr>
<td></td>
<td>Dummy of stock of opt patents (t2)</td>
<td>0.718*</td>
<td>0.600*</td>
<td>0.522</td>
<td>-0.192</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.304)</td>
<td>(0.287)</td>
<td>(0.294)</td>
<td>(0.304)</td>
</tr>
<tr>
<td>Scale</td>
<td>Log of sales (t2)</td>
<td>-0.261*</td>
<td>-0.295*</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.126)</td>
<td>(0.144)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resources</td>
<td>Log of R&amp;D (t2)</td>
<td>0.360****</td>
<td>0.588****</td>
<td>0.743**</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.068)</td>
<td>(0.108)</td>
<td>(0.117)</td>
<td></td>
</tr>
<tr>
<td>Capabilities</td>
<td>Operating income percent (t2)</td>
<td>0.338</td>
<td>0.889</td>
<td>-0.643</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.465)</td>
<td>(0.452)</td>
<td>(0.904)</td>
<td></td>
</tr>
<tr>
<td>CEO demographics</td>
<td>Photonics products (t2)</td>
<td></td>
<td></td>
<td>0.476**</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(0.123)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CEO tech background (t2)</td>
<td></td>
<td></td>
<td></td>
<td>0.598**</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(0.114)</td>
<td>(0.123)</td>
</tr>
<tr>
<td></td>
<td>CEO job tenure (t2)</td>
<td></td>
<td></td>
<td></td>
<td>0.029**</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(0.008)</td>
<td>(0.010)</td>
</tr>
<tr>
<td></td>
<td>CEO firm tenure (t2)</td>
<td></td>
<td></td>
<td></td>
<td>0.007</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(0.006)</td>
<td>(0.007)</td>
</tr>
<tr>
<td></td>
<td>CEO outside experience (t2)</td>
<td></td>
<td></td>
<td></td>
<td>0.330</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(0.157)</td>
<td>(0.169)</td>
</tr>
<tr>
<td>Competition</td>
<td>Competitor optical patents (t2)</td>
<td>-0.281</td>
<td>0.029</td>
<td>-0.011</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.148)</td>
<td>(0.237)</td>
<td>(0.234)</td>
<td></td>
</tr>
<tr>
<td>Demand</td>
<td>Carrier capex (t2)</td>
<td></td>
<td>-0.018*</td>
<td>-0.020*</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(0.006)</td>
<td>(0.008)</td>
<td></td>
</tr>
<tr>
<td>Isomorphism</td>
<td>WSJ optical articles (t2)</td>
<td></td>
<td>0.000</td>
<td>-0.001</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(0.001)</td>
<td>(0.001)</td>
<td></td>
</tr>
<tr>
<td>Time trend</td>
<td>Years</td>
<td>0.011</td>
<td>0.096*</td>
<td>0.101</td>
<td>0.215**</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.013)</td>
<td>(0.038)</td>
<td>(0.070)</td>
<td>(0.072)</td>
</tr>
<tr>
<td></td>
<td>Constant</td>
<td>-0.982**</td>
<td>-2.703****</td>
<td>-2.122**</td>
<td>-2.275**</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.311)</td>
<td>(0.445)</td>
<td>(0.752)</td>
<td>(0.879)</td>
</tr>
<tr>
<td>Firm fixed effects</td>
<td>log likelihood</td>
<td>-922.919</td>
<td>-891.585</td>
<td>-880.212</td>
<td>-724.446</td>
</tr>
<tr>
<td></td>
<td>Wald Chi (df)</td>
<td>52.55</td>
<td>127.84</td>
<td>157.91</td>
<td>157.80</td>
</tr>
<tr>
<td></td>
<td>P of chi</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
</tr>
</tbody>
</table>

Note: N lower than in TOBIT regressions because firms with only one obs or all zero outcomes dropped. N lower in model 4 due to lack of data before 1986 for photonics product lines.

*p<.05, **p<.01, ***p<.001, ****p<.0001
Appendix to Chapter Three: using optical publications as dependent variable

I argue in this chapter that optical publications are not an appropriate measure of strategic action as directed by top management. However, because other studies of firm response to technical change in the pharmaceutical industry has found a marginally significant association between management frames and publications (Kaplan et al. 2003), I test optical publications as a dependent variable here. I use a count of optically-related scientific publications for each firm using the ISI/Web of Science database. Optically-related publications were those that included the following words in all forms: detector, dispersion, DWDM, EDFA, erbium, fiber, indium phosphide, laser, lightwave, multiplex, optical, opto-, photonic, polarizing, Raman, SDH, SONET, transceiver, wave division multiplexing, waveguide, wavelength, or WDM.

For publications (see Table 3-10), normalized optical words are not significantly associated with strategic action in the form of optical publishing as a percent of total publications. Indeed, the only factor other than the lagged dependent variable that appears to be significantly associated with publication behavior when all controls are entered is the CEO’s technical background. These results are similar even when eliminating AT&T (and its heavily publishing Bell Labs division) from the sample. Consistent with the findings in the Tobit regressions, normalized optical words are not significantly associated with subsequent optical publications counts in negative binomial regressions (Table 3-11). When “testing in reverse,” there was no significant association between prior optical publications and subsequent mentions of optics in the Letter to Shareholders.

The lack of hypothesized results in the case of optical publication rates provides additional evidence that publications may be a less reliable indicator of innovative output in an engineering-based industry than in a more science-based industry like pharmaceuticals. At a minimum, it suggests that the dynamics that shape publication outcomes are quite different than those that shape patenting. Publishing emphasis in optics is most closely associated with prior publishing activities (as captured by the lagged dependent variable) and not at all influenced by top managers’ frames as measured by counts of optical words in the Letter to Shareholders. This
suggests that publication patterns may develop in the organization quite separately or indirectly from influence by top management.

Table 3-10: Frames as a determinant of response: optical words as a predictor of optical publications percent of total publications, controlling for selected alternative explanations, 1982-2001.

Two-sided TOBIT with firm fixed effects

<table>
<thead>
<tr>
<th>Measure of:</th>
<th>Dependent var: optical publications as a percent of total publications</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
<th>Model 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>n = Cognitive frames</td>
<td></td>
<td>602</td>
<td>602</td>
<td>602</td>
<td>525</td>
</tr>
<tr>
<td></td>
<td>Normalized optical words (t2)</td>
<td>-4.598</td>
<td>-5.481</td>
<td>-4.491</td>
<td>-6.767</td>
</tr>
<tr>
<td></td>
<td>(4.357)</td>
<td>(4.335)</td>
<td>(4.343)</td>
<td>(4.56)</td>
<td></td>
</tr>
<tr>
<td>Lagged dep. var.</td>
<td>Optical pubs % of total pubs (t2)</td>
<td>0.443****</td>
<td>0.424****</td>
<td>0.421****</td>
<td>0.406****</td>
</tr>
<tr>
<td></td>
<td>(0.076)</td>
<td>(0.086)</td>
<td>(0.086)</td>
<td>(0.091)</td>
<td></td>
</tr>
<tr>
<td>Scale</td>
<td>Log of sales (t2)</td>
<td></td>
<td>0.058</td>
<td>0.104*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.036)</td>
<td></td>
<td>(0.036)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resources</td>
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<tr>
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<td>(0.031)</td>
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<td></td>
<td>Photonics products (t2)</td>
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<td></td>
<td></td>
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<td>(0.035)</td>
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<td>(0.002)</td>
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<td></td>
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<td></td>
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<td>(0.000)</td>
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</tr>
<tr>
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<td>Carrier capex (t2)</td>
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<td>(0.002)</td>
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<tr>
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<td>Years</td>
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<td>0.019**</td>
<td>0.019*</td>
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<td>Constant</td>
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<td>Yes</td>
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<td>Chi squared (df)</td>
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<td>638.75</td>
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Note: "N" is smaller in model 4 due to lack of data on product lines prior to 1986. Coefficients for firm dummies not shown. *p<.05, **p<.01, ***p<.001, ****p<.0001

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Table 3-11: Frames as a determinant of response: optical words as a predictor of optical publications, controlling for selected alternative explanations, 1982-2001.

<table>
<thead>
<tr>
<th>Measure of:</th>
<th>Dependent var: count of optical patents</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
<th>Model 4</th>
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<tr>
<td>n</td>
<td></td>
<td>384</td>
<td>384</td>
<td>384</td>
<td>328</td>
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<td>Cognitive frames</td>
<td>Normalized optical words (t2)</td>
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<td>Lagged dep. var.</td>
<td>Log of stock of optical pubs (t2)</td>
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<td>0.117*</td>
<td>0.081</td>
<td>0.326***</td>
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<td></td>
<td>(0.047)</td>
<td>(0.048)</td>
<td>(0.044)</td>
<td>(0.076)</td>
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<tr>
<td></td>
<td>Dummy of stock of opt pubs (t2)</td>
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<td>1.340***</td>
<td>1.397***</td>
<td>0.906***</td>
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<td>(0.258)</td>
<td>(0.248)</td>
<td>(0.25)</td>
<td>(0.280)</td>
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<td>Scale</td>
<td>Log of sales (t2)</td>
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<td>-0.043</td>
<td>(0.101)</td>
<td>(0.110)</td>
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<tr>
<td>Resources</td>
<td>Log of R&amp;D (t2)</td>
<td>0.371****</td>
<td>0.211*</td>
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<td>(0.057)</td>
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<td>(0.086)</td>
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<td>(0.150)</td>
<td>(0.294)</td>
<td>(0.084)</td>
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<td>CEO demographics</td>
<td>CEO tech background (t2)</td>
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<td>0.528****</td>
<td>0.466****</td>
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<td>(0.085)</td>
<td>(0.092)</td>
<td>(0.098)</td>
<td>(0.084)</td>
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<tr>
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<td>CEO job tenure (t2)</td>
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<td>(0.005)</td>
<td>(0.005)</td>
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<td>CEO outside experience (t2)</td>
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<td>(0.152)</td>
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<td>Competitor optical pubs (t2)</td>
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<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
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<tr>
<td>Demand</td>
<td>Carrier capex (t2)</td>
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<td>-0.008*</td>
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<td>(0.004)</td>
<td>(0.004)</td>
<td>(0.004)</td>
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<td>Isomorphism</td>
<td>WSJ optical articles (t2)</td>
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<td></td>
<td>(0.001)</td>
<td>(0.001)</td>
<td>(0.001)</td>
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<td></td>
</tr>
<tr>
<td>Time trend</td>
<td>Years</td>
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<td>0.027</td>
<td>0.075**</td>
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<td>(0.382)</td>
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<td>Yes</td>
<td>Yes</td>
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</tr>
</tbody>
</table>

Note: N lower than in TOBIT regressions because firms with only one obs or all zero outcomes dropped. N lower in model 4 due to lack of data before 1986 for photonic product lines.
*p<.05, **p<.01, ***p<.001, ****p<.0001
Chapter Four

Inside EQUIPCO, an introduction to the field study

4.1 Introduction

4.2 Research design

4.3 Organizational context: EQUIPCO and ATG

4.4 Decision-making in the Advanced Technologies Group

4.5 Five technology strategy projects

4.6 Portraits of individuals

4.7 Scope conditions – particularities of EQUIPCO and ATG

4.1 Introduction

The preceding chapter provided results from the macro, quantitative study that suggest an association between managerial cognitive frames about technology and organizational action. The aim of this chapter is to examine the underlying mechanisms that connect these kinds of frames to strategic choice, in particularly during turbulent times such as those created by the fiber-optic revolution. By mechanisms, I mean the processes and practices that explain the relationships between the variables (Elster 1998). My interest is in exploring the day-to-day activities associated with making strategic choices in order to understand what role managerial frames might play and how. In order to capture these processes and practices, I pursued a field study in the Advanced Technologies Group (ATG) at EQUIPCO, an incumbent communications technology company. ATG is the research division within EQUIPCO and is charged with developing the technology strategy for the corporation. My data collection took place over eight months from April to December 2002, the direst period of the crash in the telecommunications industry. The study itself focused on the unfolding of five different

56 The name of the company and the division in which I did my research are disguised. In the descriptions, I have also changed the names of the projects and informants and key technical details in order to protect the confidentiality of the field site.
technology strategy projects – from their inception through a series of critical resource allocation decisions – that were responses to the collapse of the optical communications market.

This chapter is the first of two that report on this field study. Here, I will lay the groundwork for the more detailed analysis that ensues in the following chapter. In this chapter, I first describe the research design and analytical approach I took, focusing on the details of the ethnographic techniques I employed and the choices I made about data collection. Next, I illustrate the organizational context both of EQUIPCO and ATG in order to both set the stage for the subsequent analysis of ATG’s strategic choice making as well as to establish the scope conditions of the work. Finally, I tell the stories of the five projects and of my informants. These stories will illustrate the tremendous range of interpretations about the internal and external environment that were present within ATG during my observations, show how these conflicting frames played out over time and highlight the important interrelationship of frames with interests. The details reported in this chapter help enrich and bound the theory that I generate in Chapter 5 on “framing contests.”

4.2 Research design

My approach for this study was open ended and inductive but was driven by a broad interest in how firms make decisions about investments in technology during periods of high uncertainty (about the nature of the frames about the environment and appropriate response and the role, if any, they played in shaping outcomes). I used ethnographic techniques to study the making of technology investment choices and followed an interpretive approach to understand the generation of meaning by the people within the organization (Gioia and Chittipeddi 1991). Studying specific practices within a single firm makes sense for these purposes because of the desire to uncover the micro mechanisms associated with the strategy-making process (Dougherty 2002; Pettigrew 1987).

4.2.1 Selecting a field site

Because the problem of firm response to technical change is primarily seen as a problem for incumbent firms, I chose to focus the field study on an incumbent firm in the communications technology industry. I was also interested in locating a firm that had made significant investments in the optical arena as well as in more traditional communications
technologies. During the early stages of the downturn in telecommunications, it was particularly difficult to find a firm that was willing to tolerate the presence of a field researcher looking into the highly proprietary questions of technology strategy. A number of executives I approached felt that their organizations were too stressed to take the time to host a researcher. Others were concerned about protecting proprietary technologies. Therefore, as it nearly always is in this kind of research, obtaining a good field site could not have happened without a bit of luck. Through prior research for the MIT Microphotonics Industry Consortium, I made contact with Brad Copeland who headed up the ATG organization in EQUIPCO. He had similar concerns about the stresses on his organization and the need for secrecy about the group’s technologies, but at the same time, he was interested in learning from the crisis to improve strategic choices about technology. As a technologist himself, he appreciated the value of research and was willing to open his organization to examination.

EQUIPCO is particularly well-suited to the study of communications firm response to the fiber-optic revolution (and related market downturn). The company is a large incumbent with substantial businesses in both optical and non-optical technologies, serving both carriers and enterprise customers. It rode the telecoms bubble quite high and also fell quite hard during the crash. The ATG organization itself was responsible for setting the technology strategy for the corporation.

4.2.2 Gaining access to ATG

My first exposure to ATG and EQUIPCO was through a series of interviews conducted as part of the MIT Microphotonics Roadmapping project. This project was aimed at developing a roadmap for communications technology for the next several years with the idea that it would guide research trajectories for both MIT researchers and the Microphotonics Center Industry Consortium members who were funding the project. The first step of the roadmapping process involved interviews with executives from Consortium member companies and other important players in the industry.\textsuperscript{57} Overall, more than 75 people in 15 organizations were interviewed. I conducted the vast majority of the initial roadmapping interviews along with Elizabeth Bruce,

\textsuperscript{57} The results of these interviews are reported in a whitepaper for the MIT Microphotonics Industry Consortium (Kaplan 2003).
the Program Manager for the Communications Technology Roadmap. We got access to interview members of the EQUIPCO organization as part of the roadmapping project. At that time, I met Brad Copeland, the head of ATG. He indicated he was thinking about how to improve the strategic decision-making processes within his group and therefore was interested in my research. After a follow up discussion, I wrote a short proposal for a field study of the ATG organization. Brad agreed to proceed and invited me to start right away so that I could attend the mid-year Review Board decision meetings (with the caveat that I would have to sign a non-disclosure agreement, NDA, which I did). The *quid pro quo* was for me to provide an “audit” of decision-making at ATG at the end of my time with the group with suggestions for how the processes could be improved.

I had initially asked Brad if there would be a possibility to extend my observations to the members of the corporate management team. While he was very open to my work within ATG, he felt that the timing was not right to involve senior officials given the challenges they faced in dealing with the crash in telecoms and plummeting EQUIPCO performance. He said of the corporate executives: “Those guys have their hair on fire at the moment. You might be making a new shampoo, but they don’t care right now because they are still waiting to see if they have any hair left.” On the other hand, this situation made the work being accomplished even more strategically essential for EQUIPCO (and therefore more appropriate as a focus for my field research). Because the top corporate management was fully focused on EQUIPCO survival, ATG had the sole task of developing the corporate technology strategy.

When I first showed up at the headquarters location, Brad asked one of his direct reports, Vince Weston, to be my point person. Vince worked out of a different location several hundred miles away but spent significant amounts of time at headquarters. Vince got me oriented, had me invited to several meetings in the early stages and gave me a number of background documents. I was provided a conference room to use as an office when I wasn’t in interviews or meetings. This room was just down the hall from Brad’s office. When Vince was in town, we often sat in the conference room together. Vince occupied a special place in the organization as he was both a personal friend of Brad and Brad’s key advisor on strategic issues. Vince functioned essentially as a special projects person helping Brad get his arms around particular strategy problems or preparing Brad for meetings with EQUIPCO corporate management. As
such, Vince felt that he and I were both on the hook to improve the strategic decision-making within ATG, and he used me as a sounding board for his ideas.

In general, I was quite well received by all of the informants in the organization. Everyone whom I asked to interview easily agreed and for the most part did not mind being recorded. Often, they would seek me out if they had not heard from me in a few days or if some interesting conversation had occurred offline that I hadn’t been privy to. While it would be inappropriate to say that my presence did not affect behaviors, I believe that the informants were nearly universally very comfortable with my presence, at least after the earliest days. For example, in the first strategy meeting I attended, Brad remained in the meeting for the entire day. Afterwards, another of the senior executives in the group told me that this was unusual behavior, noting that he tended to come in and out of meetings and regularly referred to his Blackberry device to monitor incoming e-mails. By the second Review Board meeting I attended, Brad’s behavior had reverted to this norm. This comfort level with my presence existed despite the highly confidential and strategic nature of the technology discussions that took place. From time to time, when Brad and I would talk about something highly confidential, such as a “Trojan horse” strategy he had for a particular technology, he would note that “this is why the NDA is in place.”

4.2.3 Data collection

My approach to data collection was ethnographic. I wanted to examine events from multiple possible angles using as many sources of data as possible. In particular, I wanted to steer away from simple reliance on interviews in which informants can choose the ways to represent their activities and the organizational dynamics, changing or reinterpreting in order to preserve face (in particular to an outsider: the researcher) (Goffman 1959). I relied heavily on personal observations of the everyday activities, using other sources of data to amplify and verify the insights generated. The goal was to uncover “the soft underbelly” of strategy making (Edge and Mulkay 1976; as cited in, Latour and Woolgar 1979) by looking at what actors do individually and collectively to produce strategic choices. The ethos of ethnography is that the researcher must get close to the activities of informants – “work at the coal face” in Van Maanen’s (1988: 23) language – in order to understand the real nature of the dynamics shaping
outcomes (Emerson, Fretz, and Shaw 1995). The goal in my research was immersion in and “thick description” (Geertz 1973) of strategy-making in the ATG organization within EQUIPCO.

The research design for the data collection, analysis, theory-building and write-up stages, was aimed at meeting the tests of validity and reliability (as laid out by Yin 1984). To improve construct validity, I used multiple sources of data and reviewed insights with key informants. To generate internal validity, I compared patterns and explanations across different cases of strategic decisions within the ATG organization. To assure reliability, I maintained extremely careful documentation of all of my interactions and of all of the archival materials I gathered.

The core of my data collection occurred over the 8 months from April to December 2002. In this period, I conducted over 80 formal, unstructured interviews, observed more than 30 formal and informal team meetings (from 2 to 10 hours long), and collected related documentation for each project (e.g., spreadsheets, PowerPoint presentations, e-mail exchanges, agendas, and minutes of meetings). I attempted to participate (either by conference call or in person) in all scheduled meetings related to each of the five projects I followed as well as all of the meetings of the decision-making groups (the Review Board and the Steering Committee that I describe below). On many occasions, I was able to observe informal meetings that took place by chance (e.g., people passed each other in the hallway). I also conducted interviews with all key project participants as well as other members of the senior team within the ATG organization. Where possible, I also interviewed participants both before and after key decision meetings to understand their expectations going into the meeting and their reactions afterwards.

At the request of ATG management, I signed a non-disclosure agreement (NDA) that prohibited me from disclosing particular technical details. I notified all of my informants that I was under NDA. This agreement was a two-way street in that the informants were obligated to note when a particular issue was confidential and not to be disclosed. This only occurred two or three times during my entire period of observations. EQUIPCO retained the right of review of any work that would be published or disclosed broadly. As a result, I have made careful attempts to disguise the specific nature of the technologies. So far, they have not made any requests to change any details in the materials submitted to them. In addition, I have been subject to the regulations of the Committee on the Use of Humans as Experimental Subjects.
(COUHES) at MIT. This required me to notify my participants of the purpose of my work and give them the option of not participating or not being recorded during interviews.\footnote{The text that I was required to read to each of my informants at the first interview follows. In subsequent interviews, I simply reminded them of the prior discussion and asked again if I could record the interview. “Thank you for taking the time to meet with me. I am a doctoral student at MIT’s Sloan School of Management doing research on how companies make strategic decisions about technology. I will be using your company as a case study. My research involves developing detailed case studies of specific projects within your company. One of these projects is \textit{name of project}. I was referred to you by \textit{name of referring person} who suggested you might have some interesting insights with regard to \textit{name of project}. I am covered under NDA, and the results of my research will be reported in such a way that the identity of specific individuals, projects and companies is protected. I want you to understand that you are under no obligation from me or from your employer to speak with me. If you agree to be interviewed, you may decline to answer any specific question at any time. I would like to be able to tape record our discussion. The tape recording is a way for me personally to remember accurately the details of the interview. The recordings are for my own use, will not be distributed to anyone else, will be stored in a secure location and will be destroyed at the end of the project. You may decline to be taped if you should so wish, and, if you do agree to be taped, you may also ask to turn off the recorder at any point during the discussion.”}

My research took place in the course of seven (3-5 day) site visits to the headquarters location, five (1 day) site visits to one of the branch locations, and regular telephone meetings and interviews when I was not physically on site. The headquarters location was a collection of buildings. Security was extremely high. I had to sign up for a guest pass each day as I entered the building and the pass required me to be escorted throughout the building. Each morning, I had to wait for one of my informants to come down to get me at the guard station. At night, if I worked late, I had to search around for someone to escort me out of the building. I couldn’t get a contractor’s badge that would allow me freer access because I would have then been added to the headcount of the ATG organization, which given the times was something Brad couldn’t afford to do. Over the course of the day, I was also supposed to be escorted but this was not fully enforced except for in public gathering areas such as the cafeteria. This had the positive effect of requiring that I always go to lunch with people in the organization.

Since the company was highly geographically dispersed, the vast majority of the teams’ interactions took place on conference calls with the aid of NetMeeting\footnote{NetMeeting is a technology that allows everyone on a conference call to see the same presentation by “dialing in” to a host computer.} technology to share PowerPoint documents. Nearly all of the meetings were supplemented by a teleconference connection. Therefore, I was effectively fully immersed at the site for the full 8 months because being “in the field” took on a slightly non-traditional meaning as these contacts were often
conducted electronically. Other than the two weeks at the end of August when most of my informants were on vacation, I had daily contacts with informants. When I was not on site, I maintained regular e-mail exchanges with my informants, participated in team meetings and formal Steering Committee or Review Board meetings through teleconference, conducted phone interviews with informants in geographically dispersed locations (away from my field sites), and spoke informally on the phone with key informants.

Ethnographic techniques, drawing on their roots in anthropology, have been historically primarily about being “in the field,” in a sense, “living” with the informants (Gellner and Hirsch 2001; Van Maanen 1988). With the growing use of modern information and communication technologies, the meaning of being in the field is changing, as ethnography goes “virtual” (Hine 2000). This study combined more traditional techniques of being physically on the ground with more virtual techniques of participation via teleconference or e-mail exchange. Participation via teleconference, far from being a more impoverished version of the experience on site, was richer in many ways. First, because the participants could not see me, it was often easier for them to forget my presence. Teleconference participants appeared to be much more comfortable around me from the very beginning while my physical presence in the early days of my observations created some visible disruption in routines. Second, during teleconferences, I was able to use a headset, put my phone on mute and type the dialogue nearly verbatim. As this kind of typing would have been highly disruptive in meetings where I was physically present, I was able to capture the exchanges among participants much better in the virtual setting. Third, and perhaps most importantly, many of the people on the teleconference were experiencing the meeting in exactly the way I was. Given the geographic dispersion of the company, there were many people who rarely, if ever, came to the headquarters location. Even one of the directors (Erik Helgesen) participated in Review Board meetings via teleconference in the vast majority of cases. As I result, I could experience what it felt like to be remote from the conference room at headquarters from where the meeting emanated. I was as frustrated as they were when people in the conference room spoke away from the microphone and were inaudible. I lived with the ups and downs of NetMeeting just as my informants did.

The goal of this approach was to surface multiple overlapping sources of data for each project case (Yin 1984). Thus, for any formal meeting, I interviewed key participants before the
meeting to understand their expectations and goals, I attended the meeting and took notes, I collected presentation materials as well as agendas and action item memos coming out of the meeting, and then I interviewed key participants afterwards to get their reactions and interpretations of what had happened. Not only did I focus on the events for the chronology of each project (Bourgeois and Eisenhardt 1988) but I also sought deliberately to understand each informant’s interpretations of the situation: in addition to the “What did you do? When? Who said what to whom?” questions of Bourgeois and Eisenhardt’s “courtroom” style interviews, I also asked “Why?” While the observations and interviews were unstructured, I did focus on understanding the chronology of the project, the key turning points, the players involved, the dynamics among the team members and specifically what role frames or interpretations might or might not play in the outcomes.

Nearly all interviews were recorded and transcribed. In addition, I made detailed notes during each interview and wrote these up within a day. Each of the notes included a comprehensive report of the interview as well as a separate section with my reflections which included thoughts about emerging themes, surprises, new information, and contrasts with prior interviews. Due to company policy, I was not able to record the meetings I attended, but I took careful notes and also wrote these up shortly after the meetings. As mentioned, where I participated in meetings through a teleconference, I was able to type the dialogue nearly verbatim.

4.2.4 Analysis

My analysis followed the principles of inductive, grounded theory (Dougherty 2002; Glaser and Strauss 1967; Sutton and Staw 1995). The processing of the data began as I began my field work: I wrote commentaries on each interview and meeting and composed weekly memos summarizing emerging themes. After the field work concluded, I used my field notes, transcripts and archival materials to construct time lines for each of the projects covering both the actual events that took place and the different interpretations of those events by the key players in each project at different points in time. These chronologies included detailed information and quotes from the interviews, field notes and archival materials. This level of

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60 Two interviewees were not comfortable being recorded. For these interviews, I have interview notes only.
detail allowed me to locate the key turning points in projects and identify the mechanisms by which they were achieved. Based on the insights generated from the chronologies as well as the emerging themes from the weekly memos, I developed an initial list of themes and codes for analyzing the data. Using the ATLAS.ti text analysis software, I coded each element of the chronologies, adding new codes as they emerged through multiple close readings of the data.

Based on this information, I constructed a model by inferring from the field data an understanding of the mechanisms that led to patterns of behavior witnessed during the projects (Glaser and Strauss 1967). I iterated between raw data, emerging themes and the related literature to settle on overarching concepts and how they interrelated. To assure internal validity, I searched for patterns and underlying mechanisms by comparing across decisions to look for differences and understand why the occurred. Once I had developed a preliminary model of the dynamics associated with the strategy-making in each of the cases, I conducted a series of additional interviews with key informants to validate the themes, iterating further where differences emerged. In the next chapter, I present this model of “framing contests” derived from an analysis of the data. The remainder of this chapter presents broader background data that will help situate the analysis that follows.

An underlying principle in ethnographic research is that of capturing the “look and feel” of an organization (Van Maanen 1988). In the remainder of this chapter, I explore the organization, its projects and its people in order to capture the underlying culture of the place. By doing so, I am able to ground the dynamics of cognitive frames and strategy making that I explore in the next chapter (Chapter 5 on “framing contests”). I also establish the scope conditions of the analysis. The approach of this study has been deliberately to focus in on one organization and explore strategy making in depth. While it will allow me to capture details of the everyday processes, the findings, of course, are limited in their generalizability. ATG is a particular kind of organization with a particular history in a particular corporation. It had a relatively democratic decision making process; it had long roots as a research organization; it was dealing with rounds of layoffs during the period of my observations. All of these features (and the additional ones I describe below) both enrich and bound the insights that I can generate from this study. I describe the organization and its people in detail here to give as much granularity as possible to these features.
4.3 Organizational context: EQUIPCO and ATG

The core of my observations and analysis focused on five projects or initiatives for technology investments. In the next chapter, I will explore two of those projects more deeply and develop a model of the "framing contests" that shaped the outcomes of the strategic decisions in these projects. However, these projects took place within the larger context of the EQUIPCO and ATG organizations. In order to sit the analysis in its appropriate context, in the following sections I describe the culture of EQUIPCO and of ATG specifically, develop the chronologies of the five projects I studied in detail and tell the stories of several of the key individuals.

EQUIPCO is a large incumbent communications equipment company. It’s history had been primarily in developing telecommunications technologies for carriers. While the company had diversified in more recent years into data communications for enterprise customers, the culture and business model continued to be dominated by a carrier mindset. This meant primarily a focus on high tech, highly customized systems bid on a customer-by-customer basis. Diversification had come mainly in the form of acquisitions. The company had been a leader in introducing optical technologies into the communications system and rode the telecoms bubble higher than many companies. As a result, they also fell harder than many companies. Over the course of 2001 and 2002, the corporation laid off more than half of its workforce and sold or shut down some important parts of the business.

4.3.1 Dealing with the telecom crash

My research took place during 2002, at the deepest part of the crash in the telecommunications industry. This was a time when the corporate executives were focused entirely on survival of the company which involved cost cutting and massive layoffs. Management had not anticipated the downturn (nor had the management of nearly any company in the industry), and thus it came as an incredible shock to the system (they admitted as much in their external communications). During the bubble, expenses had run unchecked. The war for engineering talent was so great that anyone could threaten to leave the company and get a substantial raise in order to stay. The company, as did many firms in the industry, used its highly priced stock to go on an acquisition spree. Relatively junior managers could easily commit $10 million without consulting anyone. Major acquisitions were made with very limited due
diligence because of the fast pace in the market. As the industry melted down, EQUIPCO’s management had to rein in all of these behaviors. Strategy flew out the window as survival became the overriding goal.

From the perspective of people in the ATG organization, there appeared to be no strategy at all. They saw the guidance from the CTO as “Pollyanna pep talk.” With regard to one of the CTO’s presentations about the technology strategy of EQUIPCO informants remarked in a meeting,

**Vijay Kumar:** It would appear that [the CTO] is just coasting. The slides didn’t say anything. They are just stupid… I think that that’s indicative of where they are, just how lost they are or fragmented in terms of pulling together a strategy…

**Vince Weston:** Yeah, my observations [of headquarters] is that it is about firefighting at its best. New things come down and some meetings get cancelled and others begin. It is like a bunch of spinning plates.

On the other hand, for the ATG organization, this meant that they had the opportunity to drive the technology strategy for the corporation. The discussion continued,

**Vince Weston:** The good news is that politics will force them all together and everyone is going to look to the people who work for them to pull together a bunch of stuff so that they can look good. Which is good for us because we are basically worker bees and aren’t involved in the politics. Our input will definitely be fed in to [corporate management]. The work that we are starting to piece together can create a sense of stability or at least a portion of stability for new products and evolving our portfolio.

Yet, despite this disruption, change did not come quickly. As one manager commented, “This company is a leopard whose spots are very resistant to change” (Hugh Collins). One of the most overriding drivers of this resistance in EQUIPCO and ATG was the culture of technology.

**4.3.2 Culture of technology**

Technology had always been an important emphasis within EQUIPCO. Management regularly listed “technology leadership” as a primary factor in EQUIPCO’s competitiveness in its external communications. Even in the years of the crisis in telecoms (2001-2002), the “vibrant culture of innovation in our labs” and investment in R&D were featured prominently as the “lifeblood” of the company in the CEO’s external communications statements. The company prided itself in its long history being a “technology thought leader” in the industry.

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61 The individuals and their position in the organization will be introduced later in the chapter.
This manifested itself in a particular reverence for patenting. In the Letters to Shareholders in the annual report, management often discussed EQUIPCO's portfolio of patents and lauded the multiple-patents-per-day patenting rate achieved by the research organization. And, within the ATG organization, those with patent grants had plaques and certificates on their office walls to commemorate each individual patent they had been granted by the US Patent and Trademark Office. Some, such as Hugh Collins (who will feature heavily in the stories about strategy-making at ATG) only kept the most recent on his wall because he had too many to feature simultaneously. Others had only one or two and so the plaques were prominently placed in the office. During the period of my observations, two annual events to honor the people involved in producing patents for the corporation took place. They were held in the central atrium of the lab building. A senior executive (a head of one of the main business divisions) was present to hand out the awards at each. The first ceremony was for people who had applied for a patent that year, the second for people who had received patent grants that year. There were nearly 200 recipients at each event. The senior executive made a speech to introduce the ceremony. Brad also made some prepared remarks (which he had labored over for several days). Then, each individual was called to the stage to receive his or her certificate as Brad Copeland, the head of ATG, read out his or her name and the title of the patent. Most people received one or two certificates. Hugh received eight or nine at each of the two ceremonies. These events were heavily advertised throughout the organization. Many people came out to watch from the upper tiers of the atrium. Patents were a very important way to achieve prestige in the ATG organization. Hugh was revered for his prolific output.

EQUIPCO and ATG in particular were typical of engineering oriented cultures (Bucciarelli 1994; Kidder 1981; Kunda 1986; Vincenti 1990): desire to work on "cool technologies," respect for technical expertise, reverence for patents, intolerance of politics, lack of comprehension of marketing. As Brad Copeland said in one interview regarding the motivations and incentives for the people in the technical organization:

*The technology people, because that is their thing, look for cool widgets, or new technology. But I think one of the big things at the end of the day comes down to the motivator, which I call just pure recognition. Everybody wants to see that their idea is the one that is pursued from a corporate perspective and that is not about achieving specific financial incentives. It is the propagation of intellectual capital. Now I referred last time to the fact that [ATG] was kind of a school for gifted children. I think gifted children like to do well and need to compare grades. (Brad Copeland)*
The crash in the telecoms industry forced a reorientation of this technology-focused culture. No longer were they in an era when a “build it and they will come” philosophy was sustainable. The “bubble mindset” in which “cool technologies” were the drivers of decisions became anachronistic. The EQUIPCO board removed the old CEO who had come from EQUIPCO Laboratories (the precursor to ATG) and replaced him with someone from a finance background. The new CEO reorganized the company into more “customer-facing” business units. And, there was a general sense that greater “business rigor” would be required.

### 4.3.3 Advanced Technology Group (ATG) organization

The Advanced Technology Group (ATG) of EQUIPCO was a corporate level group charged with identifying and developing advanced technologies beyond the horizon of the business units. Business units had their own development groups but these were largely focused on engineering for existing products. ATG was charged not just with developing technologies but making sure that they had direct relevance to the market and to the internal customers, the business units. As a result, while the organization was mainly composed of technical personnel, they also had two groups of business and marketing people to help shape the business cases for the projects pursued by the organization (see Figure 4-1 for the general organization chart).

The addition of non-technical functions came when the group was reorganized out of the old “EQUIPCO Labs” and renamed the “Advanced Technologies Group.” But, these changes had to overcome a long history and reputation. ATG retained its “whiz-bang” culture. Even managers in the business units who worked regularly with ATG project teams described them as the “old EQUIPCO Labs guys who talk above the clouds...They have to fix that image.” As Brad Copeland described it:

> From a historical perspective, typically EQUIPCO Labs was very isolationist in its approach. They were very good at what they did, but nothing ever seemed to achieve escape velocity. We did build it from soup to nuts, but nobody ever got to taste the soup or the nuts...It was a great-looking menu but, we’re still starving. So, [for ATG], to prolong the analogy, to feed the army, maybe we just need to produce the bowls. And, someone else provides the feed.

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62 The group had a director of human resources who was also part of the ATG management team. She was officially part of the corporate human resource group but she sat with ATG management. However, she was a casualty of the layoffs. After working with Brad to make the appropriate cuts in his organization, she was laid off by corporate just about the time that my field work began. After that point, the HR function in ATG was just a service provided by a corporate staff.
4.3.4 **ATG relationship with the rest of EQUIPCO**

ATG had a special and relatively delicate position within EQUIPCO at the time of my research. As noted above, the provenance of the group was in the lauded "EQUIPCO Labs," the source of EQUIPCO's technology leadership historically. And, given the focus of senior corporate management on short term financial and organizational issues, they turned strongly to ATG to provide the technology strategy for the corporation. As Brad Copeland put it: "I now have responsibility through [the CTO] to [the CEO and his team] and probably to the Board of Directors for what the technology road map is going to look like going forward." This was particularly true because the CTO did not come from an R&D background, having been brought into the position from a management position in one of the divisions. Regularly, Brad Copeland (the head of ATG) would report that the CTO had asked him what the corporate strategy should be in a particular technical arena (e.g., "what's our hedge on 3G wireless?") or more broadly to "influence customers and provide technology to them."

Yet, ATG managers were often frustrated at the lack of leadership from the senior corporate executives. They would grasp at any kind of direction they could receive. For
example, in the case of the Last Mile project which proposed to invest in optical access technologies (which I will report on below), there was deep concern in the organization about going back into this arena. The prior CEO had made an “edict” against access (divesting the corporation of past technologies in this area), and therefore people in ATG were “fearful to even use the word ‘access.’” Similarly, one of the senior members of ATG management noted that the strategic thrusts that had been established in the ATG organization 18 months previously had been “laid out based on comments [the prior CEO] made about the corporation.” In another example related to the Lightwave project on photonic switching, one of the team members said that he had heard from someone else that the CTO had said to a customer that the ATG organization was supposed to pursue these optical technologies. Ultimately, this third or fourth hand knowledge was put down to hearsay. But, because it was one of the few pieces of data they had on the CTO’s view, it held a lot of sway.

Despite being the primary source of technology strategy for the corporation, ATG’s position was also precarious. As a staff group, they felt they had to justify their position to the lines of business. While ATG had experienced serious layoffs, it had been relatively protected compared to the cuts made by the business units. Brad Copeland was described by his staff as needing “to show the CTO that he is doing good work” in order to protect ATG from more layoffs. One noted that, “Politics consumes Brad. He spends a lot of time talking about the fact that the CTO has been minimized and that [another executive] might come and run the group.”

Notwithstanding these pressures, many objected to aligning ATG’s mission too closely to the needs of the business units. Said one senior scientist,

*There is something fundamentally wrong with aligning to the biggest business units. If we look back at the history of the corporation, and my history takes me back to the EQUIPCO Labs days, never in the history of the company have I ever seen a massive new discontinuous breakthrough product emerge from an existing large lumbering business unit. It just doesn’t happen. It always started as something new. So, aligning only to the existing business units means they are certainly not looking for that massive new opportunity. If we just look where they are looking, then neither will we.* (Hugh Collins)

4.4 Decision-making in the Advanced Technologies Group

The decision-making process within ATG was in flux during the time of my observations. Brad, as the relatively new head of the group, was engaged in a cultural transformation to make the decision-making more “investment” focused. Despite his attempts to
impose a more “rational” analysis, the decision processes tended to bring out strongly different interpretations which were linked to different individual and group interests. As a result, decision-making was highly political in many cases. At the same time, Brad noted that within ATG, the current market has “augmented the level and frequency of decision-making because of the uncertainty.” He argued that, in a predictable or growth market, decisions are relatively easy and have sure outcomes. In an uncertain market, “we have to be much more agile and adaptive, because we end up revectoring more often.” In fact, “decisions are harder to make now because the consequences are more dire. In the upswing, you can take more risks because the growth will buffer you. Now, a failure in the market could have really negative results for the company.”

In this section, I will describe some features of the context of decision-making in ATG before turning in the next section to the chronologies of the five specific projects I studied.

4.4.1 The look and feel of the place

The main building of the headquarters location was called colloquially the “Tower.” The ATG senior managers all had their offices here. It was a circular building and all of the executive offices had glass walls that faced outwards to a peripheral corridor. If I needed to see someone, it was easy for me to casually wander down the corridor and catch the eye of the person I wanted to see and get invited in to his or her office. And, if it was easy for me, it was easy for others. I witnessed a number of incidents when people, ostensibly on their way to get a drink from the coffee room, happened by Brad’s office and took the opportunity to pitch their position on a project. The Lab buildings were connected by a corridor to the Tower building. The technical area included actual labs where engineers were running experiments and building prototypes. But, the vast majority of the facility was a sea of cubicles. Finding a cubicle involved wandering around in the maze trying to find a particular pillar number as a landmark.

Only directors, of which there were very few, were permitted to have small offices with doors that closed. Being a director in the technical organization was historically a high prestige job. For a person to become a director, it was an acknowledgement of his or her deep expertise. While there was a hierarchical aspect to the designation of director (managers and engineers reported to directors), it was not entirely about organizational hierarchy. Directors reported to directors (e.g., Jack Stafford and Vijay Kumar reported to Erik Helgesen) and some directors had
no direct reports (e.g., Hugh Collins). The title therefore had most significance with regard to technical status in the organization.

ATG was an organization dominated by engineers (nearly everyone in the group was an engineer of some sort except for the head of human resources). As a result, meetings had a certain feel easily recognizable to anyone who has been in an engineering organization. In working meetings between a team leader and his or her engineering team, the engineers each brought a standard issue EQUIPCO blue engineering log book. Each engineer kept track of all activities and ideas in the book. When it was complete, the protocol was to hand it in to corporate archives (for legal purposes). The team leader might bring a laptop and make a presentation to the team about status or management decisions. Engineers would report on their work, ask questions and debate key technology decisions. The process seemed quite efficient and orderly.

In management meetings (such as the Steering Committee or Review Board), on the other hand, all participants would bring laptops and immediately log in to the network. For security purposes, EQUIPCO did not have wireless LAN’s and therefore each person would have to locate an Ethernet cable to hook the computer up. In one case (Brad’s annual strategy meeting in the fall with his management team), the meeting was delayed for 30 minutes while they found a way to get everyone connected. These connections did not appear to be necessary for the meeting (except for one person to run NetMeeting, as I will discuss below). The norm seemed to be that all participants would check e-mail and work on other projects while participating in the meeting. It was obvious that they all had their e-mail programs on because the e-mail alert beep would sound regularly from the various computers. Brad did not bring his computer because he had a Blackberry which he consulted very regularly throughout all of the meetings in which I observed him. This general behavior was, according to my informants, a product of multiple factors. Given the cut backs, everyone was extremely busy and felt the need to multitask in order to get things done. On the other hand, being “on e-mail” was also a signal that an individual was indispensable to other activities taking place at the same time and also a signal that people did not have complete faith in the value of decision-making meetings. The e-mail checking occurred most frequently in meetings that Brad attended (not surprising as Brad was always looking at his Blackberry).
The other constant feature of most team meetings as well as Steering Committee and Review Board meetings was the teleconference hook up for those calling in from remote locations. As EQUIPCO was highly geographically dispersed, it was nearly always the case that not all participants could meet face-to-face. This was particularly true during the downturn when travel budgets were eliminated. All meeting rooms had expensive teleconference equipment and the beginning of each meeting involved dialing in to the “bridge.” In addition, because PowerPoint slides were the primary form of documenting ideas, a NetMeeting connection was set up so that everyone could see the slides at the same time. As a frequent participant in these meetings via teleconference, I understood the difficulties for remote participants first hand. My own notes from a Last Mile project meeting read like this:

_Theresa is in [the headquarters location] but she dials in from her office rather than coming to the meeting because she is expecting someone to drop by. The rest are in a conference room in the Lab. The people in the room are relatively hard to hear because they are not all near the phone. Some of this seems to be because they are trying to block sound from the projector that is near the speaker phone. They take several minutes setting up NetMeeting, figuring out who should dial into whom._

In a Steering Committee meeting reviewing the Module project, I wrote:

_There are problems with NetMeeting. Stephen Merton [calling in remotely]: I don’t see slides being put up by Theresa yet. Theresa: You don’t? Let me see if I did something stupid. (long pause) Do you see something now? Stephen: Not yet. George Arden: This happened the last time when the second presentation didn’t come up in NetMeeting. Theresa: Let’s restart NetMeeting. (long pause) OK start dialing. (Long pause)._  

It was also the case that the people who dialed in to the meeting often were not paying close attention, at least in the meetings with a larger number of people. Vijay Kumar did not work at the headquarters location, so he dialed in to all Steering Committee meetings. He told me that he always put the phone on mute and just went ahead with his own work unless one of his own projects was being discussed.

### 4.4.2 Decision-making

All investment decisions in the ATG organization were subject to a formal decision-making process which involved two main committees. A technical Steering Committee, made up primarily of senior technical personnel, reviewed and shaped projects until they were ready to advance to a decision. An investment Review Board made up of the group’s senior management team had the formal responsibility of approving and monitoring projects. Figure 4-2 shows the
ATG organization chart with the positions of the individuals I studied most closely and their membership in each of the decision-making bodies.

Figure 4-2: Key actors in the ATG organization

This two-tier process had been put in place about 18 months before the period of my fieldwork in order to apply more discipline to the decision-making process, especially in assuring an adequate business case had been developed. The Steering Committee and Review Board required each project being reviewed to prepare a business case using a template that included: a decision statement (time frame plus financial and human resources), a description of the technology, analysis of the addressable market and EQUIPCO’s potential share (to produce a revenue value of the project to the corporation), letters of support from business units and end customers, an analysis of risks and the proposed mitigation strategy, a rationale for why ATG was the right group to run the project, program milestones, and a project plan.

In this context, Brad was trying to create a relatively democratic process, but not one that was focused just on compromises that diluted the ideas.
My participation is not as a referee. It is as a co-participant, as it were. I may have a louder voice or I may have the tie-breaking vote, but I have one vote. What I want to see happen is that I want these discussions to take place, and I want the decision to be presented at that forum. So the Review Board is more of an information session as opposed to a refereeing session. We as a team have come together. We have shed blood and tears and sleepless nights to come to this end point, and it is not a dilution or compromise of everybody’s feelings. (Brad Copeland)

When I started my field work, Brad Copeland described the decision-making process for technology investment as relatively formal. First, there was a Steering Committee that vetted the technologies. Each project team or proposer had to fill out a loosely defined template to “go through the math” (covering market, product displacement, and other issues similar to those in a startup business plan). The technology was weighed relative to EQUIPCO and ATG priorities. The question was: “is he dreaming in Technicolor or does he have something here?” If the technology passed the test, then it would be reviewed in a quarterly (more ad hoc) meeting with the Review Board. This was a second level of approval and review. Investment decisions always went through these layers, at least formally. Brad operated the group on an “explore-qualify-transition” or “EQT” model. “Explore” covered technologies that are 4-5 years out. “Qualify” was for prototype and proof of concept. “Transition” was to package and bundle within the line of business (get the product shipped to the customer). The budget was about 12 percent E, 70 percent Q and 18 percent T. There were 65 total projects in his “funnel” in mid 2002.

While these procedures sound quite formal and rational, it will become clear in the analysis of the projects that the decision-making did not always follow this path cleanly. The most important effect of the formal procedures was that resource allocation decisions became public and therefore open to dispute. While there was much wrangling in the backrooms, and decisions were not always (or even often) made in the actual formal meetings, the necessity of going through the process made possible the framing contests I observed (and will describe in the following chapter).

Brad came from a technical background but, having advanced to a senior management position, he saw the value of multiple disciplines. As such, he used the Steering Committee to make cultural change. He was comfortable that some people were unhappy with it in the early stages. He felt that they just needed to keep going through it in order to learn about how to incorporate the business imperative into technical projects. It was a selection mechanism for
Brad. The people who got it would advance, the people who didn’t would be “marginalized over time.”

I find that the technology community at large in a number of different institutions, not just EQUIPCO, are very good at what they do but they are business ignorant. They live in a very isolated little world that revolves around bits. And, I am very glad that that exists. But, unless we can figure out how to make money from it, there is no point in doing it. We are not an academic institution. So, I think that part of the issue is the design community at large has only a subset of information upon which to draw for solutions and perhaps do not have the same business grounding that other areas of the company do. So, that would be the generic comment. So, I understand where those emotional feelings would come from, but I am comfortable with the decision process and where it has led us. (Brad Copeland)

The frustrations about the process were high within the members of the Steering Committee and eventually they had an explicit discussion of the role of the process in changing the culture. This discussion was between a more junior manager, Howard Harper, and a number of directors in ATG (Theresa Veneto, the head of the Steering Committee, Josh Zemlinsky and Erik Helgesen).

Howard Harper: In preparing something for the Steering Committee, if you have to work with the business unit and don’t bring them into the meeting, you end up having to encode them into slides and it generates a lot of follow up. Second, I think that the best case scenario is that the project gets through on the first cut, but to do that, you have to put as much effort into the slides as possible. The feeling is that we are spending a lot of time on slides and I don’t have time to get my hands dirty in the lab.

Theresa Veneto: But, if you haven’t done the upfront thinking, then you can do whatever you want in the lab and it won’t make sense.

Josh Zemlinsky: On the topic of the template, the first time you go through it, it is hard. But, it is worth learning it. We put in a template in my group, and once you go through it, it gets easier.

Howard: I agree, but maybe only if the projects you are doing are related to each other. It becomes new legwork.

Josh: Probably the culture shock of the doing the template in the first place is a big win that you don’t have to repeat.

Erik Helgesen: There is certainly a value of having a template. It is a factor of life. The question is, are we having the right ones and what to do about it?

Theresa: The point he brought up is a culture change. I’m sure that the technical part of the slide deck doesn’t take much time while the other parts take longer. But, that’s a culture change.

4.4.3 How this played out: the case of the “bubble charts”

When Brad took over the Advanced Technologies group in 2001, his first order of business was to realign the portfolio and cut costs to reflect the dramatic downturn in the telecommunications equipment business. By mid 2002, he was beginning to think beyond the short term demands of the environment to rebalance his portfolio again. He had also embarked
on an effort to upgrade the business and strategic skills of a number of the key players in his organization. This primarily took the form of sending them to a two-day course on Technology Strategy at MIT’s Sloan School taught by Professor Rebecca Henderson. Chris Chang, who had recently been promoted from a more technical network architecture position to a director level role in “economic analysis,” attended the course in the spring of 2002. He was very taken by the tools introduced in the course and tried to work them into several different projects he had underway. In the fall of 2002, Brad announced that he would bring together his entire “cabinet” (his senior management team) at the end of October to discuss the strategy for the Advanced Technologies group and to think about realigning the project portfolio. Chris, recalling the aggregate project plans (“bubble charts”) from the course, proposed to Brad that he would do a version of these charts for the meeting as a discussion starter. This is a tool common in the management of technology that plots projects or products in a matrix with two dimensions. Originally, in the Wheelwright and Clark (1992) paper that introduced these notions, the dimensions were the extent of product and process changes required. Those projects with low change on both dimensions were line extensions, with moderate change were “next generation” or “platform” projects, and high change were considered “radical breakthroughs.” These matrices have been adapted over time to use different dimensions on the axes depending on the specific use.

Chris and a member of his team worked together to develop the matrix. To plot the size of each of the bubbles, he used the budget for the project for the previous two quarters. While he felt that this was not a perfect measure of size, it was the only data that he was able to obtain. The two axes he chose were “product reach” and “market reach.” After some intense days of work, he sent the charts along to Theresa in her role as the head of the Steering Committee process (having a perspective on each of the projects). When she saw the charts, she strongly disagreed with the placement of the projects and the measures used to size the bubbles. But, she did not see the materials until shortly before Brad’s Cabinet meeting and was not able to invest in “correcting” the charts according to her views.

In the strategy meeting, Chris presented the aggregate project plans to the rest of the management team. Brad was dissatisfied because Chris’ version showed too many projects in the upper right quadrant (more radical innovation). He stated that the Advanced Technologies
Group had no “Hail Mary’s” and should have some. He wanted the chart to prove his point, and to the extent it didn’t, he wanted the bubbles moved so that the point was clear. Others in the meeting debated the placement of certain projects, moving them from more incremental to more radical positions or the reverse. These conflicts about the placement came in two forms. In one case, people felt that the dimensions on the axes of the chart were wrong and therefore did not capture the ways in which a particular project would have impact. For example, while a standards project was not particularly high on technical reach, it would have a major impact on competitiveness for EQUIPCO. In another case, people felt that the projects were placed incorrectly given the dimensions that existed. These represented different interpretations of the technology itself. For instance, the Module\textsuperscript{63} project was initially place in the lower left quadrant (relatively incremental), but Vijay Kumar (the leader of the project) and Erik Helgesen (his boss) got into a debate about its placement. Erik felt that it was indeed incremental and Vijay argued that it could have a more significant impact.

A long discussion ensued in which there was lots of debate about which were the right dimensions. Were product reach and market reach the right dimensions? Or should they consider other important factors such as technical reach, EQUIPCO internal change requirements, competitive edge established, cost reduction impact, risk, or return? Chris proposed that they redraw the bubble charts using multiple different dimensions and then compare different charts to see the different messages that would emerge. Vince Weston got up at the whiteboard and argued that the ultimate measures should simply be risk and return and these would encapsulate all of the other factors. Many felt that it could be a waste of time or a lot of work to do several versions of the charts. The second debate was about how the size of project should be measured: current budget would capture the current balance of investment, total budget would be better for an overall risk/return picture; potential impact would capture the benefits. They also weren’t sure whether the evaluation should take place at the project or the “thrust” level (groups of several projects in one activity area). There was lots of confusion about the tool itself, questions which Chris wasn’t prepared to answer as he was not deeply familiar with it (having only been exposed to it in the course). Quite a few people questioned how these tools would help them manage the portfolio. They weren’t sure that it made sense just to look at

\textsuperscript{63} Module is one of the projects I studied in depth and will be described later in this chapter.
having an even mix of projects in the various quadrants without considering how that might match with an overarching strategy.

Frustrated with the discussion, Brad finally said that he wanted to revisit it in a conference call in November in which they would all get together and just place the bubbles in the right positions. Theresa was tasked with preparing for this call (despite the fact that Chris had initiated the analysis). After the meeting, Theresa noted that developing the “correct” charts would not be as simple as Brad wanted it to be. They couldn’t just do it over the phone without detailed preparation beforehand. Theresa had wanted to take over the analysis because she felt that she knew more about the projects and would be better equipped that Chris to get the charts “right.” But, she recognized that it would be a lot of work and that she would have to spend a lot of time getting people on board with the conclusions.

Theresa felt that the main theme that Brad was pushing in the strategy review was the lack of “upper right” quadrant projects. Theresa felt that Brad was wrong on this, that there were some high risk/high return projects. This led her to two conclusions: (1) there are different views about what the definitions of the categories are and these need to be clarified and aligned in the group, and (2) Brad tended to get tired of the existing projects and excited about “new toys” (therefore, he didn’t see existing projects in the upper right because he was bored with them). In addition, Theresa said that they had already recognized this in the Steering Committee and were trying to fix it by adding a new research thrust called “new businesses.”

After the meeting, Theresa recounted her experience with the tool this way:

“I went to Chris and I said, ‘let me take a project that we both know about, because you ranked it completely differently than I would.’ Fortunately, when you both understand the project well enough, that thing goes well. Brad got stuck on, for example, technology reach. Certainly, if he read it to be what he meant, it was not rightly plotted, but he was looking at the product reach not technical reach. There was not product reach versus market impact, so we did not even have the two axes that we really cared about on they map… Like any exercise, if you have not thought about it for more than five minutes, you are going to have to do work on it. [Brad] says an hour and a half, but that is an hour and a half after I think about the terms, define them, put together a matrix and examples within it and actually test it with the [Steering Committee]. I keep saying that – and it drives me insane – that this thing is a tool, and it will not be the answer, the easy answer for all of our problems. It gives you a big aggregate picture of the way the things sit, and then you can say, ‘I am uncomfortable that there is not enough stuff here.’ … If I am looking for return on investment, I need to see return on investment. If I am looking to see whether I am investing enough in a certain area, enough radical stuff, then the size of the bubble matters. If you have 50 one-dollar projects, you say, ‘oh 50 is enough,’ but what if you really want $2 million being spent on one project? How would you know this if you did not include investments? And so this is why, pending the question, different information is necessary. Okay, now I am going to choose

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these axes to answer this question, which I think is very appropriate. If you are to say, ‘well, they want to answer another question,’ then maybe we use other axes.”

Two months later, no conference call had taken place. A few members of the marketing team noted that, while Theresa was the “prime” on this effort, she was really too busy to do anything on it. They didn’t understand why Theresa was prime given that Chris brought it to the management group. The fallout from the October strategy discussion had been to think about “how to plot the bubbles for real.” There was a “quantitative” effort to find measures (“to make it consistent without making it a science”) which one of Chris’ direct reports had undertaken, and then Theresa combined the criteria into risk and return. One member of the marketing team (George Arden) said that his biggest fear was that it would be a big waste of time for everybody and he didn’t think that the Advanced Technologies group needed this mirror in order to set new aspirations. In the end, the hour and a half phone conversation to plot all of the projects never happened. The matrices fell to the bottom of Theresa’s priority list, and nothing ever came of the exercise.

The “bubble chart” project failed because different people had different interpretations for how it should be used and what questions it should answer. And, they had different personal interests in the outcome of the analysis. Brad encouraged the use of the tool because he thought it would illustrate his view that the group did not have enough “Hail Mary” projects (his term for radical innovation). When the tool did not produce the results he expected, he felt that this was the result of incorrect interpretations by other people. Chris wanted to use the tool to demonstrate his business knowledge and show that he was taking an important leadership role in strategy development for Advanced Technologies. Theresa felt that the group was reifying the tool and hoping to get more out of it than a tool can provide. It appears that she also felt that it should be her role to implement any portfolio related tools as she interpreted her role as the head of the Steering Committee to be about portfolio management. The individual members of the Review Board all seemed to want to make sure that their own projects did not all fall in the incremental camp, though they weren’t pushing for everything to be radical either. Most were confused by the tool in particular because they were unclear about what question it was attempting to answer. The discussion did highlight that different people felt that different criteria (as embodied in different dimensions of the matrix) matter. Some felt that technology impact was the critical dimension. Others would rather focus on the product impact because that is
closer to the business unit. Others were more interested in the impact to EQUIPCO (either to the economic model or with regard to required forms of organizational change). The tool became a focal point for surfacing different viewpoints about the portfolio, but even more importantly and more broadly, about the objectives of the Advanced Technologies Group and the nature of what it meant to have impact. The “bubble chart” got shelved because it would have been too much work, or too difficult to resolve the differences in views and people weren’t clear about what the importance of actually achieving the resolution would be.

4.4.4 Improving the Steering Committee process

 Throughout the period of my observations, there was continual background chatter about the lack of strategy and about the dissatisfaction with the Steering Committee and Review Board process. In the early Fall, Erik Helgesen had an offsite meeting with his key managers who raised a number of concerns. This became the impetus for a meeting of the Steering Committee to talk about the strategy of ATG and the role that the Steering Committee was supposed to play in developing and executing it. The discussions revealed their collective desire for a clearer strategy and yet their lack of understanding about what a strategy was. The strategy for ATG up until that point had primarily been expressed in the form of strategic “thrusts” in various technical areas (e.g., photonics, standards, etc.). Perhaps the best way to tell the story is present some of the discussion verbatim

**Jack Stafford:** My impression is that we do strategy but I have no idea if the coverage across the industry is very good. In our particular areas, we do strategy and bring it to the Steering Committee. But, I don’t know whether across the organization we are addressing all the areas we need to.

**Erik Helgesen:** I’m not sure we need to address absolutely everything.

**Jack:** What is missing is a spectrum above the projects.

**Erik:** We agree on that.

**Theresa Veneto:** We actually started with thrusts, tried to understand why they were important, we had a couple of meetings where we brainstormed. We all agree that it is hard to make strategy, so we really have to be intent on doing it. We have to put the time into it, or it’s not going to happen. So, let’s do a strategy session next week. Let’s see how serious we are about it.

**Howard Harper:** I did remember we had a discussion about strategy but it was around the time of the Olympics and we got derailed by the hockey finals.

**Erik:** One issue is the things that that we should be doing as the Steering Committee that we aren’t doing now, including strategy. The other is how to have a more streamlined process, how to help everybody free up some time so that we can do the things we are essentially not doing.

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And, the third is about the thrusts. People are saying that we laid out thrusts a year ago based on comments that [the former CEO] made about the corporation. There were quite a few comments on how we should restructure the thrusts and move forward with a different focus.

**Hugh Collins:** Point of clarification, did you say the thrusts were obsolete?

**Erik:** I'm saying we have to establish new thrusts.

**Hugh:** I think you are right.

**Jack:** I would suggest that the thrusts are not functional thrusts. We don't deal with things as thrusts but only individual projects.

**Theresa:** You bring up a good thing. When we started this program, we had thrusts, each had a core team who were the subject experts, they had to establish the projects and prioritization and they then came to the Steering Committee. We tried to instill that, but I don't believe that the teams continued. We started with good intentions. This time around, we need to realize that we had these intentions and they didn't work out.

**Terence Smith:** But, we have to realize that last time the thrusts were just given to us by Max Kagan when he set up the Steering Committee structure. Now, we need to really think about what is our strategy and where is it we want to go.

**Howard:** We had thrusts before. Maybe thrusts didn't survive exactly because at the Steering Committee level we worked at the project granularity. So, while we may have had core teams along the thrusts, we ended up focusing on projects.

**Theresa:** With thrusts such as photonics and strategic protocols, I have never asked if they put the right projects into the thrust. I am assuming you put the best projects into it.

**Hugh:** So, let's not talk about ancient history. We are where we are. I want us to come back to thrust management and I think we should try it out. Theresa pointed out that in the past she had assumed that the thrust primes had made the right decisions about project priorities. Did others assume that?

**Erik:** I'm not sure the core teams were really functioning. There is another point about why the core teams didn't function, is that they clog the decision-making process. They go from core team to Steering Committee to Review Board. There is no way that projects with so many committees function in a timely way.

**Theresa:** We do have a lot to do. The strategy piece is important, but is going to be harder to streamline. We are going to need a good meeting to discuss how we are going to get it done without taking a ton of time.

The goal of the meeting was to discuss changes to the Steering Committee's activities. Originally scheduled for one hour, the meeting ran more than three. A lot issues were put on the table, but the group did not end up making any changes as a result. As Theresa pointed out, they recognized that making the kind of strategy they were hungering for would require more time (and more skills) than they had at their disposal. The net result was a continuation of a more project-based approach to strategy.
4.4.5 Summary

These various vignettes provide a broader context for strategic choice within the ATG organization in EQUIPCO. They illustrate the dislocations created by the crash in optical communications. They also reveal the strongly different interpretations of the technologies and the tight link between these interpretations and interests. Tools that were introduced to provide a rational “answer” ended up being used as rhetorical devices in the battle of beliefs in the organization. These themes will emerge in even greater relief in the next section as I explore the dynamics of individual projects.

4.5 Five technology strategy projects

The lens I used to understand the role of frames in understanding strategic choice during this period of uncertainty was the project. I selected strategy projects or initiatives as my unit of observation. To focus my work, I selected five cases that gave me wide variation across a number of dimensions. The purpose of this research design was to develop grounded theory that could be validated across multiple situations. Limiting the sample of projects to five allowed me to follow each project to a reasonable level of detail while at the same time affording me the ability to make comparisons in order to test the boundaries of the theory.

4.5.1 Project selection

In order to select the cases, I started with a series of unstructured orienting interviews with all of the group’s senior management team and additional managers and engineers. These interviews focused on developing a baseline understanding of ATG’s decision-making processes and on identifying specific projects that might be fruitful to follow in depth. I was also provided with the entire list of existing projects “on the books” (meaning that they had been officially approved and a budget had already been allocated to them) and through the interviews accumulated an additional list of projects that were emerging. I sought to identify cases that were in critical technology areas and in their early stages or at a critical juncture as I began my field work. To assure variation, I took care to study very different projects within the firm so that the findings would apply across a broad range of situations, from incremental to more radical innovation, from decisions to reduce investment to decisions to make an important
resource commitment, from more technology-oriented projects to those more focused on assessing market opportunities.

These projects were chosen for their contrasts: they were based on different kinds of technologies, were led by different people, were opposed for different reasons and followed very different trajectories from initial proposal through the various investment decisions along the way. The idea is that common themes should be reflective of underlying structures rather than any more superficial commonalities in the projects. In addition to formally following these cases, I also collected general information on several other projects through the course of the interviews and observations. These data gave me a qualitative sense that the cases I selected were roughly representative of other projects in the portfolio and helped me calibrate the findings from my focal projects.

Each of the five projects proceeded through a series of critical decisions that involved resource allocation (of monies or people). The project was the unit of observation in my field work because it could be identified ex ante. Ex post, the decision was the unit of analysis. Table 4-1 lists the projects, describes their purposes and outlines each of the critical choices.

Table 4-1: Description of the 5 projects studied, units of observation and units of analysis

<table>
<thead>
<tr>
<th>Unit of observation: the project</th>
<th>Unit of analysis: pivotal decisions (resource allocation decisions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;Lightwave&quot;: Project to develop an optical switch for a new market segment</td>
<td>• Decision to reduce budget for development of next generation technology by 50 percent</td>
</tr>
<tr>
<td></td>
<td>• Further reduction to point of closing the project down</td>
</tr>
<tr>
<td>&quot;Last Mile&quot;: Project to identify market and technical opportunity in new arena</td>
<td>• Choice to initiate major exploration project in new market</td>
</tr>
<tr>
<td></td>
<td>• Decision to narrow focus to a particular application area, for a specific business unit and product line</td>
</tr>
<tr>
<td>&quot;Multiservice&quot;: Ongoing effort to introduce a protocol technology that would simplify multi-service problems for access for enterprises to the Metro network</td>
<td>• Investment in developing a specific function as an incremental improvement for a specific product line</td>
</tr>
<tr>
<td></td>
<td>• Decision not to fund larger project due to lack of business case</td>
</tr>
<tr>
<td></td>
<td>• Later decision to dedicate resources to development (despite lack of approval by Steering Committee)</td>
</tr>
<tr>
<td>&quot;Module&quot;: Line extension for existing business unit to add new functionality to current product line.</td>
<td>• Addition of selected resources to develop technology for a particular customer application</td>
</tr>
<tr>
<td></td>
<td>• Later decision to expand project scope to more strategic opportunities (merge with Savior project), invest in technology development</td>
</tr>
<tr>
<td>&quot;Savior&quot;: Embryonic project to define a strategy for a major new &quot;disruptive&quot; technology that would compete with current channels</td>
<td>• Decision to dedicate initial resources to explore ideas in major new business arena</td>
</tr>
<tr>
<td></td>
<td>• Merge with phase 2 of Module project, fund technology scoping effort</td>
</tr>
</tbody>
</table>
Each of these projects can be seen as different kinds of response to the crash in optical communications (Table 4-2). Some advocated continued (or discontinued) research in the optical arena. The debate in these cases continued to focus centrally on optics. For other projects, the idea was to focus on other growth areas, not just for EQUIPCO’s core customers (the carriers) but also to serve entirely different markets (such as enterprises).

Table 4-2: Five projects, five responses to the crash in the optical technologies market

<table>
<thead>
<tr>
<th>Project</th>
<th>Response to crash in optical technologies market</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lightwave</td>
<td>Need to keep up extensive investment in next generation optical technologies. The downturn in the industry is temporary, new optical technologies will be required soon.</td>
</tr>
<tr>
<td>Last Mile</td>
<td>The downturn in the industry is due to a bottleneck at the access point. Not enough individuals and business have broadband access. New access technologies that are relatively cheap to implement will open up demand for optical technologies throughout the system.</td>
</tr>
<tr>
<td>Multiservice</td>
<td>The economic downturn means that enterprises (carriers' customers) cannot afford to invest in new equipment. Yet, networks should be upgraded. Therefore, a bridge technology that allows multiple forms of old customer premise equipment to connect into new networks is required.</td>
</tr>
<tr>
<td>Module</td>
<td>Carriers will not be the key customers. Instead, EQUIPCO needs to focus on the carriers' customers and the content providers. These companies don't necessarily need to invest in new optical technologies but rather need to optimize the existing electronic technologies they have in order to take advantage of optical technologies.</td>
</tr>
<tr>
<td>Savior</td>
<td>The need to invest in new optical technologies is minimal. Carriers will be unable to spend much on equipment in the next several years. In fact, EQUIPCO should refocus its efforts on the enterprise segment.</td>
</tr>
</tbody>
</table>

In the following sections, I describe each of these projects in turn. By necessity, these stories are highly compressed. The project chronologies I have developed are each more than fifty pages long. What I have attempted to capture here are the contexts, critical turning points and illustrative exchanges that capture in some sense the essence of each story.

4.5.2 Lightwave—should we maintain our investment in developing key optical technologies?

I start with the Lightwave project because it is an important reference point for the ATG organization in all of the subsequent investment choices that they made. This project was different from the others studied in that I only observed the last phases of the decision-making. It was a project that had been running for a few years before I arrived, and the critical decision to
minimize investment was made just as I entered the organization. Therefore, for this story, I have relied more heavily than usual on archival and interview data in which informants were recollecting events in the past.

Lightwave was a major program to build an optical switch for the Metro (regional) market. It was launched in 2000 during the peak of the telecom bubble as a revolutionary technology program to extend the impact of optics from the traditional long haul point-to-point transmission market to the more mesh-like regional or “Metro” market, and soon accounted for nearly 25 percent of the ATG budget. But by 2002 the bubble had burst and a battle about whether or not to maintain the level of investment surfaced. The dispute was around beliefs about the size of the market opportunity, the appropriate technological solutions and the principles that should govern the decision about investment. The technology team, headed up by Jack Stafford and Hugh Collins, continued to believe well into 2002 that the near-term demand for optical technologies in this new space was significant (well over a billion dollars). While they recognized that the industry downturn had affected the immediate purchasing patterns of their carrier customers, their conviction about the value of the project rested on the idea that optical technologies were the “way of the future” and would help resurrect the market. They saw their role in the corporation as providing “visionary” technology and thus believed that the decision about investment in the technology should be governed by purely technological principles (meaning, if it was an exciting technology, it should be developed).

But, with the bursting of the bubble in 2001, some pockets of opposition to the project began to surface both from people in the business analysis groups and other senior technical executives outside of the project. They believed that the market had been sufficiently damaged by the economic downturn that investments in more optical switching was premature by several years and also felt that much less ambitious and likely non-optical solutions would be most appropriate. Feedback from the relevant business unit indicated that a switch, if needed at all, would be much smaller than originally anticipated. There was also an increasing pressure on budgeting as cuts were being made across the corporation. They believed that ATG should not develop technologies that were not supported by a business unit. Therefore, they generally opposed further investment in the Lightwave project. Nevertheless, the project passed through Review Board meetings in July and December of 2001 at proposed funding levels, though the
meeting minutes reflect an acknowledgement that there was a “split” about whether this is the
time for photonic switching in the Metro market.

Throughout late 2001 and early 2002, with growing frustration, a number of different
people in the business function as well as Theresa Veneto, the head of the Steering Committee,
began to do analyses independently to convince people with data that the Metro photonics
opportunity was smaller than previously thought. Simultaneously, EQUIPCO pulled back from
similar photonics investments in the long haul business unit and the entire corporation began
several rounds of major layoffs. Theresa held private conversations with Brad Copeland to “get
his mind around” the need to take action. Some members of the management team not directly
affiliated with the project raised their objections in several different settings but failed to get any
traction. From their standpoint, the project team was too enamored of photonic technologies to
see that the market adoption would be much slower than anticipated. In the April 2002 quarterly
review, the project again got approval to move forward but the challengers to the project
extracted an agreement from the project team to incorporate feedback from the relevant business
unit and the market.

Subsequently, George Arden (one of the marketing team members in charge of
developing business cases), did a new analysis of the Metro photonic switch market; using three
different sources, he produced a new estimate of market size that was 80 percent lower than the
estimate used by the project team. He had also developed an analytical tool to assure
consistency across business case analyses for ATG projects and this analysis showed support
only for a small, targeted effort. The response of the technical team was to attack the tool. From
George’s standpoint, “If you challenge projects they are bringing forward, then the attack is on
the tool. It is like that tool is no good…they just say ‘there are serious fatal flaws in this thing.’”
When the use of data to convince failed, ultimately, people had to resort to other tactics such as
establishing or undermining legitimacy. When George’s new market analysis met resistance, the
technical team leaders “tried to discredit the approach. They did not like it, so they said ‘so you
are going to keep working on this to get better numbers’. And, I said. ‘Au contraire. I am not
going to work on this any more. There is no new data; I have collected everything that I can. I
am not going to spin my wheels.’” The differences in views about the market and the
appropriate solution became increasingly polarized, as Susannah Watts (a member of the business analysis team) indicated:

One, they do not listen and they are very unwilling to listen to anything that does not hold with their immediate beliefs and two, there is very little room for any healthy debate. So the minute you start to get into questioning at all – I mean I am not aggressive about it, but I know other people have the same issue – and say ‘well why do you think that because the data I have tells me this,’ they get immediately defensive. People get stuck in their positions, and you make no progress going forward. And the amount of effort that has to go into trying to establish anything is kind of concerning.

In the May 2002 review, the new data, combined with the increasing pressure from multiple forces, did get used by the Review Board to make the decision that the investment in Lightwave was “way out of whack with the corporation” and impose a 50 percent reduction in the project. According to Terence Smith, the head of the marketing function, this decision was made with “a lot of dissension. It took six months of trying to prove the business case [for reduction].” For Jack Stafford (one of the team leaders), this was not only a blow to the project but a personal embarrassment: “There is probably a reasonably good story to maintain the effort [based on long product development cycles], but I don’t think that the executives understand that… I wish they had saved me from the embarrassment of standing up in front of them to present my ideas.” Subsequent Steering Committee and Review Board meetings ironed out the details of the reduction a month later, and these meetings went smoothly, though Jack Stafford declared in the meeting that “the cut was a deep one, it was a painful one, and we went round and round because there is no particularly elegant solution.” And, Hermann Meier, a key project manager, raised the concern that they “need to make the photonic people feel comfortable that they are working on something with some longevity.” Theresa Veneto described these meetings as “easy decisions…though it has been a long journey from January to now, and a year and a half for me.” She attributed the difficulties to differences in the frames people held about the market and their views of their own identities:

So subjective reality. How you see the world. Not only where you’ve been and what you do, it’s what you actually see. You don’t always see the same thing right. So, when you speak, you get multiple interpretations. People take away what they want to take away. Instead of testing it. And, that’s why you have to almost get too detailed in your explanation to ensure that there is no ambiguity, especially if it’s a strategy that changes the culture… It’s how you see the world, how you interpret the new information, and very importantly how you see yourself.

While this initial decision to make the 50 percent cut was lengthy and highly contested, over the course of the summer, through private conversations, a further decision was made to
basically close down the project entirely, leaving only a small advance team ("cryostasis" as the team called it). This decision was ratified in the formal review meetings in the fall, but occurred with little debate. Most attribute this to two factors: first, the project team itself had more time to internalize the data about the market and began to understand that demand had definitely “right shifted” and, second, other projects (such as “Multiservice”) rose up to take up the slack. This gave people something else to work on and be passionate about. What started out as a highly contested, emotional debate about maintaining the investment in photonic technologies, ended with a relatively smooth phasing out of the project.

4.5.3 Last Mile—should we invest in new access technologies?

The Last Mile project was initially proposed by Hugh Collins, a senior scientist in ATG, to expand optical or high bandwidth access technologies. As optical technologies spread throughout the communications system, the “last mile” was the least penetrated because the economics had not historically supported expansion. With the crash in the long haul optical market, people like Hugh Collins perceived that a solution to the glut of bandwidth in the long haul was to increase the ability of users to access it by installing high bandwidth, likely fiber-based, connections to those without them. The contested views in this project revolved around differences in beliefs about the future level of demand (“access optimists” vs. “access pessimists”) and about the appropriateness of optical technologies (in particular the “Widget” that Hugh had previously prototyped) as a solution to the access bottleneck. The project proceeded through three hotly contested decisions, an initial decision to initiate a “100 day” study to scope out a major technology development project, an interim decision to continue the study despite very strong opposition to halt the project, and a final decision to make a small investment in technology development to support a single EQUIPCO product line.

Many people placed the origins of the Last Mile project in the demise of the Lightwave effort. The “cynical” view that some admitted having was that the Last Mile project was proposed as a way to absorb the headcount being eliminated from Lightwave. Alternatively, some suggested that the problems with Lightwave pushed them to search for solutions to the barriers to demand for optics (in other words, to breakdown the access bottleneck and therefore drive more demand into the Metro and long haul markets). According to Hugh Collins, “We were in the n-th round of trying to beat down the Doubting Thomases on Lightwave when we
realized there was a message coming out: large buildings in the network were already largely fibered and the equipment was already there. So they weren’t going to be a customer, at least for some time.” Others claimed that the urgency came from the business units where were apparently losing bids or not even getting them because EQUIPCO did not have a meaningful offering in access technologies.

Whatever the belief about the origin, the project was “painful” from the very beginning. Hugh Collins, as project leader, appeared at the kickoff meeting with a “fully formed” 238-page PowerPoint document. At the first sign of resistance from various parties, both technical and marketing, he decided to invite them all to be part of the project, thus forcing the challenge inside the project. The same people who had advocated the reduction in the Lightwave project were challenging the need for investment in access technologies, in particular because the main proposal was for the development of “Widget” technologies. “Widgets” were a fiber-based solution to access which many were concerned would require massive capital expenditures on the part of the service providers in order to install it and therefore would be beyond their reach financially in a heavily capital constrained environment.

The initial request was for a 100-day project to assess the need for access technologies and propose a development program going forward. Subteams were set up to examine the market, the network architecture and specific technologies and partners. Strong differences in views surfaced, including conflicts about both the nature of the challenge facing EQUIPCO and the right kind of solution: the need for an access offering, whether to focus on the traditional service providers or on MSOs (cable operators), the ability of EQUIPCO to manage the different economic model required for access technologies, the viability of photonic based solutions (as opposed to copper or wireless), the imminence of “killer apps” that would drive dramatic increases in demand, and the value of building the technology internally vs. partnering with outside firms. These differences created a tense and conflictual process. To make sure that the relatively large assessment effort did not spiral out of control, the Review Board set several interim deadlines. The expectations about what was to be delivered at each of these meetings was also a point of contention, with the challengers expecting “go/no go” decisions and the proposers viewing them simply as update points.
In the evolution of the Last Mile project, the frames of the proposers and challengers differed significantly. Each group engaged in efforts to shape the frames of others, and other time, these efforts led to investment decisions. Regarding the Widget/anti-Widget debate, Hugh saw himself as an expert in access technologies and Widgets in particular, and felt that those who did not understand (those “who spell ‘access’ with a ‘k’” as he termed it) should not have a legitimate claim on influencing the decisions about the project. From his perspective, if the marketing team did not want to spend “a red cent” digging up a road to put in fiber, it must have been because they did not understand. His remedy for lack of understanding was data and analysis. In this project, it came in the form of PowerPoint documents running in the hundreds of pages filled with data to show the need for optical technologies to solve the access problem and profiling detailed specs of proposed solutions. The data-driven approach went hand-in-hand with a belief in discussion and consensus as a way to mobilize people to support a particular frame. Initially, proposers and challengers felt that they could win the day if they could only get the other side to understand their views.

Due to these differences of views, team meetings were dominated by discussions around the credibility of the data being used to support one side or the other. When the business team presented an analysis of market economics that they claimed supported the view that the solution had to be “backhoe free” (in other words, no new installation of fiber), the technical working team claimed that the economics were not granular enough and launched a counter effort to specifically map out the limitations of the existing copper for key customer segments. Hugh Collins, original head of the Last Mile project put it this way:

Like most things, there is no absolute truth in anything. And, if you want to find the aspect to say it is a dog project, you can prove it conclusively it’s a dog. If you want to find the aspect to say, yeah, here are the golden nuggets that could make something really useful out of it, you’ll find it.

Much of the debate got crystallized around whether people supported or opposed a Widget-based solution. These struggles were complicated by the high level of uncertainty about the future evolution of the market – both the technical and business team struggled to identify potential “killer apps” that would drive a discontinuous increase in demand for bandwidth. Though neither side could agree on these drivers, the technical team continued to hold a belief that a killer app would emerge while the business team insisted that if one couldn’t be identified,
then it was unlikely to materialize. Albert Lee, the prime on the marketing side, highlighted this
tension:

_The real unknowns are the potential ‘next gen’ applications and services which could change
spending and bandwidth. There is some disagreement. Hugh is seemingly much more balanced
that I would have given him awhile back, but Jack and others are arguing that there will be super
disruptive applications. Most other people saying that they are working hard to look for a killer
app but can’t find it. We can’t plan for an unknown disruption that may or may not come. We can
consider it, but it is not the most likely scenario. The people holding out are the ones we talk to
the least. Jack Stafford and Edward Fischer are the two biggest proponents for new disruptive
applications, maybe because they have similar backgrounds and experience._

By mid-July, the business team had concluded with “90 percent” certainty that the Last
Mile project should not continue after the interim review date, while the technical team were
more convinced than ever that a solution was needed and was possible. In the joint team
meetings, there was general praise from the technical team for the business team’s work, but in
subsequent meetings among the technical team, they were “questioning, disputing, doubting” the
findings. Hugh Collins admitted that where he agreed with the findings, he would accept them,
and where he disagreed, he would conduct his own analyses to prove them wrong in an effort he
called “debunking the debunkers.” Hugh Collins noted about the challengers to the project that
“If they find facts to support their view, they grab it at face value. Anything that contradicts their
view, they put through a micro-fine sieve.” Reciprocally, the marketing team had a similar view
about the technical team’s response to data: as Susannah Watts reported, “If they don’t like the
data, they say it is flawed and go on their merry way…”

According to Vince Weston, who by this point was being eased out of the project by his
fellow business team members, the marketing people “gave such a biased view of the market—
they clamped down on the market so bad that someone presenting [to invest in it] would look
foolish. It was sheer ‘we’ve made up our mind’ on the marketing side.” Hugh and Jack, the
most senior people on the technical team, said to the marketing people, “we think you did good
work but we don’t believe it.” The debate on the market sizing went something like this: the
marketing team numbers showed relatively low levels of demand for bandwidth. Jack said,
“Once people get it, they will always want more.” Susannah said, “Well, I have dialup and it’s
just fine.” The marketing people simply said that “for the foreseeable future, there will only be a
need for 100kb usage per line and therefore there is no market.” Hugh walked out of the meeting
in mid-debate out of frustration. As a result, no decision was made; Brad gave the project go
ahead for one more month to resolve the differences in views, but Hugh was replaced by Hermann Meier, a more junior manager (and protégé of Hugh).

During this next stage, some progress was made in aligning views through an intensive e-mail exchange among several of the key parties. However, as the date for the next review approached, Hugh and Hermann “staged a coup” (in Hermann’s words) by ceasing to communicate at all with the business team and spending their time searching for a willing partner among the business units. They felt that the only way to move ahead was to get a business unit lined up to support the effort (and after trying several potential avenues within the corporation, they found receptivity with some of the managers in one product line area). When the next review date approached, the business team, infuriated that they had not been consulted in the development of the final proposal, got the meeting postponed and forced the group to work together to come up with a consensus. The net result: the proposal was scoped down to a small team conducting further exploration of potential line extensions for one EQUIPCO product line. Interestingly, all of the different players felt that they won: the proposing team got to invest further (in an area that was one of the many they had identified from the outset) and the challengers made sure that the project did not grow out of control and “become Lightwave by another name” (which meant, from their perspective, another project with a large amount of investment in the optical market area that was unlikely to pay out).

4.5.4 Multiservice—should we invest in developing and prototyping a new algorithm?

The Multiservice project was an algorithm that would allow carriers to provide multiple services to their customers without requiring the customer to scrap legacy installed equipment on their premises. It was developed initially by some relatively junior mathematicians in Jack Stafford’s group in response to his request for people to look into future technologies. Jack attempted to bring the project to the Steering Committee but was told he needed a business case before it would be considered. The contest in this project stemmed from different beliefs about the viability of a business case (and indeed what should be included in a business case) and the ability for EQUIPCO to profit from the innovation given existing business unit capabilities. Specifically, the proposed approach focused on optical applications of a technology that could in theory be applied more broadly. This approach was based on a particular view of the future evolution of the Metro (regional) network technologies and architectures. The project proceeded
through three different decisions. The first was an approval to develop the technology for a specific and slightly tangential niche application. A marketing person (Tom Rentham) assigned to help out was unsuccessful in finding a case for the project overall, but did identify this small niche application while working with a product line manager in a business unit. The second decision was a refusal by the Steering Committee (and Theresa Veneto, its leader) to invest in the project when an adequate business case could not be produced. Frustrated by what he perceived as narrow-mindedness about the market opportunity and months of foot-dragging by the Steering Committee, Jack Stafford took the case directly to a customer, got their support and began fully staffing up a major development effort. This third decision was only ratified two months later by the Review Board.

Different framing strategies were also used over the course of the decisions in the Multiservice project. The first decision was so unproblematic (a business unit requested help on the developing the technology for a related niche applications) and the business case therefore so compelling (small investment to help a business unit) that little effort was needed to align frames. However, the second decision (not to invest in the major development project) was much more contested. Jack Stafford was convinced of the potentially “revolutionary” value of the technology. He met with Brad, who had a background in this kind of technology, and sold him on the idea that this was “the future” for service providers. Yet, Tom Rentham, who was assigned to develop a business case, found strong resistance from the business units who thought the technology was “threatening and cannibalizing” of their value added services or who believed that “customers will not initially accept that…You need a transition strategy, an evolutionary strategy for your customer. You cannot flash convert all of them to [the technology].” Given this resistance, Tom felt that the project could not be supported because he believed the Steering Committee decision making process that required a solid business case was valuable. This was the frame that won the day when the project was turned down (“put on the back burners”).

Frustrations ran high. Jack Stafford felt that the business team was not being creative enough to deal with new technologies that the business units and market did not know that they wanted. Those challenging the project (the business team as well as several members of the Steering Committee) felt that Multiservice was too narrowly focused to serve a viable market
and it was “crazy” to think carriers would install a new technology when their existing capacity was not exhausted. But, according to Jack, “These numbers [provided by the business units] come from the linear thinking that seems to drive things [around here]. And anything that is disruptive, people cannot get their heads around it.” And, he argued, “technology is gut feel... We have a broad knowledge about what is happening in the industry and the way this technology could help. The question is how to get people to move beyond their mind blocks...”

Jack appeared before the Steering Committee three different times over the course of the year, each time to be sent back to develop a business case with support from the business unit. He felt that he was not being trusted to go ahead based on his own expertise about the technology and thought that all of the effort to develop a business case distracted from his effort to get things moving. On the other hand, those challenging the project felt that the enthusiasm for Multiservice was colored by a “bubble mindset” where an engineer falls in love with technologies because they are “cool” without considering market realities. And, they felt that the specific target market the team had proposed created only a small niche opportunity with a relatively weak customer base.

When Tom got laid off and George Arden took over the marketing role on the project, Jack went the very next day to see if he could get a more favorable read on the business case. But George’s analysis of the addressable market proved no more supportive of the project. George got so aggravated at being pushed to build a case he did not believe that he refused to work further on the project.

Jack eventually got help from Edward Fischer to see a customer (a major service provider) directly. In contrast to the EQUIPCO business units, he found that this particular customer was quite intrigued by the technology and agreed to use it in a trial of a new network. At that point, Jack did not even attempt to go back to the Steering Committee for fear that the project would be rejected again. He simply began to staff up a major development project, seeking personal approval from his boss, Erik Helgesen. He said, “I made the decision to go ahead with it. You make those decisions because you know that it is a good idea...If you do not do that, if you wait around for formal approval, then you never get anything done, because you miss the window of opportunity.”
This happened through informal discussions with his boss and Brad Copeland. Several times, Theresa Veneto pushed to have the project reviewed by the Steering Committee and the Review Board, but Jack Stafford found a reason in each instance to put off the review. Finally, through strong-arming tactics (Theresa Veneto went to Jack Stafford's boss and to Brad Copeland and insisted on the review), the project came before both groups. In the absence of a business case from the business team, Jack Stafford put together some numbers based on very rough estimates, but the investment had already been made, for all intents and purposes, so the project got a "go."

From Jack's perspective, the approval came from his ability to argue for strong customer support. "I think that it was primarily that we got a letter from [the carrier] basically saying, 'This is cool stuff. If it works the way you say it does, then it will revolutionize the way we do networks.' So, usually when you get those sorts of endorsements, nobody wants to touch it, in terms of saying 'No.' Plus I had some private conversations with Brad, and we certainly know that he was behind it." On the other hand, Theresa Vento argued that she was using the customer and business unit support as a proxy for market data. Describing her logic, she said, "You'll be permitted [to invest] if you get a customer and a business unit saying that their gut is saying this makes sense and they are going to support you. So you are not standing alone and it is tested enough with a few people. We will hedge it, I am willing to hedge. But don't come to me alone, and say 'Believe in me, trust me.'"

4.5.5 Module—should we expand our investment in a web-enabling technology?

Module was a technology that could be embedded in a server blade and accelerated web applications that run from the servers. The first phase of the project was in support of a line

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64 He said that they used analyst projections of market size, then made assumptions about what percent Multiservice technologies would be able to grab. They decided to keep the number fairly small so they picked 10%. Then, they estimated that EQUIPCO would get a 25% share at least because there were only three other competitors at that moment. Jack Stafford regards this as a fairly conservative estimate. Therefore, if it looked attractive under this scenario, then he figured that there was only upside.

65 A blade server is a computer system on a motherboard, which includes processors, memory, a network connection and sometimes storage. It reduces the space requirement and costs for servers by allowing the servers to be rack mounted in a cabinet that has common cabling, power supplies and cooling fans. In addition, they allow for flexible expansion because they can be added as required. The most typical use is for serving web pages. They are designed to replace more traditional box-based servers.
extension for a business unit and was not contested in any public way. The second phase which proposed to expand the capabilities in a way that moved towards convergence of computing and networking drew fire because of differences in views about the future direction of the corporation (either to stay close to the Layer 0/1 focus on hardware or “move up the stack” towards applications). The original project emerged in 2001 from an intersection between the research interests in programmable hardware of a young engineer (Stephen Merton) who was doing his PhD dissertation at a local university after hours while employed at EQUIPCO and his supervisor (Vijay Kumar) who had a vision for the increasing convergence of computing and networking. Based on the core insights for providing a hardware solution for web acceleration (traditionally the domain of software architects), they went to the business unit where they thought they would have the most receptivity and jointly generated the first stage of the Module project. The project proceeded with a combined development effort in which Stephen was seconded to the business unit. The team became aware of the fact that some people in ATG were questioning the viability of the technology that they had proposed for Module. Stephen explained that this came from a fundamental split in views about technology solutions.

...whenever you talk there are contradictory forces. There is hardware and then there is software, and you are either a hardware person or you are a software person. There is always a pull between, a tug-of-war, between the two, and when you talk acceleration then you are talking replacing some of the software with hardware. Sometimes there is still some pushback because it is something that the software person does not know. And that is something new. So there is the change factor and the software person says, ‘I do not want to, right now. I have a processor that can run all my software. I do not want to add and make it more complex by doing this, because it was difficult to do because of the way the technology works.’

Yet, given the economic crisis in the company and the industry, it was very important for the ATG to demonstrate relevance to the lines of business, so the fact that the project was so tightly integrated with the business unit meant that the first stage of the project passed the ATG committees easily. Questions that some other members of the technology group had about the viability of the proposed technology solution were only ever voiced privately.

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The network topology is conceived of in layers according to the OSI (Open Systems Interconnect) stack developed by the International Standards Organization (ISO) where Layer 0/1 is the physical layer, Layer 2 is for datalink protocols (e.g., Ethernet), Layer 3 is for network protocols (e.g., IP), Layer 4 is for transport (e.g., TCP), Layer 5 is for the session (initiated contact between computers), Layer 6 is for presentation (e.g., translates a click of the mouse into information a computer can understand), and Layer 7 is for applications (e.g., e-mail client). EQUIPCO had historically been focused on Layer 0/1 but this was the technical area worst hit in the optical market crash.
As the first stage was drawing to a close, Stephen and Vijay began to lay the groundwork with the Steering Committee for a second stage that would dramatically extend the acceleration capabilities. There were very different views about the degree to which Module was an incremental line extension for the existing product line or the seeds of a potentially revolutionary technology. Stephen and his business unit counterparts tended to see the project only as an enhancement to the existing way of doing business, in particular as a way to improve the offering to server companies. However, Brad Copeland felt that it could be a first step for EQUIPCO to “move up the stack” and operate not just at the network level but also in the higher, application layers. Given this tension in views, Stephen Merton and Vijay Kumar had some difficulty in defining the right scope and requirements for the second stage. While there was not much conflict within the small team, it was still difficult for them to get their arms around the opportunity. It was about this time that Vijay was asked to get involved in the Savior project (described below) and he began to see how they were “two complementary and synergistic” projects. While Stephen continued to make efforts to distinguish the Module project from Savior, Vijay began to see Stage 2 of Module as an essential component of Savior. And, because Savior was about a more revolutionary view of the industry, the proposal for Stage 2 became more ambitious over time. By late November, Vijay Kumar proposed Stage 2 to the Steering Committee and the Review Board as a project that was “not a linear extension” of Stage 1, and would go after “an unexploited segment where no one has gone before” to play a part in creating a market disruption in the evolution of the datacenter. “Part of Stage 2 was to introduce a new fabric into the technologies already developed for Module. But as things were moving quickly at webspread, the acceleration part became more important than just building out Module” in which acceleration could be applied not just to content but also services. The Steering Committee challenged the project team to identify and begin to quantify the potential of the applications for this new technology.

George Arden was added to the project to develop the business case. However, his efforts were not particularly fruitful because he was applying his usual market sizing approach for a market that had not yet been defined: after two weeks of swimming in the data, he said, “Where I am having difficulty is in putting together a business case for EQUIPCO. There’s a gap. You can describe the application and some of today’s technologies, but there isn’t information on the future.” The team presented a relatively low number for the potential market
given the revolutionary way the technology was described (only $100 million) though they were convinced the market was much larger – it was their inability to specifically quantify the nature of the opportunity that got in the way. Nevertheless, the Review Board was convinced that the effort was worth pursuing at least to the point where the team could identify the specific applications and opportunities, and the investment was approved.

4.5.6 Savior—should we invest in a disruptive technology that would bring us into competition with a key sales channel?

The Savior project was an example of the extreme early stages of the development of a potentially radical strategy. Similar to the Module project, Savior sought to address the challenges of the convergence between networking and computing, but unlike Module, the project started out with a grander notion of the role that EQUIPCO could play and of the risks of not playing. Brad Copeland tasked one of his individual contributors (Vince Weston) to come up with some new strategic ideas. After a period of exploration, Vince brought Vijay Kumar on to the team (given his background on the convergence issue) and they formed the core of the exploration effort (a few other people participated from time to time). Neither were particularly constrained by existing ways of doing business at EQUIPCO – Vijay had had extensive work experience outside of EQUIPCO before joining the firm and Vince had always had a reputation as a rogue in the organization – and as such, they were able to push their ideas quite far a field. They began to develop images of a “god box” providing many functions, a vision that would take EQUIPCO into radically new technical and market arenas. The team met one to two times per week for regular brainstorming sessions, and over a series of weeks, they continually expanded the scope of the technology, adding many potential functions. The implication of the project as it was shaping up was that EQUIPCO would need new skills, would have to compete with its existing customers and would have to change its identity from a network equipment company to one that was on the forefront of network and computing convergence.

To avoid potential challenges to this embryonic project, Vince Weston, as the team leader, had the team “work in the dark,” deliberately and successfully avoiding public scrutiny by the rest of ATG for fear of “attracting the bureaucratic machine.” But, in anticipation of the kind of resistance that they would likely face in proposing such a radical solution, the team constantly raised doubts among themselves about the ultimate viability of the project within the organization. They played around with multiple different analogies and articulations of the
project that would either minimize the perceived risk or increase the potential of acceptance. Many of the team discussions were a search for the right analogy that would crystallize the idea of the project in a way that could be sold to the rest of the organization, such as being “like a backdoor Akamai” or “the Mastercard for networking.” But the team fluctuated back and forth about whether EQUIPCO had the market position or the capabilities to execute on such a strategy, and whether they would be able to garner support within ATG for a major investment in developing the technology. When they were feeling the least optimistic, they thought about abandoning the project or repurposing it as a line extension for a single product line within EQUIPCO. When Vince got positive feedback from Brad, he took it with caution.

You’ll notice more and more that I will have to start being the cowboy riding my little horse pushing the cattle that way and this way. It will grow and grow. Because more people will be interested. Brad will be one of our worst enemies because he’ll be so enthusiastic that he will bill it as a big rock and roll band. We don’t even know how to play guitar yet and you have us playing in Madison Square Garden. Brad told [the CTO] that we are building a whole vision for a new network architecture. Once it grows, it means that Terrence and Theresa will come in. And, I will attract the bureaucratic machine. I know I’m bad at that, but have you noticed how much traction I get when I make them go away?

Savior was finally forced out into the light when Brad Copeland decided to hold a meeting with his senior team in late October 2002 to develop a new strategy for ATG at a point when they were able to take a breather from the cost-cutting and downsizing. Believing that the Savior project could be a means to add more “Hail Mary’s” (high risk, high return) to the portfolio, he insisted that Vince present it to the group. As Vince had suspected, a great deal of resistance to the project surfaced. Many of the other senior executives felt that it represented an economic model that was too far from the traditional EQUIPCO model and therefore would be doomed to failure – EQUIPCO normally would give away software to sell more boxes rather than charge for the application features that were the main benefit of Savior. Others saw the “technical merit but not the business merit” of the project. Some perceived that this kind of project had been tried in the past and had failed; others were worried that Savior risked being “another Betamax” (pursuing a standard that did not win in the market). Despite these concerns, there was enough interest in the project, in particular on the part of Brad Copeland that the senior team made the decision to fund an exploration phase where many of the questions about business viability and technical design could be addressed more closely. The last voice of resistance was quelled when they agreed to call the project “exploratory” rather than “development” which legitimized them proceeding without a fully fleshed out business case.
Because Savior finally got a public airing within the senior management team, many of
the project dynamics changed afterwards. A concerted effort was made to combine Stage 2 of
the Module project with the ideas in Savior; and a project being run by another member of the
management team was shut down for being redundant with this effort. Vince split the project in
two parts: one combined with Module to develop a much more aggressive, “non linear” focus
for that project; and the other remained a more high level strategic analysis that got pushed up
the chain to corporate management as a suggested strategic thrust for the corporation.
Importantly, Savior created a strategic context that made it possible to push Stage 2 of Module
forward. The notion that this new stage of Module would be supporting a more radical strategy
legitimated the fact that they could not pin down a specific market size or opportunity. It also
forced them to declare the project “exploratory” which at least temporarily minimized the threat
to others in the organization. However, this set up the project up for a more contentious debate
when the project would move forward to the development stage.

4.5.7 Summary

The stories of these projects highlight a number of themes that will be explored in more
depth in the next chapter. First, different people had different frames about the market, the
technology, the potential technical solutions and the means for arriving at a strategic choice.
Conflict was often intense and was engendered by the tight intertwining of frames and interests.
This is not to say that the conflict was necessarily problematic, as Brad Copeland said about his
group:

I think the people in the technology organizations are passionate about what they do, and there
are technology preferences and people tend to promote number one what they fully understand
or are good at and number two the area that they feel has the most upside for a variety of
reasons. And, that is the right thing to do. I want the passion. I want the emotion. I want you to
pour your heart and soul into this… it’s a tough crowd, they are very opinionated and everyone’s
extremely sharp. When you are up presenting, whether or not you have your bullet proof vest on,
you are going to take a few hits. And, sometimes it’s taken personally although it is not directed
that way, and sometimes it’s not… But, the fact that there is such emotion and such variety of
opinion is a clear and positive indicator that this is an absolutely critical deliverable for the
company… I would be worried if it was not there. But, it is not personal tension, it is very different.
It’s opinionated, informed perspectives on the appropriate path forward. (Brad Copeland)

4.6 Portraits of individuals

While the unit of observation in this study was the project, I examined these projects
through the lenses of the individual informants. Their stories help shed light on the dynamics I
encountered in my time in ATG. In a discussion with Vince Weston, he reflected on challenges of making the ATG organization more strategic. “They don’t have a crusade,” he said. “They are just making better swords that can kill more effectively. But, wouldn’t it be better if they had an organized killing machine called an army that had a mission that they could all rally behind? Then they could really win.” We played around with ideas about why many people in ATG don’t understand what a vision is or don’t get the need for real business economics. I asked if it was because they are all engineers, but he pointed out that he and Susannah are engineers, and they both get it. I asked if it was the old “EQUIPCO Labs” mentality, but he noted that Vijay Kumar is not from the Lab, and he doesn’t get it.

“All I can think of is that they are products of their environment. Susannah has a lot of product line management experience and gets product economics. I was in the venture/deal-making part of EQUIPCO so I understand business cases. The others don’t have that kind of background. For example, Vijay just sees the Module project for its technical merits. Stephen Merton thinks that the entire vision of Module is to sell it to [Customer X]. Everyone only sees his slice of the pie.” (Vince Weston)

This section of the chapter explores some of these “slices of pie” for selected informants.

4.6.1 Brad Copeland

Brad had run the ATG organization for about 18 months when I began my field work. At EQUIPCO for his entire career, he was about 40 years old and had risen fast in the organization during the fast growth market. Trained as a network architect, he was well-regarded by people in the technology organization. He drove a Hummer, went hunting on his vacations and was getting his pilot’s license. In many ways, he was the archetype of the engineer made good during the telecoms bubble. He was brought into ATG to introduce more discipline in the decision-making process and continue the transition of the organization from the old “EQUIPCO Labs” to an investment oriented organization. In describing his role to me, he said,

*Part of the job that I have is to understand the horizontal landscape, what the market conditions are, where the entire industry is going, because that has significant implications to the contents of our technology portfolio. What do we invest in? There are lots of cool things we could be experimenting in, but that would be just for research sake. And, we are not in the research business. If I cannot articulate, at least on a pro forma basis, a potential path to commercialization, then we probably shouldn’t be doing it because there is no pro forma ROI. We can’t defend the investment. How are we going to apply the technology we are going to generate to make money. Remember when I said, technology is interesting, but generating revenue from it is intriguing? Intrigue me!*
He felt his job was to “launch initiatives, then let the experts run them.” He said that he had a “higher up the mountain” perspective. His goal was to make sure that the decision-making processes he put in place were “process lite.” But, two of his close advisors on strategy issues (Theresa and Vince) expressed concern that he was too focused on the next new technology, and that “process lite” had become “process heavy” because Brad had no patience in helping people learn the new skills they needed. This problem came in part because of Brad’s conflicting experience. Having made his name in the organization as a technologist, he was ultimately swayed by “cool technologies,” but as a Senior Vice President in EQUIPCO and head of ATG, he had the responsibility to rationalize the portfolio and introduce decision making rigor. These experiences often led to opposing tendencies in his views.

Shortly after he entered his job at ATG, the market crashed. It became his responsibility to layoff a major portion of the members of the organization and to “revector” a number of projects. But, stepping back from the experience, he reflected that,

_The current economic conditions are an incredible learning opportunity. Personally, I've never gone through anything this tumultuous or anything this depressing. In the industry, it is pretty amazing what is happening right now. But, to come out of this and to create a corporation that is very strong and very focused is something that I want on my résumé. It is easy to do well in the good times. It is a challenge to do well in the difficult times. I also think that the difficult times are how we identify and produced our true leaders in the company. So, this is helping me understand where the strengths are in the organization. So, it is very positive._ (Brad Copeland)

But the toll was clear. He had to devote a significant amount of time, in particular over the summer of 2002 in making the critical lay off decisions. As a result, he relied quite heavily on Vince Weston in particular to advise him on strategy issues.

### 4.6.2 Vince Weston

“My function is pot stirrer, and then to pitch in when I stir the pot too much,” said Vince in one of our early conversations. Vince had been assigned as my key point person at in the ATG organization. He reported directly to Brad, and had been charged with developing new ways of thinking about strategy-making in the group. Trained as an industrial engineer, he used to be in the EQUIPCO corporate venture capital group. He started out at the headquarters location but was transferred to a different location to lead up the venture capital effort in that region of the country. He eventually picked up responsibility for Europe and the Middle East as well. When the telecoms market crashed, Vince moved over to ATG to head up the economic
analysis team. He was, for a time, a member of the Review Board, but he resigned that spot, complaining that the strategy process wasn't working. Chris Chang took over Vince's economic analysis team. Vince became an individual contributor working on special projects for Brad.

Vince seemed to have fallen from grace in ATG. He surmised that this was because he had been responsible for a number of the cuts in the organization (including revamping and nearly eliminating the external relations group) and because his venture capital mentality didn't mesh well with the culture of ATG management. But this was a double-edged sword. He also got drawn on to projects because of his ability to address the hard issues. In the Last Mile project, the "meat grinder" model of the decision-making process developed by the team had a special stage called the "Weston Filter" which represented the moment when the team had to answer all of the tough questions that Vince would ask.

Vince's VC background meant that he was frustrated with both sides of the house. He opposed technology projects that didn't have a credible business case. At the same time, he complained that the economic analysis team was just producing charts instead of "helping to build widgets." His views was that the ATG organization needed to function like a venture capital group in the sense that it should produce "cool technologies" that would have significant market impact and draw on the broader capabilities of the EQUIPCO organization (either products or channels).

4.6.3 Hugh Collins

Hugh was regularly described by others in the organization as a "guru in everything optical and photonic." His background factored heavily into his view of the broadband access solution on the Last Mile project. First, he had a "long history" in access technologies in EQUIPCO, having worked on nearly all of the company's access projects over the years (both copper and fiber). He felt that the former CEO didn't understand the strategic importance of access or how to make money in access when he made the decision to get out of the business. At the time, Hugh felt that they were making a big mistake and vowed to monitor the situation to the point where things became dire for the company. In his view, "EQUIPCO made a blunder in closing down access. We need to be back in it ASAP or sooner."
In addition, in the Lightwave program, they were doing work on a city-wide design and realized that the biggest problem was with aggregation at the edge. That is when he started looking at access again. Indeed, after the Lightwave project was shut down, he argued that it was an early conversation he had had with Brad that led to the downsizing of the project (this despite his strong opposition to shutting down Lightwave before it happened). He said that he argued to Brad that photonic technologies would have problems because of lack of bandwidth at the edge and therefore the technology development program was peaking too early. Given this, he felt that it was natural for him to turn to look at access. He also ran a few “Widget” programs in EQUIPCO. In one case, the team he was leading got to a fully functional product that was being produced at a test level. However, the project got “thrown out.” He attributed this to a fear of cannibalization by other groups in EQUIPCO with competing technologies. He felt that “this company has been Widget-ophobic for years.” Finally, Hugh was also the EQUIPCO representative into an international standards body on Widgets up to about 1997-98.

It was therefore not surprising to him or anyone else in ATG that Hugh was promoting the Widget technology as the solution to the Last Mile project. And, he felt that his view should predominate over the views of those who, as he said, “spell access with a ‘k’” (and therefore were not experts in the area). Thus, when the voices opposing Last Mile were taken seriously, he was flummoxed. “The process is so constipated, so smothering,” he said. “The very same people who are refusing to make a contribution are then criticizing the project and grandstanding once they are in a meeting in front of Brad.” Describing why he had stormed out of the Last Mile mid-point decision meeting, he said, “If I hadn’t walked out, I would have ripped into them. I don’t know if you have ever seen me really lose it, but it is a scary thing. It would have been the talk of EQUIPCO the next day.” But, the result of standing up for his beliefs was that he was removed from his position as the head of the project (which reduced his power in ATG).

4.6.4 Vijay Kumar

Vijay had a very diverse background, from an undergraduate degree in the classics to a Ph.D. in electrical engineering. He worked for many years in a software project linked to a DARPA contract (US government research program connected with the Defense Department). When that fell apart, he moved to an enterprise networking company just as it was being acquired by EQUIPCO. He remained located at the old headquarters of the networking company.
and avoided traveling to the headquarters location. In general, he did not like meetings — “They frustrate me. I am not a political animal.” He used principles that he learned from DARPA projects where researchers are allowed to define their own problems and research questions and then go out and solve them. He complained of “excruiciating meetings [at ATG] where consensus has to emerge” where there was “avoidance of the blunt reality, that the world is moving at web speed” and ATG was not. “I almost fear having a new idea because I’ll have to spend three months in the Steering Committee.”

For Vijay, the key was creating the right “habitat” for research, though he admitted that creating the habitat is not an exact science. In the case of the Module project, he created the habitat through his advisory position for Stephen Merton’s dissertation (which Stephen was completing while working at EQUIPCO). “Stephen was already pursuing a PhD in a good technical direction. The key was trying to find a way to connect it with a business need.” Two years prior to the commencement of the Module project, Vijay wrote a paper predicting that communication and computation would come together. “It was a shot in the dark” but with no technological solutions. For him, Module was a step in that direction. Because of his background, Vijay was able to help Stephen express his ideas. In these discussions, Vijay’s ideas entered into Stephen’s project. In general, Vijay felt that “my subconscious keeps pushing [computing-networking connections] into my brain.” Based on this experience, he reflected that “Our past is very important in the future” for making decisions.

4.6.5 **Susannah Watts**

Susannah was a manager in the business analysis function reporting to Chris Chang. Her original training was in optical engineering and she had spent most of her EQUIPCO career in product line management functions. She was in favor of changes that Brad was trying to make in the decision-making process but she didn’t have much hope the effort would succeed, describing it as “a road to hell paved with nothing but vitriol and bad intentions.” Susannah often wrote long e-mails to me analyzing the ATG organization from her perspective both as one of the few women in the organization and one of the few people with extensive experience working in product line management. In one e-mail to me, she described many of the ATG people as “techies or geeks” who were better at “human-to-machine interfaces than human-to-human”
which resulting in a lack of skills around communication and the inevitable “misunderstandings, second guessing and other human social issues.” The e-mail continued,

I have to say that ATG is the most pure and extreme set of these behaviors I’ve ever encountered in EQUIPCO, and there is no counterbalance. I think that a lot of this is because ATG doesn’t have all the business and operations groups that other teams have to balance things out.

On a much lighter note, it does have humor in it as well. ATG is a pretty Dilbertish place to work. I can honestly say that the mind-boggling insults/comments calling into question my capabilities mostly make me smile...because the person insulting me genuinely is oblivious to the fact that they have insulted me. Quite often they genuinely think that they are giving me a complimentary pat on the back!!

Collected samples from my year in ATG, the more memorable highlights are: “WOW Susannah for a girl, you understand this math very well”, “You look nice today, I didn’t realize you had legs, you always wear trousers” ........Uh???? “Being a marketing person, you won’t understand that we in ATG like to apply more analysis to engineering problems. We won’t go into the details here because you won’t understand it and will probably be bored”

And the absolute gem from last month: “Gee that was a nice Optical 101 summary and you got it all right, well done”...my response to this particular line......gee, I should hope so, seeing that I designed optical systems for 10 years most of which were successfully deployed by customers...The response...You don’t look that old...you can’t be more than 40 you don’t have any gray hair....my response...well that’s because I’m only 34, I said 10 years not 20 and my hair is rapidly turning gray working in ATG!

Despite Susannah’s background in optical engineering (or perhaps because of it), she was opposed to the optically-based Lightwave and Last Mile projects. Her experience in product line management overrode the more technical perspective. She did extensive analysis of the communication market, triangulating from a vast amount of analyst reports and using her own market intelligence. In her view, these data did not support a business case for optical investment. However, it was difficult to bring these analyses to the attention of the technical team who responded with “vitriolic attacks.” She said their attitude was reflected by statements such as: “If we don’t like the data point, we say it is flawed and go on our merry way.” Even in the face of this opposition, she continued to stand up against the optical projects. It came at some personal cost (she was quite unhappy in her position67), but she felt obligated to stand on principle.

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67 Indeed, about six months after I completed my field work, she asked for and received a transfer into a business unit group.
4.6.6 Jack Stafford

Jack was the epitome of the "EQUIPCO Labs" engineer. He had spent his entire career in EQUIPCO Labs and ATG. He had risen through the ranks by dint of his skills as an inventor and had become a director with a large number of engineers reporting to him. He reported to Erik Helgesen (who had come to EQUIPCO along with Vijay Kumar in the acquisition of the networking company) but continued to revere Erik's predecessor, one of the top directors in EQUIPCO Labs who had been forced into early retirement during the wave of layoffs. He was responsible for software implementation, algorithm development and advanced network processors. He was also responsible for the Lightwave program. His background was in hardware and physics. Common to the views of many in the technical organization, he felt that "technology is gut feel." "We have a broad knowledge about what is happening in the industry and the way this technology could help. The question is how to get people to move beyond their mind blocks..."

In reflecting on the decision to minimize investment in the Lightwave project, he commented "There is probably a reasonable good story to maintain the effort. Project development takes five years to get to market but the evaluation cycle requires projects to have revenue in three years...but I don't think that the executives understand that." He resisted efforts by the business team to reduce the investment because he believed that photonics was an important area for investment and EQUIPCO risked falling behind if this level of investment were not maintained. But, his interests were also threatened because he was so closely tied to being a leader of the Lightwave project, the largest research and development effort going on in ATG. Minimization of the Lightwave project decreased emphasis in the organization on an area where he was clearly an expert. Reducing investment in the project was also against his interests because he would no longer command such a large group of engineers. Jack presented a case in favor of continued investment, but he wished the Review Board had "saved me from the embarrassment of standing in front of them to present my ideas" when they had already made up their minds. From his standpoint, investment and analyst reports came out saying that optical switching is going to happen in 2005-6 which was outside of the window for ATG, so the marketing people said "there is no market here." He said that it was very hard to argue against analyst reports.
In his view, the Steering Committee was “bogged down in assessing programs. The process to bring something to the committee is complicated with lots of templates. It took three months for the original Lightwave program information to be put in the format.” “It is good to think about business value, but getting these data is hard for the technical people, and the business people in the group are linear thinkers. All they do is call the PLM’s [product line managers in the business units].” For him, the resistance to the Multiservice project was a prime example of this behavior. He thought it was being “held back” because the marketing people said they “talked with the PLM” and there was no interest. He was frustrated when he didn’t get approval from the Steering Committee to go ahead with investment in Multiservice. “There was no trust to say ‘go ahead.’” He felt micromanaged because they gave the impression that they didn’t trust him to shut down the project if he didn’t get positive feedback from customers or the lines of business. To retain a sense of autonomy, he simply went ahead and staffed up the project without formal approval (though he got approval after the fact).

4.6.7 Edward Fischer

Edward Fischer had been at EQUIPCO for less than two years. He was hired into ATG at the end of November 2000, but he had been involved in the communications industry for years. He was an Ethernet pioneer since the 1970’s and had worked for a major semiconductor firm. In addition, he started up a couple of companies: he was the founder and CEO at one and a vice president at another. He didn’t like being “number 2” in a small organization, so he moved to EQUIPCO. He has had many different roles and responsibilities throughout his career which he claimed offered him alternative views about situations. He worked out of the Silicon Valley offices of EQUIPCO and had only been to headquarters once. Thus, while he was a member of the technical organization, his accumulation of experiences was very different than those of people who had spent most of their careers in EQUIPCO Labs and ATG. His experience in small companies made him more sensitive to business and market demands. Similarly, by virtue of being located in Silicon Valley, he understood the bold startup mentality.

Edward was a significant voice on the Last Mile project arguing that the market for bandwidth would grow exponentially. He was “a strong believer for higher bandwidth demand in the home.” He had done a lot of work on video applications (his job title was Network Architecture and Applications), so he saw the potential of video to be a driver of increased
demand. He faced a lot of resistance from the marketing team on the project who insisted that the market would grow at a linear pace, if at all. But, in his view, “the status quo took EQUIPCO out of the access business to begin with.” He argued that “I don’t like to use the rear view mirror” to forecast. The current status of things would not be an indicator of needs in the future. “I heard people say the same thing about Ethernet years ago at [semiconductor firm]” (where they didn’t think that PC’s would be much of a business). But, “things change in surprising ways.” His enthusiasm for advanced technologies was tempered by his belief, which came from his years in startups, that the business case was essential. As such, he strongly believed that projects should follow the Steering Committee process. When he was asked by Erik to join the Multiservice project, he insisted that Jack’s decision to invest be vetted by the formal decision-making committees.

4.6.7 Theresa Veneto

Theresa Veneto was a member of Brad’s senior management team and the head of the Steering Committee. As such, she controlled the agenda of that group as well as of the Review Board. She was the only woman on the ATG management team and one of the few women in the organization. She had been instrumental in putting the Steering Committee decision-making process in place, and, as head of the committee, she had a strong interest in making sure all projects pursued by ATG followed the Steering Committee protocol. In her position, she functioned as a gateway to the formal decision-making process. If she did not feel a project was ready for review, she would not put it on the agenda. If she felt that an initiative should be reviewed, she put it on the agenda, sometimes without consulting the affected parties, and insisted a review take place. Her interests were to make sure that the various people making proposals took her seriously: she was adamant that teams incorporate all of her input in their project proposals.

She viewed ATG as a service organization that needed to prove its value to the rest of the EQUIPCO organization. For example, she felt that the decision for the initial Module project investment was “easy because of the connection with the business unit and the customer.” Her general view of much of the technical organization within ATG was that they tended to pursue technologies because they were cool without much consideration for the customer or market. From her standpoint, the vast majority of the technical team all grew up in an organization that
just gave them money and let them go for long periods of time. This made her “a strong proponent of interim decision points” which she enforced for many of the projects. She said that people like Hugh Collins just didn’t understand the process and therefore made it harder on themselves. While the Steering Committee process may have felt like micromanagement to many on the technical teams, she argued that people who didn’t understand the process made it more complicated than it needed to be. Nevertheless, she was the focus of a great deal of wrath from the technical organization, in particular on the Lightwave, Last Mile and Multiservice projects. While she got a lot of pressure to back off, she said “I refuse to change the process” because she felt that the validation of the Steering Committee process was part of a cultural change.

Unlike a number of people in the technical organization, she was not trained in optical engineering and was not wedded to optical technology solutions. As such, she strongly opposed the Lightwave project and was instrumental in getting the investment radically reduced. She saw the decision-making on the Last Mile project as a means to reinforce the victory she had achieved on the Lightwave project. She wanted to make sure that this project didn’t simply become a substitute for the Lightwave effort. As the Last Mile project came up for various decisions, she had “backroom” discussions with Brad in each case to make sure he would reinforce the decision-making criteria and the Steering Committee/Review Board process. Her interest in making sure projects went through the Steering Committee process eventually led to the blow up in the July midterm review meeting for the Last Mile project when Hugh walked out of the meeting. Although Hugh had a private conversation with Brad in mid-July which Hugh interpreted as approval, this occurred while Theresa was on vacation. When she returned, she told Brad that this wasn’t the way to make decisions and insisted that a midterm review take place. This created confusion for Hugh who didn’t feel he should continue to be challenged on the project. When Theresa insisted in the meeting on getting Hugh to talk about specific recommendations, this was the straw that broke the camel’s back and Hugh walked out. Theresa took it personally: in a voice mail to George Arden the next day, she said: “suffice it to say, he walked out on me.”

Eventually, however, she came to support the investment in Last Mile. Her initial frame was that there was no market for access. However, because she had a strong interest in
supporting the formal decision making process that she had helped set up, she changed her position once the team was able to meet the key criteria established as part of the Steering Committee process (namely, finding support from a business unit). She saw the cultural change as a long process which she tried to reinforce with as many small victories along the way as she could.

4.6.8 Summary

These brief histories demonstrate how each individual’s experiences shaped how they thought about projects and decisions. They each had multiple histories and the result was often conflicting views. The stories also reveal the complex interrelationship between frames and interests. People often pursued their beliefs even at the cost of some of their interests. At the same time, their interests were shaped by their frames, and reciprocally, different frames were made salient by interests in different project contexts. In the next chapter, I explore these themes in greater depths in the context of the Last Mile and Multiservice projects. I use these data to generate a model of “framing contests” by which strategic choices were made.

4.7 Scope conditions – particularities of EQUIPCO and ATG

From these stories about the culture, the projects and the people, I have demonstrated that ATG is a particular kind of organization with a particular history in a particular corporation. It had a relatively democratic decision making process; it had long roots as a research organization; it was dealing with rounds of layoffs during the period of my observations. All of these features both enrich and bound the insights that I can generate from this study.

First, while the quantitative study reported in Chapter 3 focused on the frames of senior management teams, this study was located at the next level down in the organization. The Advanced Technologies Group reported into the executive team at EQUIPCO. However, because of the financial crisis being faced by the company, the corporate executives were entirely preoccupied with cost cutting, layoffs and company survival. As a result, at the particular point in time when I conducted my observations, ATG was the sole locus of corporate technology strategy-making. Therefore, despite the fact that this study did not focus specifically on the senior corporate executives, it should not be construed as a study of middle management...
activities in the way that Burgelman described the autonomous decision-making at Intel (Burgelman 1991; Burgelman 1994).

The analysis itself has focused on specific projects undertaken by members of the ATG organization to reach a strategic choice about investment. I do not believe however that it would be appropriate to equate project-based work only with work that happens at middle or lower levels of the organization. While I use the term “project” to cover the efforts I observed, they might be more appropriately construed as initiatives which were formalized to a greater or lesser extent and included different degrees of technology development work. In this sense, projects could be undertaken at any level of the organization. One can easily conceptualize a strategy initiative at the highest levels of the corporation. Thus, both because projects or initiatives can be undertaken at many levels of the organization and because ATG was the sole corporate group charged with making technology strategy at EQUIPCO, I make no specific claims about whether the phenomena I observed are specific to middle management. Indeed, I claim that these dynamics would likely be observed at senior team level as well.

Second, ATG was a particularly democratic organization in the sense that the Steering Committee and Review Boards were the final arbiters on the projects in most cases. Brad Copeland did not attempt to make all of the investment decisions himself. This more democratic process may have increased the political activities of the members of the organization, or at the very least, made them more visible to the researcher. On the other hand, Eisenhardt and Bourgeois (1988) have argued that politics will likely be more intense in dictatorial organizations. Since I only studied one organization in depth, I have no basis for addressing this proposition. However, this field study at a minimum demonstrates that intense politics can be present in more democratic settings as well. The formal decision-making bodies – the Steering Committee and Review Board – actually provided a forum for political action to play out. It could be that if Brad Copeland had run a more dictatorial organization, the politics would have occurred in a much more sub rosa manner. More top down management may not have lessened the political activity, but this activity may have taken a different form.

Third, the research design for this project aimed specifically at examining an organization facing discontinuity in its markets and technologies. The high degree of information ambiguity and the disruption of pre-existing frames are likely to have provoked a wider range of
interpretations of the internal and external environment. As a result, the potential for conflict may have been greater than in a more stable period. The contests around meaning might not be as intense in other, less extreme, settings.

Finally, ATG was a technical organization at its roots and populated almost entirely by engineers. Even many of the people in the marketing or business analysis functions were trained originally as engineers. The ATG organization itself had started out as a purely technical "Lab." Studies of engineering organizations (Bucciarelli 1994; Kidder 1981; Kunda 1986; Vincenti 1990) show that engineers pride themselves in rational, unemotional analysis and the search for elegant, technical solutions to market or technical problems. Their currency is technical expertise. This may explain why the first recourse for people in ATG as they battled out contested meanings about the market and technology was to data and analysis. While the decisions were rarely reached purely on the merits of the technical analysis, most projects started as a competition between analyses (often in the form of huge PowerPoint documents). In a less engineering dominated organization, the battles may have been fought in different ways, using different strategies.

As a result, the findings from this field study are bounded in several important ways: to periods of discontinuity and high information ambiguity, to technical groups reporting into senior management, to democratically run organizations, and to engineering cultures. It remains an open question as to whether the findings can be extended to other contexts.
Chapter Five

Framing contests: micro mechanisms of strategy-making in the face of technical change

5.1 Introduction

5.2 Challenges for understanding strategic choice – a review
  5.2.1 Three problems in strategic choice
  5.2.2 What a cognitive perspective helps explain
  5.2.3 Some emerging solutions

5.3 Specific methodological considerations for this analysis
  5.3.1 Appropriateness of research setting and cases
  5.3.2 Analytical approach – focus on the decision as the unit of analysis

5.4 Frame analysis – role of frames in strategic choices in two projects
  5.4.1 Last Mile
  5.4.2 Multiservice

5.5 A model of framing contests
  5.5.1 Frame repertoires and frames
  5.5.2 Framing strategies
  5.5.3 Frames and framing strategies intertwined with interests and political strategies

5.6 Conclusion

Appendix to Chapter Five – description of frame analysis

5.1 Introduction

The purpose of this micro field study was to explore the role that frames play in shaping strategic choices in a firm facing a major discontinuity. By frames, I mean interpretive schemas that actors apply to perceive and understand the world around them (Goffman 1974). As demonstrated in the previous chapter, EQUIPCO and its Advanced Technologies Group struggled to cope with the shifting realities associated with the crash in the optical technologies market. Different people had different interpretations of the market, technologies, and EQUIPCO capabilities. Their historical reliance on technical intuition for making strategic
choices about investments did not seem adequate in the face of such an industry and company crisis when resources were extremely scarce and technology investment decisions were perceived as life or death for the future of the company. Because the environment and technology (and organizational rules and procedures) were uncertain, beliefs about what was going on were contested, and meaning had to be negotiated. During the Last Mile project, Hugh remarked: “Like most things, there is no absolute truth in anything. And, if you want to find the aspect to say it is a dog project, you can prove it conclusively it’s a dog. If you want to find the aspect to say, ‘yeah, here are the golden nuggets that could make something really useful out of it,’ you’ll find it.” Rational analysis in the canonical sense could not necessarily resolve the differences, since project team members and decision makers experienced both an inundation of potentially relevant information and a paucity of “hard facts.” Whether a project was a “dog” or had “golden nuggets” was highly dependent on the frame of the perceiver.

In this chapter, I focus in on two of the five projects I studied in order to conduct an in-depth analysis of the micromechanisms connecting frames to strategic choices. These two projects – Last Mile and Multiservice – were chosen for their contrasts: they represented very different kinds of responses to the crash in the optical technologies market, were based on completely different kinds of technologies, were led by different people, were opposed for different reasons and followed very different trajectories from initial proposal through the various investment decisions along the way. The idea is that common themes that emerge from the study should be reflective of underlying structures rather than any more superficial commonalities in the projects. Each of these projects involved three strategic choices about resource allocation over the course of my observations. They are specific cases of strategy-making during a discontinuity.

The problem of technological discontinuities is an extreme example of a broader set of issues around strategic choice. The heart of the problem is informational ambiguities, which, while always present, are particularly extreme during periods of discontinuity. Information from the internal and external environment cannot be comprehended as a set of clear and easily recognizable signals. This problem is encumbered by two additional factors, those of multiple actors and incongruent incentives. Multiple actors with different understandings of the environment are involved in making strategic choices. And, they may not have incentives to share their information. These factors further complicate the acquisition and communication of
information necessary to make strategic choices. While research in cognition has suggested that
cognitive frames are the means by which managers cope with information ambiguities, little
work has attempted to examine how frames relate to information ambiguity, multiple actors and
incongruent incentives as interdependent factors. However, it is precisely the combination of
these problems that make the task of strategic choice complex. This gap suggests several
research questions: What are the cognitive frames constructed to make sense of ambiguous
information? How are these frames enacted by multiple actors to make strategic choices? And,
how are these frames connected to interests?

The nature of these questions and the current lack of theorizing about them collectively
led me to an ethnographic and inductive approach examining the day-to-day practices that
produce strategic choices. Using evidence from the Last Mile and Multiservice projects at
EQUIPCO, I analyzed the role of cognitive frames in strategy-making dynamics as they are
produced in the course of situated action (Suchman 1987). This was aimed at joining micro-
organizational processes with macro-organizational changes by “bringing work back in” to
strategy (Barley and Kunda 2001; Hendry 2000b; Johnson et al. 2000; Whittington 1996). The
purpose of this field work examining cognition “in the wild” (Hutchins 1995) was to reveal the
micromechanisms behind the role of frames and framing in shaping strategic choice. Setting the
research during the turbulent time of the crash in the optical market was intended to expose
dynamics that would be buried beneath the surface during more stable periods (Meyer 1982).

To explicate the mechanisms linking cognitive frames and strategic choice, I draw on
framing theories in the social movements literature that explore interconnections of frames and
interests at a community or society level (Benford and Snow 2000; McAdam, McCarthy, and
Zald 1996; Snow, Rochford Jr., Worden, and Benford 1986; Snow and Benford 1988; Zald and
Berger 1978). In this view, changes in the environment create the opportunity for new
interpretations, and social movements coalesce to produce and dispute these new meanings. I
suggest that it is possible to apply these notions within the firm to illuminate the dynamics of
strategy-making. In the context of EQUIPCO’s strategy-making in the uncertain conditions of a
discontinuity, shifts in political opportunities, such as those generated by the emergence of the
optical revolution in the communications technology industry, engendered disputes about
meaning. The resolution of these disputes in the context of specific projects—in the form of framing contests—produced investment choices about technologies.

To preview my findings, from my observations at EQUIPCO, I built an inductive model of strategy-making that integrates managerial frames with political perspectives in order to take into account the key strategic challenges of information ambiguity, multiple actors and incongruent incentives. In this model, individuals have a repertoire of potential frames based on their experiences, some of which are made salient by the particular decision context at hand. Proposers and challengers on a project develop framing strategies intended to increase the resonance of their own frames and therefore influence the investment decision.

As I will argue in this chapter, this framing process is not an alternative to more interest-based political models. Indeed, in the case of the two projects (and six decisions) that I studied, I find that interests and frames, and their related processes, were strongly intertwined. Traditional models of political processes argue that people use political strategies to pursue their interests. In my observations, the strategic choices could not be understood without considering a parallel process of framing. Much as individuals had repertoires of frames, they also had several different interests, only some of which were salient in a particular decision context. These interests shaped the salience of particular frames, but reciprocally, people’s frames also affected how they perceive their own interests. I observed that the framing strategies of proposers and challengers were often inseparable from their political strategies used to promote their interests. While the outcomes were shaped by those who had the most power at the end of the process, one of the critical ways to gain power was to craft a frame that resonated most strongly with the decision makers. My exploration of the mechanisms associated with frames in this one firm’s response to technical change suggests that it is the resolution of the internal framing contests that can explain the strategic direction taken.

In this chapter, I first review the literature about the three challenges in strategic choice and show how cognitive perspectives have or could contribute. Next, I note some specific methodological considerations associated with this analysis (beyond the general methodological

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68 Ryan (1991) originally coined the term “frame contests” in her work on media strategies for grassroots organizing.
approach for the field work described in the previous chapter). In the subsequent sections, I describe the dynamics of the several decisions studied and use this evidence to derive inductively a model for the framing contests through which strategic choices were made. I explore the nature of the frames themselves, describe the kinds of framing activities used to influence decision outcomes, and show how the framing process interacts with a political process in which individuals pursue their interests in attempting to shape strategic choices. I conclude with implications for streams of research in managerial cognition and technology strategy.

5.2 Challenges for understanding strategic choice – a review

Making decisions about technology investment in a period of discontinuity is an extreme case of a broader set of problems about strategic choice – problems of information ambiguity, multiple actors and incongruent incentives. While these problems are in practice highly interdependent, in research on strategic management, they are most often treated separately. In this section, I briefly review the nature of these problems, show how research on cognition has begun to shed light on the problems individually and look at some emerging clues about how to investigate the dynamics associated with their interdependence.

5.2.1 Three problems in strategic choice

Problem 1: Information ambiguity. One of the most critical challenges in strategic choice is coping with ambiguous information from the internal and external environment. For the main camps of strategy research – the positioning and resource based view – information ambiguity is a relatively unproblematic issue. Much of the current strategy canon rests on an (often implicit) assumption of the single leader or dominant coalition “deliberately choosing a different set of activities to deliver a unique mix of value” (Porter 1996: 64). In the Porterian model, strategic choice is about positioning the firm by selecting which industries in which to participate and what strategic stance to take (e.g., cost leadership or differentiation). The underlying model asserts that paying attention to signals increases knowledge which then improves assumptions and strategic choice (Porter 1980: 198-199). Companies that fail or underperform essentially ‘get it wrong.’ This set of assumptions is not unique to the Porterian positioning camp in strategy but also underlies the Resource Based View. This stream of research, starting with Wernerfelt (1984) and Barney (1991), that attributes heterogeneity of firm performance to internal resources or capabilities, relies on the notion that management’s unique
insight into an opportunity drives competitive advantage and performance. The leader is rational – or boundedly so (Cyert and March 1963/1992; March and Simon 1958) – and thus the key to making better decisions is getting more and better information. This assumption can be extended even to the dynamic capabilities perspective which argues that "the key role of strategic management is appropriately adapting, integrating, and reconfiguring internal and external organizational skills, resources, and functional competencies to match the requirements of a changing environment" (Teece, Pisano, and Shuen 1997). The assumption is again that knowing the requirements of a changing environment is straightforward.

Information ambiguity may be more problematic than it is portrayed in the core strategy literature. Under that conception of strategic choice, the firm, or the business unit, is the fundamental unit of analysis, and the single decision maker at the top is at its core a proxy for the firm as cognizer. But, as other scholars in very different strategy research traditions have argued, firms are not simply macro-level wholes but rather made up of different actors with different views and interests who interact to shape strategy. These scholars have addressed two additional problems with regard to strategic choice, those of multiple actors and of incongruent interests.

**Problem 2: Multiple strategy makers.** Various scholars have argued that the unit of analysis in strategy should be the process or set of practices that produce strategic choice. Whether it is a Mintzbergian notion of emergent strategy (Mintzberg, Raisinghani, and Theoret 1976; Mintzberg and Waters 1985; Mintzberg 1973), the Bower-Burgelman model of autonomous decision making (Bower 1970; Burgelman 1996; Burgelman 1983), or a more practice oriented view of micro-processes (Johnson, Melin, and Whittington 2003; Whittington 1996; Whittington 2003), in this view, strategy-making is not a top down process from a single leader but rather involves multiple actors. Early, highly granular studies of strategy-making demonstrated vividly how various coalitions in organizations formed and unformed to influence particular decisions (Baldrige 1971; Pettigrew 1973). Contested and political behaviors are common within top management teams (Eisenhardt and Bourgeois 1988), and this work has portrayed various different people or groups as shapers of strategic choice, sometimes in contradiction to the intentions of top management (Burgelman 1991). This stance does not necessarily exclude the role of the top leader in the organization, though this role is often constrained to setting context or establishing strategic intent (Lovas and Ghoshal 2000). The underlying assumption of this stream of research is that, given environmental turbulence (and the
resulting information ambiguity), multiple people or groups in the organization have different information and therefore can, and do, make different choices about strategic direction. Aggregating information is difficult because it is hard to communicate what one really knows of the tacit dimensions of knowledge (Polanyi 1966)

**Problem 3: Incongruent interests.** Another set of scholars in the organizational economics tradition have highlighted the additional complication that these various individuals throughout the organization may not have incentives to share the information that they have. Differences in individual interests can lead to opportunistic behavior within the firm. As Williamson suggests, “Opportunism refers to the incomplete or distorted disclosure of information, especially to calculated efforts to mislead, distort, disguise, obfuscate, or otherwise confuse…” (Williamson 1985). Hence, incongruent interests within the firm can further complicate the acquisition and communication of the information necessary to make a decision (Aghion and Tirole 1997). Differences in interests lead to different information sharing both in amount and in kind. Career concerns, for example, influence the amount of effort put into work (Holmstrom 1982/1999), and different incentives can lead to different kinds of knowledge transfer (Osterloh and Frey 2000).

**5.2.2 What a cognitive perspective helps explain**

Various streams of research on cognition have implications for understanding the three problems of strategic choice highlighted above. Cognitive approaches suggest that it is precisely the inherent ambiguity of information that invites multiple interpretations, and that these interpretations matter for decisions and action.

**Exploring problem 1: where there is ambiguous information, managers’ interpretation matters.** The core of managerial cognition research has challenged the notion in strategy that information can be unproblematically perceived. From its roots in notions of bounded rationality (Cyert and March 1963/1992; March and Simon 1958), the managerial cognition field has begun over the past few decades to refine our understanding of the information problem by suggesting that it is managers’ interpretations or cognitive frames of the information rather than the underlying information itself that matter for strategy (Huff 1990b; Ocasio 1997). Consistent with psychological research on bias (Kahneman and Lovallo 1993; Kahneman, Slovic, and Tversky 1994), this work has suggested that interpretations often differ
significantly from ‘reality’ with resulting implications for strategic choice (Bourgeois 1985; Sutcliffe and Huber 1998; Sutcliffe 1994)

As a particular example, a large number of studies have suggested that management definitions of the firm’s strategic group (one of Porter’s core notions) shape the information gathered, the interpretations made and the strategies chosen (Baum and Lant 1995; Baum and Lant 2003; Ginsberg 1994; Lant and Baum 1995; Porac et al. 1989; Porac et al. 1995; Reger and Huff 1993). Managers are particularly likely to differ in their views of competitive categories in turbulent environments (Reger and Palmer 1996). Broader cognition research on firm response to highly ambiguous situations such as technological discontinuities or secular market changes shows that heterogeneous outcomes could also be attributed to differences in managerial interpretation (Barr 1998; Barr et al. 1992; Gavetti and Levinthal 2000; Henderson and Clark 1990; Kaplan et al. 2003; Siggelkow 2002; Tripsas and Gavetti 2000).

While often not explicitly addressing cognitive frames, much of the work on senior teams and change is consistent with the idea that interpretations matter for strategic outcomes (Bantel and Jackson 1989; Boeker 1997; Lant, Milliken, and Batra 1992; Prahalad and Bettis 1986; Rosenbloom 2000; Sorensen 1999). Demographics are often used as proxies for managerial cognition (Ancona and Nadler 1989; Norburn and Birley 1988; Virany and Tushman 1986; Wiersema and Bantel 1992). For example, where environmental change is discontinuous, replacement of the entire senior team is often associated with better firm performance (Tushman and Rosenkopf 1996; Virany and Tushman 1986).

While arguing that interpretation matters, for the most part, these streams of literature accept the Porterian portrayal of the CEO or dominant coalition as the sole decision makers in organizations, making the connection between information (about the internal and external environment) and strategic choice. They also draw on a very psychological understanding of cognition as entirely in the mind of individuals, where shared frames are simply an analytical construct that comes from looking at the average or intersection of individuals’ views. The models developed by these scholars are variance (rather than process) theories of social action that mainly focus on establishing cognitive frames as a separate variable explaining strategic choice and action.
Exploring problem 2: where there are multiple players, interpretations are contextual and negotiated. A separate stream of research in social cognition has examined how interpretations are enacted more broadly in organizations where multiple players are engaged in producing choices. The premise of social cognition research is that people act on the basis of interpretations of the world, and in doing so enact particular social realities and endow them with meaning. This research makes an explicit critique of the more cognitivist perspectives embedded in the managerial cognition literature (c.f., Lave 1988: 88-89), and instead has portrayed organizations as interpretive or sensemaking systems (Daft and Weick 1984; Weick 1995) in which the “collective mind” is generated through a system of “heedful interrelations” among multiple actors (Weick and Roberts 1993). In this construction, frames are enacted in, not separate from, their contexts. Different environments yield different knowledge and also different forms of knowing (Hutchins 1995; Lave and Wenger 1991). A focus on the micro-level processes shows that choices both shape and are shaped by cognitive frames. This stance has been used to explain intended and unintended consequences of technical change as resulting from conflicts in the different technical frames of key actors as they are enacted in particular organizational contexts (Orlikowski and Gash 1994).

This approach takes a more sociological notion of cognition by emphasizing the interaction of individuals and their contexts (Goffman 1974). Shared frames are not simply an analytical construct, but rather are negotiated meanings produced through the actions and interactions of actors. Social cognition research looks not only at these shared frames but also at the means by which they converge or diverge. Scholars in this stream of research tend to produce process rather than variance theories, preferring to focus on the construction of choices over time.

Exploring problem 3: even with incongruent incentives, incentive alignment may not be the ideal outcome. Few, if any, researchers on cognition have addressed interests explicitly in their models. However, two of the underpinnings of the incentives literature could be enriched by a cognitive turn. First, Williamson’s notion of interests is that all individuals are essentially the same, and that beyond some basic requirements for material subsistence, the major incentive is esteem or status (Williamson 1985). But, as Douglas (1990) points out, Williamson and others do not address how this status is collectively negotiated in the organization. This conceptualization of interests does not take into account that the interests
themselves might be subject to interpretation. In particular, in more dynamic, ambiguous information situations, it may not be clear what the interests are or what the incentives should be. Second, the typical solution proposed to resolve the lack of congruency of interests and information is to achieve incentive alignment (Holmstrom 1979; Kerr 1975). The better aligned incentives are, these scholars argue, the better the outcomes. By definition, this makes conflict dysfunctional. While some research into strategic decision making suggests that it might be the case that conflict has negative effects (Eisenhardt and Bourgeois 1988), other analysis suggests that conflict and politics can actually, especially under highly turbulent situations, produce ‘better’ decisions (Jehn 1995; Morrill 1995).

5.2.3 Some emerging solutions

The research presented in this chapter is motivated by the belief that a study that takes into account all three of these interdependent problems of strategy would provide fruitful insights into strategic choice particularly in such situations of high uncertainty as periods of technological discontinuity. While cognitive perspectives expand our understanding of these problems individually, there have been limited attempts in the management literature to examine their intersection. Thomas’ (1994) and Pettigrew’s (1985) case studies of the dynamics of organizational change are noted exceptions because they consider “worldviews” and power simultaneously. However, they treat power as an exogenous factor rather than something

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69 Emerging research on behavioral economics and behavioral game theory has begun to explore these connections. Yet, because these approaches privilege economic explanations, they cannot accommodate processes of socially negotiated meaning. Frames still remain purely cognitive effects. These models incorporate notions of bounded rationality (which often takes the form of cues) and social utility functions (in which incentives are shaped by social interaction) to explain strategic action both within and between firms. The goal of this work has been to ground economics, and game theory specifically, more deeply in cognitive science, where cognition appears in the form of social utility functions (Camerer 2003). These models suggest that even holding beliefs constant, people prefer to make decisions where they have more information (Camerer, Loewenstein, and Weber 1989), that coding systems developed to cope with the limits of bounded rationality can bias strategic choices towards more frequent events (Cremer, Garicano, and Prat 2003), that rather than “rationally” calculating probabilities, individuals update using categories (and can get stuck in categories even when these beliefs run counter to their own interests) (Mullainathan and Thaler 2002), and that social utility shapes choice and is contingent on actions of others (such as whether I know someone to reciprocate or not) (Gilovich 1993). Rotemberg and Saloner (2000) most explicitly address the three problems in strategic choice in combination by modeling the process dynamics portrayed by Burgelman’s qualitative field studies and including a role for management vision. Their model incorporates the idea that CEO interpretations create a context within which middle managers, acting on their own incentives, can make decisions about strategic direction even if these decisions eventually depart from the CEO’s sense of the firm strategy. While provocative, their argument ultimately hinges on incentives as the only mechanism for producing strategic choices, neglecting the possibility that various members of the organization might have different interpretations, and that the resolution of the conflict between them would produce strategic choices.
endogenous to the framing process and do not consider mechanisms for frames to change over time.

Research in the social movements field, in particular that which focuses on framing and frame alignment in societies and communities (Benford and Snow 2000; McAdam et al. 1996; Snow et al. 1986; Snow and Benford 1988; Zald and Berger 1978), provides a model that that may have application within organizations as well. This work suggests that groups coalesce around different views when changes in the environment create political opportunities for action (Gamson and Mayer 1996; Snow et al. 1986). Actors within social movements are “actively engaged in the production and maintenance of meaning,” and the framing process is “an active processual phenomenon that implies agency and contention at the level of reality construction” (Benford and Snow 2000: 613). Proposers (“protagonists”) and challengers (“antagonists”) engage in framing contests in an attempt to shape outcomes. They play out framing strategies to build their own case or neutralize the impact of opponents. These strategies are selected based on the specific issue and the difference of their own frames from those of their opponents. The effectiveness of the strategy determines the degree to which the frames resonate with others (Snow and Benford 1988). The greater the resonance, the greater is the influence on outcomes.

The social movements framing model goes some way to incorporating the interdependencies associated with information ambiguities, multiple actors and incongruent interests. This research suggests that ambiguous information from an uncertain environment is not only subject to different interpretations by different groups, but that it creates political opportunity for new interpretations to emerge and be heard. This view contrasts with a pure cognitivist approach in which bounded rationality is based only on the technical limits of the mind. In this model, individuals and groups not only see the world according to their own frames but engage in purposeful action to shape the frames of others. As a result, power is based on the ability to control the construction of the frames that predominate as strategic choices are made.

Taking these concepts down a level of analysis, I suggest that they can help explain the strategy-making dynamics within firms during periods of discontinuity where interpretations of the market and technology, of the solution and of the means for arriving at a decision can be highly disputed. In this case, the resolution of these disputes occurs in the context of specific
projects and produce strategic choices about technologies. The analysis in this chapter is
designed to draw a model of this framing process from a in-depth understanding of two of
EQUIPCO’s strategy projects.

5.3 Specific methodological considerations for this analysis

The overall approach to the field research that informs this analysis is described in
Chapter 4. Here, I highlight the specific considerations associated with an exploration of
strategic choice-making in EQUIPCO.

5.3.1 Appropriateness of research setting and cases

The industry and company context is particularly appropriate for an analysis of strategic
choice-making under uncertainty. In Chapter 2, I described the evolution of the communications
technology industry and in particular the impact of the fiberoptic revolution. The emergence and
rapid proliferation of optical technologies is tightly tied to the boom in the telecommunications
equipment and components industry in the late 1990s and the subsequent bust in 2000-2002.
Despite this economic downturn, the technologies continued to change rapidly, generating a
great deal of uncertainty and ambiguity. While the bursting of the telecommunications bubble
brought carrier investment in infrastructure to a relative standstill, there was ample evidence that
the pace of technological change had not slowed during 2002 when I conducted my research.70
The ongoing flux and the fact that the industry continued to move at multiple clock speeds (Fine
1998; Fine and Kimerling 1997) at the same time, increased the uncertainty of decision-making
about such strategic issues as technology investments, product design, market segment targets
and business models.71 This “high velocity environment” (Bourgeois and Eisenhardt 1988) was

70 New research continued in areas as diverse as increased photonic integration to reduce packaging problems, to
quantum cryptography, to further breakthroughs in low attenuation and plastic fibers, to quantum-dash lasers and
semiconductor optical amplifiers. See “Optical innovators keep up the pace,” by Tami Freeman, Fibers.org,
February 13, 2003 and “Optical innovators maintain the momentum,” by Jacqueline Hewett and Tami Freeman,
Fibers.org, January 29, 2003

71 For example, there were several competing technologies for next generation products such as filters (thin film vs.
fiber Bragg grating vs. arrayed wave guides), optical switches (MEMS, bubble, liquid crystal and others), and
platforms (e.g., silicon, indium phosphide, lithium niobate, or gallium arsenide). There was also a good deal of
uncertainty around the kinds of technologies that would best meet the needs of the increasingly important metro
(regional) and access (“last mile”) market segments that lagged behind long haul in moving from analog to digital to
optical. And, few in the industry shared an understanding of the nature of the “killer apps” for driving demand
growth in the future.
particularly suited to an analysis of strategic choice-making because there was a threat of obsolescence, the pace and direction were not predictable, decisions to exploit new technologies were usually expensive, and engineering, construction and operating lags reduced flexibility at a time when more flexibility would be desired (Bower 1970).

The economic downturn, which was at its most dire during the period of my fieldwork, resulted in significant layoffs and budget cutting throughout the industry. EQUIPCO was no exception. While the extremity of this situation was certainly unusual for the industry, it acted to heighten the visibility of the features of interest in the strategic choice-making process. Certainly, the stakes were perceived to be higher than in the preceding “bubble” period when resource decisions were made quickly with little oversight and money spent profligately across the industry. And, in the particular case of EQUIPCO, since the CEO and the rest of the corporate executives were involved in short term issues such as layoffs, cost cutting and corporate survival, the ATG organization in which I conducted the field research became the sole locus in the corporation for making longer term technology strategy. These extreme conditions served to bring out the strategy-making dynamics in greater relief than would have otherwise been the case and made the ATG division an appropriate place to examine strategic choice-making about technology.

5.3.2 Analytical approach – focus on the decision as the unit of analysis

As outlined in the previous chapter, my approach to this analysis was open ended and inductive but driven by a broad interest in how firms make strategic choices about investments in technology during periods of high uncertainty (about the nature of the frames about the environment and appropriate response and the role, if any, they played in shaping outcomes). I used ethnographic techniques to study the making of technology investment choices and followed an interpretive approach to understand the generation of meaning by the people within the organization (Gioia and Chittipeddi 1991).

My unit of observation was the project while the unit of analysis was the decision itself.72 In each project, there were myriad decisions made each day regarding which analyses to conduct,

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72 While the analytical approach was to study the decisions as they were produced, these were impossible to identify ex ante. At the starting point of the research, the only evident subject of study was the project and, perhaps, the initial decision to be made. Therefore, the research proceeded by identifying projects to follow in detail. The
which data to use, whom to talk with, etc. I focused on those pivotal decisions in which budget allocations were changed (decisions to invest or to cut funding for particular projects). These decisions were public in the sense that they would be made (or ratified) formally by the management team in review meetings (though they might have actually been made informally at other times). For the purposes of this analysis, I have chosen not to examine other important decisions such as layoffs that affected project composition or the change in staffing of a project (if these had no associated budget implications) because these decisions were not public in the same way, often being made by the senior executive in private without consulting the management team. It is the publicness of the decisions that provoked the framing contests I analyzed (Goffman 1959).

Using the decision as a focal point of understanding management and strategy goes back at least to Barnard (1938). In the context of strategy, Allison (1971) famously used the decision as the unit of analysis to understand government policy in the Cuban Missile Crisis, and there has been some traction in studying decisions in the management literature as well (cf., Bourgeois and Eisenhardt 1988; Papadakis et al. 1998). Using the decision as the unit of analysis is not unproblematic: there are many questions about the possibility of separating intent from decision and action, about the precise locus of a decision, about the possibility of capturing the informal decision rather than the formal ratification, about the risk of decontextualizing the decision, and about the difference between the front stage of visible decisions relative to the back stage of non-decision-making (Mintzberg, Waters, Pettigrew, and Butler 1990). The ethnographic approach I used in my study of EQUIPCO's strategy-making should address many of these concerns by capturing the precise moments when decisions were taken (whether formal or informal), asking people about their intentions, tracking how decisions were produced, and siting the decision within the broader organizational context.

Because the research was focused on the role of cognitive frames in producing these decisions, I analyzed the individuals and groups of individuals who enacted the frames and attempted to get their frames to predominate at the point of decision. Thus, the model I developed incorporates decisions and individuals as well as the interactions between and among

decisions emerged over the course of the evolution of the project. The full list of relevant decisions could only be identified after the period of observation was complete.
them. Specifically, I focused on analysis of frames by person in each decision context in order to understand the sources of the frames and their application in choice-making. In the appendix to this chapter, I describe the steps of this frame analysis in more detail; however, the essence was to identify the underlying elements of each individual’s frames and determine which were salient for a particular decision. As Johnston noted about frame analysis of social movements, "This approach requires the methodological artifice of freezing the ongoing negotiation and emergence of collective action frames in order to take soundings. This is the only way to measure how frames change over time, how much, and how these variations might be related to other factors in mobilization" (Johnston 2002: 66). From this analysis, I was able to map out the frames that were salient for proposers, challengers and members of the Review Board as decisions got made. By taking these snapshots and showing how they changed over time, I uncovered the dynamics that shaped these outcomes. The results of these analyses are presented in the next section.

In order to explain the patterns I observed, I then developed a model that captured the underlying dynamics associated with frames and strategic choice. My analysis followed the principles of grounded theory from cases (Dougherty 2002; Eisenhardt 1989a; Glaser and Strauss 1967; Sutton and Staw 1995; Yin 1984). I used my field notes, transcripts and archival materials to construct time lines for each of the projects covering both the actual events that took place and the different interpretations of those events by the key players in each project at different points in time. These chronologies included detailed information and quotes from the interviews, field notes and archival materials. This level of detail allowed me to locate the key turning points in each project and identify the mechanisms by which they were achieved. Based on the insights generated from the chronologies as well as the emerging themes from weekly memos I wrote while in the field, I developed an initial list of themes and codes for analyzing the data. I coded each element of the chronologies, adding new codes as they emerged through multiple close readings of the data.

Using this information, I constructed the framing contests model by inferring from the field data an understanding of the mechanisms that led to patterns of behavior witnessed during the projects (Glaser and Strauss 1967). I iterated between raw data, emerging themes and the related literature to settle on overarching concepts and how they interrelated in a model. To assure internal validity, I searched for patterns and underlying mechanisms by comparing across decisions to look for differences and understand why the occurred. Once I had developed a
preliminary model of the dynamics associated with the strategy-making in each of the cases, I conducted a series of additional interviews with key informants to validate the themes, iterating further where differences emerged.

In the next section, I present the findings from the frame analysis for the Last Mile and Multiservice projects. In the subsequent section, I present the model of "framing contests" that explains these patterns.

5.4 **Frame analysis – role of frames in strategic choices in two projects**

The analysis in this chapter covers two projects – Last Mile and Multiservice. Each of these projects reflects a different strategic response for EQUIPCO to the crisis in the optical technologies market. Last Mile was a proposal to introduce optical technologies all the way to the end user access point. By increasing the accessible bandwidth for the user, the demand for bandwidth throughout the system would also increase, relieving the glut in the optical core. Multiservice was a proposal to develop a bridging technology that would allow customers to maintain legacy equipment while taking advantage of new optically-enabled technologies in the network. Table 5-1 summarizes the main thrust of the two projects (unit of observation) and the specific pivotal decisions studied in each (unit of analysis).

In the case of Last Mile, the eventual decision was to invest at a level much lower than originally proposed. In the case of Multiservice, the investment ended up substantially higher than initially scoped out. Both of these projects played out as contests between proposers and challengers about the frame that should predominate when the investment choices were made. The proposers advocated an investment in a particular technological arena. These proposals emerged from a set of frames held by the individual or group making the proposal. As the proposers made projects public within the organization in order to get funding, some form of challenge materialized. These challenges arose from a separate and conflicting set of frames. Both groups engaged in framing strategies to mobilize or influence each other and the decision

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73 It was the publicness of the project that made framing contests possible (Goffman 1959). In other projects not covered in this chapter (for example the Savior project which was reviewed in Chapter 4), one way the project leader could avoid a framing contest was to keep the project from the public eye, where "public" is understood to be within the awareness of the decision-making bodies in ATG. On the other hand, in order to get funding, the project would have to be made public at some point. Keeping a project sub rosa was only a temporary strategy.
makers (the members of the Steering Committee and the Review Board). The chronologies of each of these projects was reviewed in Chapter 4. In this section, I highlight the role frames played in shaping strategic choices.

**Table 5-1: Description of the projects studied, units of observation and units of analysis**

<table>
<thead>
<tr>
<th>Unit of observation: the project</th>
<th>Unit of analysis: pivotal decisions (resource allocation decisions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;Last Mile&quot;: Large project to identify market and technical opportunity in access technologies</td>
<td>• Decision 1: Choice to initiate major exploration project in new market&lt;br&gt;• Decision 2: Decision to continue investing in project for another month (continue analysis until the end of August)&lt;br&gt;• Decision 3: Decision to narrow focus to a particular application area, for a specific business unit and product line</td>
</tr>
<tr>
<td>&quot;Multiservice&quot;: Effort to introduce a protocol technology that would allow carriers to offer multiple services to their customers without them having to scrap legacy equipment</td>
<td>• Decision 1: Investment in developing a specific function as an incremental improvement for a specific product line&lt;br&gt;• Decision 2: Decision not to fund larger project due to lack of business case&lt;br&gt;• Decision 3: Informal decision to dedicate resources to the development of the technology (later ratified by steering committee)</td>
</tr>
</tbody>
</table>

To ground the exposition in its organizational context, I repeat the ATG organization chart focusing specifically on the positions and roles of individuals related to the Last Mile and Multiservice projects (Figure 5-1).
5.4.1 Last Mile

The description of the Last Mile project in Chapter 4 highlighted the intense battle of beliefs that took place over the course of the project. Proposers[^74] led by Hugh and later Hermann and challengers including Susannah and Albert disagreed intensely about the basic understanding of the market (e.g., would carriers be willing to pay for new technology?), about the type of solution that would be appropriate (e.g., should optical technologies be part of the answer?) and about the way to arrive at the investment decision (e.g., should the business case or technical logic predominate?). These differences in frames came from differences in each individual’s and group’s different knowledge accumulations from their own experiences in different contexts (e.g., Hugh’s extensive experience with “Widget” technologies, Susannah’s long experience working in the business units). An actor’s beliefs sometimes conflicted with his or her own interests (e.g., Hugh stormed out of the Review Board meeting at the time of the second decision.

[^74]: This was a relatively large project within ATG. Over the course of the effort, more than 10 people were involved on the proposers side and an equivalent amount on the challengers.
in order to protect the project but he ended up minimizing his own role. And, the beliefs and interests were tightly interrelated (e.g., Theresa initially opposed the Last Mile project but eventually believed it should be approved because the team had followed the Steering Committee decision process that she had championed).

As the project progressed, the proposers and challengers each engaged in intense data collection and analysis to support their own positions. Despite massive efforts on both sides, this failed to make much progress in aligning frames. At this stage, the groups each sought other sources of power or legitimacy: the challengers evoked market necessities and the need to follow the Steering Committee process; the proposers lauded their own technical expertise and eventually the desirability of supporting business unit needs. This was accompanied by intense lobbying of members of the Review Board by both sides. After an initial proposal for a multi-million dollar development project, the ultimate decision was to invest in a smaller effort to support a particular business unit. Reframing the project as support for a business unit rather than an independent development project neutralized the opposition to the project.

These framing strategies changed the frames used by the different groups from the first decision to initiate the project to the final decision to invest in a small development effort. Through the frame analysis, I identified seven major frames that were salient in the Last Mile project (the Appendix provides more details of the techniques of this frame analysis): optimism about the access market, pro-optical beliefs about technology, pessimism about the access market, advocacy of a ‘technology first’ stance, focus on the value of business cases, attribution of value to analytical rigor, and prioritizing business unit needs. Grouping the project participants according to their roles either as proposers, challengers or decision makers (members of the Review Board), I find that the salient frames varied both across groups and over time. These frames were not mutually exclusive. An individual could draw on multiple frames in a particular decision context, though one would usually be more salient than others. For example, for the proposers, the “access optimist” and “pro optical” frames were most salient at the outset. Figure 5-2 reports on the emphasis on each frame by group. The percent bars represent the average percent of underlying elements of each frame that were salient for the individuals in the group. Figure 5-2 shows that in the Last Mile project, the proposers started out with frames emphasizing access optimism and belief in optical technologies, while the challengers had not galvanized around much in the early stages.

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Figure 5-2: Last Mile project, frame by group for each decision

Percent of potential frames made salient in each decision

Figure 5-3 shows the net impact of these framing strategies over the course of the project from the first decision to the third. Over time, through the dynamics of the framing process, the technological leadership and responsiveness to business unit needs frames became more salient for the proposers. Meanwhile, the salience of frames emphasizing the lack of opportunity in access markets and in the need for a business case intensified for the challengers. The Review Board members actually had to relax their views about the value of rigorous analysis in order to fund the project; their criteria rested instead on the passion of the team leadership and the value of supporting a business unit. Nevertheless, they only funded the project for a small proportion of the initial request.
Figure 5-3: Last Mile project. Change in salience of frames, Decision 1 to 3.

Change in percent of potential frames made salient in each decision

5.4.2 Multiservice

The description of the Multiservice project in Chapter 4 highlighted a similarly intense battle of beliefs that took place over the course of this project as well. Proposers led by Jack and Edward and challengers including Tom, George and Susannah disagreed about the basic understanding of the market (e.g., would service providers be willing to invest in new infrastructure?), about the type of solution that would be appropriate (e.g., whether the technology should or would be incremental or radical), and about the way to arrive at the investment decision (e.g., should a business unit be on board in order to justify the project?). These differences in frames also came from differences in individuals’ different knowledge accumulations from their experiences (e.g., Tom Rentham’s previous experience in a project that
failed due to lack of business unit support, Jack Stafford's long experience in EQUIPCO Labs and ATG).

The contest played itself out differently than in Last Mile. Jack and his team developed extensive technical data to justify the value of the project. Decision 1 (to spin off a small piece of the technology to a business unit) was relatively uncontested because the logic resonated with everyone. For the second decision, which was a proposal to invest in a substantial development effort, the contest was quite heated. Tom, as the designated member of the marketing team to support the project, was essentially neutral (by his admission) when he began his effort to develop the business case but soon came to oppose the project solely on the grounds that business unit support could not be mustered. So intense were his beliefs that a project was not worth pursuing without an endorsement from the line of business that he refused (as did his successor on the project, George Arden) to engage in further analysis. Jack failed to garner support for the project using his technical data, so the battle moved to other grounds. His boss, Erik Helgesen, brought Edward Fischer onto the project as a co-leader, and this helped the team refocus on alternative frames, such as finding support from an EQUIPCO customer. The success in this pursuit gave the proposers a way to reframe the project as technology leadership for the customer and thus neutralize the opposition. This new framing tied in to another source of legitimacy in EQUIPCO – being "customer facing" – and therefore overcame opposition based on the lack of specific support from a business unit. (Of course, the business units later came on board once the customer had signed on to do a trial.)

For the Multiservice project (Figure 5-4), the salient frames were different from those in the Last Mile project. One significant frame was around the preference for incremental projects that did not require carriers or their customers to install much new infrastructure. This was similar to the "access pessimists" in the Last Mile project. For the first decision on Multiservice, an investment in developing the algorithm for a related niche applications, everyone was relatively aligned in this area. The other major frames were the importance of a business case, the value of the Steering Committee approval process, the value of technology for its own sake, and the focus on responding to market and customer needs.
Moving from the first decision to the second (from a small incremental project to a proposal for a major investment in development) changed the salience of each frame, with less emphasis on incremental action and more emphasis on technical leadership. At this stage, the proposers still believed that the project would be approved on its technical merits in the Steering Committee process. When that proved not to be the case (Decision 2), they strengthened their focus on meeting customer needs. Because Jack Stafford was able to get a customer on board, he was effectively able to neutralize the opposition to the project who had been insisting that it follow the regular decision making rules. Figure 5-5 shows the changes in frames from Decision 2 to 3 (because Decision 1 was essentially a spin off of the project). The challengers decreased their insistence on a fully vetted business case and on business unit support in favor of a belief that technical leadership should win when the customer wants the technology.
5.5 A model of framing contests

The insights from the field data indicate that framing shapes strategic choice in three interrelated dimensions: frames, frame repertoires and framing strategies. First, frames have content: they orient interpretations in a particular direction. This content comes from accumulations of past experience that may be understood to be organized in the form of repertoires. Second, frames can serve as structures in an organization to the extent that they are shared and collectively enacted. Frames are thus both individual and social: they only shape organizational action to the extent that they come to predominate in an organizational at the time a decision is made. Collective frames are enacted in particular decision contexts and are therefore the result of emergent processes of framing. Third, these framing activities can often be purposeful as individuals act to promote their own interests. The interactions associated with these three dimensions are the essence of the model of framing in strategy (Figure 5-6). The frame repertoire is the accumulation of an individual’s past interactions. An actor draws on his
or her frame repertoire to enact a frame within a specific decision context. The interaction of the individuals’ frames with those of others shapes the framing strategies resulting in the collective enactment of a dominant collective frame that informs the decision. At EQUIPCO, the dominant frames were not known a priori in the organization (Fine 1984; Strauss 1978) but rather emerged as products of the framing contests that reflected differences in meaning that the uncertain environment had for the different actors.

**Figure 5-6: Role of frames in strategy-making**

In this section, I examine each of these dimensions of framing in turn in the context of the Last Mile and Multiservice projects. I then explore their interrelationship with interests in order to develop a full model of “framing contests.” This full model highlights parallel but interlinked processes of framing and politics triggered by particular decision contexts that shaped choices about technology investment.

**5.5.1 Frame repertoires and frames**

**Frame repertoires.** People evoked different kinds of frames to give meaning to the uncertainties they faced. These frames were constructed from an individual’s larger repertoire of frame elements (or building blocks) that had built up over time based on personal history. Hugh’s views about the Last Mile project came from the accumulation of his experiences in
EQUIPCO, in ATG (and its predecessor EQUIPCO Labs), in the technical function, in his training in optics and in several “Widget”-based projects. Susannah’s opposition to Last Mile came in large part from her experiences in the business units and in her economic analysis role in ATG though it was also informed by her training in optical technologies. Theresa’s changing views about both Last Mile and Multiservice were the result of shifts in the salience of various elements in her repertoire: her technical training and experience in electronics vs. her experience as the head of the Steering Committee. Frames were bundles of these different building blocks or elements. Actors enacted different frames (bundles of elements) from these repertoires in different contexts. More individual histories are described in detail in Chapter 4 and a detailed list of the specific elements of frame repertoires that were salient in Last Mile and Multiservice projects are listed in the appendix of this chapter. The appendix outlines the multiple sources of accumulations that occur as individuals interacted in multiple different contexts.

The notion of frame repertoires is similar to Swidler’s (1986) concept of cultural repertoires or “tool kits” from which people construct responses to specific situations. In my study, project participants’ frames did not simply spring up randomly but rather were the encoding of previous individual and organizational experiences including individual career histories, project experience, the nature of the technology, individual and group demographics, firm accumulations of capabilities and industry norms (Zerubavel 1997). An individual’s multiple different histories generated knowledge accumulations or stocks of knowledge (Bourdieu 1977; Giddens 1984) that were enacted as a frame in a particular instance. Frames are not the direct result of a person’s training, position in the organization, function, location in a firm or an industry, but rather come from an enactment of the knowledge that accumulates as a result of these factors. In this view, certain elements in repertoires may be shared by dint of the common experiences of individuals but they will be enacted differently by each person.

Where these kinds of accumulations have been explored in the literature, it has been primarily in the research on “thought worlds” which are derived from participation in different functional groups (such as R&D or marketing) and have been shown to lead to conflicts of interpretations during new product development projects (Carlile 2002; Dougherty 1992). It was certainly the case that the functional orientation of the project members in ATG had a strong influence on their salient frames in any particular decision context. However, the findings from my field study suggest a more multidimensional notion of which the departmental or functional
orientation was only one part of the repertoire enacted in a particular situation (Fine 1996). The differences in views I observed were not given by a participant’s function alone but rather drew on the multiplicity of histories (experiences) of each individual.

**Types of frames.** The elements in the frame repertoires do not have direct bearing on the outcomes of strategic choices. Instead, it is in how they are enacted in the concrete situations of particular decision contexts that matters. In examining the specific ways that frames were enacted, I found that the frame elements clustered into three different categories of understanding that mattered in EQUIPCO technology investment choices: the diagnoses of the challenges facing EQUIPCO (including the nature of the environment, the problem definition, the firm’s capabilities); the potential technological solution (including the economic model, the product architecture, the type of technology); and the governance system for arriving at a decision (including who should have power in the decision-making process and what kinds of evidence should be valid). Contests occurred within each category and often across categories. All of these types of frames were important because they affected the response to information, the interpretation of the data, the definition of the project scope and impressions of the viability of a project (see Table 5-2 for examples of these frames).

Diagnostic frames contributed to the participants’ understanding of the problem: whether user demand for bandwidth would increase in a linear or discontinuous manner, whether server manufacturers were customers or competition, whether EQUIPCO could manage the economics of the access business. The managerial cognition literature’s characterization of frames has focused almost exclusively on diagnostic frames including: the environmental landscape (Gavetti and Levinthal 2000; Levinthal 1997), nature of the technical change (Garud and Rappa 1994; Tripsas and Gavetti 2000), the competitive structure (Daft and Weick 1984; Porac et al. 1989; Sutcliffe and Huber 1998), the degree of threat or opportunity, munificence or scarcity in the environment (Dutton and Jackson 1987; Gilbert 2002; Jackson and Dutton 1988), and the firm’s capabilities (Prahalad and Bettis 1986). The cases of strategic decisions about technology

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75 While I derived these categories inductively from the field data, they are consistent with frame analysis done on social movements – e.g., Benford and Snow’s (2000) categorization of diagnostic, prognostic, and action mobilization frames.
at EQUIPCO demonstrate that not only were these factors subject to interpretation but those interpretations varied widely within the organization.

Table 5-2: Typology of frames and examples of disputes in Last Mile and Multiservice projects

<table>
<thead>
<tr>
<th>Type of frame</th>
<th>Description</th>
<th>LAST MILE</th>
<th>MULTISERVICE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diagnosis of the challenge</td>
<td>• The nature of technical change (evolutionary or revolutionary)</td>
<td>• Whether or not EQUIPCO could manage the economics of the access business</td>
<td>• Whether or not service providers would be willing to invest in new infrastructure</td>
</tr>
<tr>
<td></td>
<td>• Threat or opportunity from the market</td>
<td>• Whether demand would increase in a linear or discontinuous manner</td>
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<tr>
<td></td>
<td>• Structure of competition</td>
<td>• Whether or not carriers would be willing to lay new fiber</td>
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</tr>
<tr>
<td></td>
<td>• Munificence or scarcity of resources</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>• Firm capabilities</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Solution</td>
<td>• Incremental or radical technology</td>
<td>• Whether or not an optically-based solution was required</td>
<td>• Whether the project was an incremental, niche opportunity or a radical technology</td>
</tr>
<tr>
<td></td>
<td>• Competence enhancing or competence destroying</td>
<td>• Whether the technology should be developed in-house or outsourced</td>
<td>• Whether or not an optically-oriented solution was appropriate</td>
</tr>
<tr>
<td></td>
<td>• Product architecture</td>
<td></td>
<td>• Whether or not the technology would be revenue and competence enhancing or cannibalizing</td>
</tr>
<tr>
<td>Governance of the decision</td>
<td>• Who has authority to make the decision</td>
<td>• Whether technical experts or market analysis should judge the value of a specific technology</td>
<td>• Whether it was sufficient for the project leader to do a side deal with management or if the Steering Committee and Review Board had the final say</td>
</tr>
<tr>
<td></td>
<td>• What criteria should be used for the decision</td>
<td></td>
<td>• Whether or not a business unit needed to be on board to justify a project</td>
</tr>
<tr>
<td></td>
<td>• What kind of evidence is valid</td>
<td></td>
<td>• Whether technical experts or market analysis should judge the value of a specific technology</td>
</tr>
</tbody>
</table>

In addition to the frames about the environment, frames about the prognosis were also contested. These frames shaped participants’ understanding of the appropriate solution: whether a project was an incremental line extension or a platform for a radical technology, what form a solution should take (e.g., whether a solution was best implemented in hardware or software), whether a project would take advantage of existing corporate capabilities or obsolete them. These frames are consistent with definitions of innovation found in the literature – incremental or
radical (Abernathy and Utterback 1978) and competence enhancing or competence destroying (Tushman and Anderson 1986) – but the disagreements among participants’ interpretations demonstrate that the nature of the innovation itself was not predetermined but rather subject to interpretation.

Frames about the governance system for making choices were also contested in the EQUIPCO projects. These frames shaped the understanding of who had authority to make the decision, what criteria should be used and what kind of evidence was valid. Those people (mainly technical) who had come from the old central research organization tended to want funding to use to follow their “gut feel” about technologies. They wanted to be trusted as experts to make their own decisions without needing to be beholden to anyone. According to one member of the Last Mile marketing team, “They come from an old school of ‘give me a pot of money and let me go.’” Another group of more senior managers who were tasked with changing the processes and the culture to be more focused on venture capital-style investing believed that all projects should go through a rigorous review in the formal decision-making bodies (the Steering Committee and the Review Board) and should not receive investment unless key criteria from a template were met. Another group (primarily the marketing team and several of the senior executives) believed that little funding should be provided to those projects without explicit support from the business unit and a business case to match. In the projects, this often played out as negotiation between beliefs about who had power to make a decision, who should be part of the process, what rules for decision-making should exist and what the agenda for the decision-making meetings should be (Fine 1984). The appendix to this chapter includes a list of all of the frame elements that were relevant for the actors in the Last Mile and Multiservice projects.

Frames in action. Frames were enacted in particular decision contexts. On the Last Mile project, Hugh Collins described his beliefs about the market opportunity as: “Oh my gosh, EQUIPCO has made a blunder by not being in broadband access technologies. We need to get into that space somehow ASAP or sooner.” His diagnostic frame of the market was connected to a solution frame emphasizing the value of optical technologies and a governance frame that technical expertise should predominate in the decision making. Challengers argued that this proposal emerged because people were still in the “bubble mindset,” meaning the mindset during the telecommunications boom of the late 1990’s when companies made massive investments in
new technologies “because they fall in love with technologies because they are cool without considering market realities.” The success of the challengers lay in their ability to both weaken the diagnostic frame and unlink the solution frame from it. While they could not ultimately deny that there were some gaps in broadband access coverage in the market, they were able to reframe it as a set of niche opportunities rather than a wholesale problem. In addition, they established the notion that even if there were some opportunities, the solution did not have to be optical, that “backhoe free” solutions would be preferred. On the other hand, the proposers salvaged the project by moving the governance frame of the decision makers from one dominated by business case logic to one that privileged passion and the potential for technical leadership.

On the Multiservice project, Jack Stafford proposed a technology that he thought would overcome a widespread problem of legacy equipment in the industry. He attributed the resistance to his proposal to the “linear thinking” of the business units and the ATG marketing team: “people cannot get their heads around anything that is disruptive.” Instead, he argued that “technology is gut feel... We have a broad knowledge about what is happening in the industry and the way this technology could help. The question is how to get people to move beyond their mind blocks.” But, the challengers to the project believed that the technology had only niche applications due to its optical focus. From their view, the project therefore had no business case and should not be funded. Success for the Multiservice proposal came when Erik Helgesen insisted that Edward Fischer join the project as co-leader. Though Edward was also (along with Jack) a proponent of “cool technologies,” his background in Silicon Valley startups led him to stress the importance of signing on customers. As a result, he refocused the team’s efforts on engaging a customer in putting the technology in a trial and realigned the frame to emphasize not pure technology but technology leadership for a customer. The success of the challengers in the second decision lay in their ability to question the diagnostic and solution frames of Jack Stafford and his team and to prevail on the decision makers to hold to the governance frame that the formal, Steering Committee process should be followed for major new development project decisions. The Jack’s success in the third decision came from his ability to uncouple the solution frame from the diagnostic one and instead link it to a governance frame that emphasized meeting customers’ advanced technology needs.
Table 5-3: Examples of different elements of frame repertoire made salient by particular project and decision contexts

<table>
<thead>
<tr>
<th>BRAD COPELAND</th>
<th>THERESA VENETO</th>
<th>HUGH COLLINS</th>
<th>JACK STAFFORD</th>
<th>TOM RENTHAM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Job, functional group</td>
<td>Head of ATG</td>
<td>Director, technical group</td>
<td>Senior scientist, technical group</td>
<td>Director, technical group</td>
</tr>
<tr>
<td>Review Board?</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Steering Comm.?</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

**LAST MILE PROJECT**

<table>
<thead>
<tr>
<th>Role on project</th>
<th>Only in job function</th>
<th>Head of architecture sub-team</th>
<th>D1-2: head of project. D3: advisor to head of project</th>
<th>Member of technical sub-team</th>
<th>Member of marketing and architecture sub-teams</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decision 1</td>
<td>Wants a program to look at getting &quot;access to access,&quot; not a major development project.</td>
<td>Only interested in access project to the extent it helps sell other EQUIPCO products; not interested in a product revenue story. Should not look to invent a new broadband access technology. Have to fill out the templates for the Steering Comm. in order to get approval. Requires e-mails from people in the business units</td>
<td>EQUIPCO's &quot;broadband bright!&quot;: need to be in access to have an end-to-end solution. It is an &quot;absolute disaster&quot; not to have a larger presence in access technologies. Solution will be fiber-based (&quot;Widgit&quot; technology). Because &quot;business units have not signed up to a long-term vision that is beyond their radar screen,&quot; ATG has to push new technologies.</td>
<td>EQUIPCO needs an end-to-end solution, but not sure if anything needs to be done by ATG. Wants to see the analysis from Hugh. He thinks that 100 days is not nearly enough. It takes a long time to work with the product groups. And, they have even less than 100 days for a decision to not go ahead if market viability can't be shown.</td>
<td>Carriers will not invest in new infrastructure. EQUIPCO needs an access solution, but &quot;What we do not believe is that we need any development we need to try to do that. It is really a strategic marketing and a strategic channel relationship we need to develop.&quot; &quot;No proprietary solution.&quot; &quot;Need to apply the process...to see if there is a business case for EQUIPCO.&quot;</td>
</tr>
<tr>
<td>Decision 2</td>
<td>Sees the gap in the EQUIPCO portfolio, but &quot;we have to navigate in multiple directions. And, we need to understand where the market opportunities are relative to those directions...and what our core competencies are.&quot; ATG used to be isolationist, now needs to connect better to the business units and the market. &quot;greater magnitude associated with the broader scope decisions than the narrow scope decisions and you have to get it right&quot;</td>
<td>Continued belief that ATG should not do any technology/product development. Interim decision points are not updates but rather go/no go decisions (part of Steering Comm. discipline). Process needs to be taken seriously.</td>
<td>Threat from competition: need to have an end-to-end solution. &quot;And I agree with them that those good old days for putting this stuff in the ground on the assumption customers will use it and buy it, they have gone. But, that does not mean to say we cannot making some use of fibers where it makes economic sense.&quot;</td>
<td>&quot;They did not have clear definition of what it was they were actually doing.&quot;</td>
<td>Similar to previous frame. More emphasis on the need for a business case. &quot;Bottom line, don't think about putting a backhoe in. It is way way cheaper to live with the copper.&quot;</td>
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<tr>
<td>Decision 3</td>
<td>&quot;I want the passion. I want the emotion. I want you to pour your heart and soul into this.&quot; &quot;Recall that at the end of the day my job is to hedge activities for the company and I can't do that with a singular approach.&quot;</td>
<td>Willing to accept a small development project if it is &quot;contained&quot; and if the business unit has specifically asked for it.</td>
<td>ATG's role to provide technical leadership to support business units. Optics may be a part of the solution. &quot;We have to do a more contained&quot; project. &quot;Given we are so publicly out of access and our customers now know we're out of it, we would have to rebuild our credibility with them to get back in. We do not have enough bandwidth to do that with all the other things we got to do.&quot;</td>
<td>Response time is the driver of bandwidth demand so &quot;30 kbps per employee is useless.&quot; &quot;It is not going to be everything copper.&quot; But, &quot;there is a huge amount of competition in this area. And so you do not make a lot of money on it. So it is better to partner with somebody externally.&quot; &quot;The disappointment I have is that they are focusing on the technology and not focusing on who is doing the technology out there and who</td>
<td>[Laid off before decision tabled.]</td>
</tr>
<tr>
<td>Role on project</td>
<td>Only in job function</td>
<td>Only in job function</td>
<td>Only in job function</td>
<td>Head of project</td>
<td>Lead marketing team member</td>
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<tr>
<td>Decision 1</td>
<td>&quot;No brainer.&quot; Interesting technology with specific application in a business unit.</td>
<td>Where there is obvious business unit support, the project should go ahead.</td>
<td>Interesting technology. Should go ahead if the business unit wants it.</td>
<td>&quot;Where you get traction in business unit is where you have a very linear process.&quot;</td>
<td>&quot;Me being in the role, drove home that mindset that we got to actively sell this before it’s finished. We don’t just do the infinite detail and then hope that someone picks it up.&quot;</td>
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<td>&quot;So when the alligators are biting and some business unit needs something done, we will pull resource and put it on that and what will happen is, the larger vision will never get enough resources to get to where it wanted to go.&quot;</td>
<td>His goal is &quot;to get a direct connection to some business unit for a product so that the technology development can be steered to have a better fit to the product.&quot;</td>
</tr>
<tr>
<td></td>
<td>&quot;That’s a really nice bridge technology. That’s the future.&quot; Key is finding &quot;the right place to do it&quot; (right business unit).</td>
<td>&quot;Because you can arbitrarily pick and do many different things and lot of them sounded pretty cool, but if you look at them in terms of what is the likelihood they will make it to market successfully…” “Need to add another dimension, not just the technology but also need the business case to show likelihood that the technology actually get into the market. I told you that you should have waited a few weeks until you had all of the data.” They need to make sure they &quot;go beyond the realm of personal interpretation of the data by getting others to agree to it.&quot;</td>
<td>&quot;It is very significant for few product lines and it certainly helps [key product] penetrate where it wouldn’t have gone before, but I do not think it is earth shattering. Why? Because it is not doing that huge shift of the business epicenter of the company.&quot;</td>
<td>Urgency argument: this is an activity that is moving rapidly in the industry. We can sit back and let others take the lead, or we can exert some leadership. Technical experts should predominate in the decision-making. &quot;Technology is gut feel.&quot; Counter to Steering Committee approach: &quot;They want to have all the ducks lined up before they even start things. All that does is slow down the process. Multiservice is a “disruptive technology.” Marketing and business units have “linear thinking that seems to drive things and anything that is disruptive, people cannot get their heads around it.”</td>
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<td></td>
<td>Continuing focus on business unit needs. &quot;Strong belief that the technology is useful,&quot; but because it is &quot;threatening and cannibalizing to the business units,&quot; should not go ahead with the project.</td>
<td></td>
</tr>
<tr>
<td>Decision 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>[Laid off before decision tabled.]</td>
</tr>
<tr>
<td>Decision 3</td>
<td>&quot;Why is this project being discussed? I thought it was already underway for several months.&quot;</td>
<td>&quot;You’ll be permitted if you get a customer and a business unit saying that their gut saying this makes sense and we are going to support you, so you are not standing alone and therefore you’ve communicated enough and it is tested enough with a few people, we will hedge it, I am willing to hedge.&quot;</td>
<td>Decision-making is &quot;process heavy&quot; and implemented in a heavy handed manner making the technical people feel that they are being micromanaged. Results in “spending hours, weeks, months to generate charts to get through them which is sapping the effort [to work on the projects] because we are spending 20-30% of our time to work the story to get through them.” &quot;This company does not have trust in its visionaries.&quot;</td>
<td>Customer need argument. Customer asked for a prototype, which gives us the justification to go before the investment board. &quot;If you wait around for formal approval, then you never get anything done, because you miss the window of opportunity.&quot;</td>
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</tbody>
</table>
Not every frame element was relevant for individuals in every decision context. And, frame elements could also be integrated into quite different frames. Actors enacted different frames in different decision contexts (and thus different frames were salient). Examining the overlap of people on the Last Mile and Multiservice projects, I find that these individuals drew differently from their repertoires depending on the context (as demonstrated in Table 5-3). For example, for the Multiservice project, Jack Stafford held a view that ATG should develop new technologies rather than outsource them, but for Last Mile he was strongly opposed to internal development. This difference of views held despite the fact that adequate outsourcing options existed for both projects. Similarly, Brad Copeland was focused on the role of ATG as a technology leader in Multiservice but emphasized the importance of a strong economic business case for Last Mile.

5.5.2 Framing strategies

To the extent there were differences in individual frames in these uncertain contexts, contests emerged about the interpretation that should predominate in the decision. It should be clear from the stories of the Last Mile and Multiservice projects that the actors were not the equivalent of “cultural dopes” (Garfinkel 1967) who were simply victims of their own frames. They acted purposefully to shape the frames of others in order to mobilize support for (or decrease the resistance to) the project. Orlikowski and Gash (1994) in their discussion of technology frames introduce the notion of frame congruence based on the difference of one frame from another. Choices about which strategy to use were highly context-dependent. Depending on the congruence of an actor’s own frame from others and the degree of resistance received, engaging in framing strategies was more or less necessary. In the case of EQUIPCO, when frames were relatively highly congruent across all of the relevant actors in a decision, then little opposition surfaced and no framing contest took place (as in the first decision in the Multiservice project to spin out a piece of the technology to support a business unit need). The proposed collective frame thus resonated within the organization and came to predominate as the investment decision was made.

However, given the highly uncertain times faced by EQUIPCO, actors’ frames were not often congruent and framing contests thus surfaced. Given strong differences in views within the organization, the proposers and challengers were not able to impose their own set of frames on
the decision-making process, at least not without contestation. Instead, they engaged in a framing process where they attempted to neutralize the opposition and sway the decision makers in their favor (Fine 1984). Both sides employed a number of framing strategies. Each endeavor to shape the frames associated with a decision was met with counterframing — "attempts to rebut, undermine, or neutralize a person's or group's myths, versions of reality, or interpretive framework" (Benford and Snow 2000: 626) — from the opposing side. At EQUIPCO, these framing and counterframing strategies took place in three iterative phases: credibility battles, legitimacy battles and (re)aligning frames. Each actor’s goal was to achieve a degree of resonance that mobilized support for a particular view. Figure 5-7 is a schematic of the dynamic of framing strategies that highlights the important relationship between the degree of congruence and the presence of contests. These framing strategies have political overtones which I shall discuss in the following section. For the moment, I will focus on how these kinds of strategies were aimed at shaping a collective frame that would predominate as the investment decision was made.

**Figure 5-7: Framing strategies**

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**Credibility battles.** As an engineering organization, the first recourse was often to the data. Many studies of engineering cultures highlight the deep belief in rational analysis and data (Bucciarelli 1994; Kunda 1986). Consistent with this view, people in the ATG organization of EQUIPCO noted that the company "is an engineering organization with engineering values and
engineering analysis. You have to persuade people analytically.” The battle most often began here. Much as convincing with data was the first real framing strategy used, the first line of defense was to challenge the credibility of the data. Challengers often engaged in counter-framing along these dimensions. In the Last Mile project, Hugh started with a 238-page PowerPoint document examining all of the technical facets of the project. The marketing team worked long hours late into the night for several weeks to provide a counter analysis showing, as they claimed, that the market for optical access technologies was not sufficient to justify an investment. Hugh then launched an analysis of true copper capabilities in order to “debunk the debunkers.” In the Multiservice project, Jack asked the marketing team to develop a business case to support his project. When neither Tom nor George could find data to support the case, Jack developed his own numbers, accusing the marketing team of “linear thinking.”

The credibility battle often ended in impasse as the “facts” became extremely malleable in the hands of the proposers and challengers. In one discussion in the Last Mile project, the group could not even agree on the correct interpretation of a single chart about DSL (digital subscriber line technology for bringing high speed access to the home over phone lines) market growth rates that they all were viewing simultaneously. Some saw the data as suggesting that DSL was growing rapidly and others argued that it was flat or decreasing. When Albert Lee of the marketing team used his data to argue that “build it and they are going to come and pay for it’ is completely discredited,” Edward Fischer responded “this is a lot of good work, but I have to disagree. I think we can count on a disruption in the next 2-3 years. I have been doing my own calculations.” The conclusion of many of these meetings was to go out and gather more data to resolve these kinds of disputes, but it became obvious to many that, as Hugh suggested, people will find the facts to make a project look like a “dog” or will find the “golden nuggets.” As a result, the contest in frames moved to battles over legitimacy of claims and claimsmakers.

**Legitimacy battles.** When the use of data failed to persuade, proposers then turned to framing strategies aimed at increasing the legitimacy of their own claims and/or decreasing that of others. These efforts were essentially attempts to find a basis of power, either through
expertise, position, or reference to other powerful actors or cultural values.\textsuperscript{76} In both projects, the project leaders argued strongly for the power of expertise. This is also consistent with the cultural values of an engineering organization (Bucciarelli 1994; Kunda 1986; Vincenti 1990). Hugh insisted that those “who spell ‘access’ with a ‘k’” should not have a claim to influence the decision on the Last Mile project. This was an attempt to both legitimize his view and delegitimize that of the challengers. Jack also continually referred to the “linear” thinking of the business units and the market team, claiming that this was “undermining the creativity” of the technical team. They both refused to acknowledge the expertise of the members of the marketing team in their own domain (market analysis). Each side attempted to call on important values within EQUIPCO, either old ones (e.g., Jack’s continual reference to the role of ATG as the source of EQUIPCO’s thought leadership) or new ones (e.g., the Last Mile marketing team’s insistence that EQUIPCO no longer placed primacy on optical technologies).

Both proposers and challengers sought out positional legitimacy by lobbying Brad and other Review Board members in “backroom discussions.” In the Last Mile project, Hugh met separately with Brad in an attempt to get him on his side in order to legitimize his claims in the second decision meeting. Susannah legitimized her stance by getting Theresa, as the head of the Steering Committee, to insist on giving a hearing to the marketing team’s point of view. In the Multiservice project, Theresa registered her view that the Steering Committee process was indispensable by getting Jack’s boss, Erik Helgesen, to force Jack to bring the project up for review. Finally, the battles were often won by achieving referent power, either by the proposers who identified a business unit or a customer to support their views or by challengers who insisted that none could be found.

(Re)aligning frames. The projects often reached conclusions when one or the other side found a way to reframe the effort. The literature on frames in social movements has focused extensively on this aspect of framing strategies. It argues that individuals in social movements engage in goal directed efforts to align frames about a particular issue within society (Benford

\textsuperscript{76} These are largely consistent with the sources of social power identified by French and Raven (1968): reward power and coercive power can both be seen as a product of position, referent power, expert power and legitimate power (through reference to cultural values).
Benford and Snow identified different sets of activities aimed at expanding or changing the frame to encompass viewpoints held by either neutral groups (the audience) in order to mobilize their participation or by opposition groups in order to neutralize their stance (Benford and Snow 2000). Observations of the strategic choice-making process at EQUIPCO indicate that these types of activities were essential to project outcomes but occurred alongside battles for credibility and legitimacy.

Hugh Collins started out selling the Last Mile project with a vision of EQUIPCO as a company that needed to live up to its “broadband birthright,” arguing that it was an “absolute disaster” not to have a larger presence in access technologies. He claimed that if EQUIPCO was going to stake its territory as a network company, then it needed to be in all parts of the network. This line of reasoning did not galvanize many people to his side, so he expanded it to include the notion of a competitive threat: EQUIPCO was losing bids to other competitors because it did not have a full portfolio. He put off some initial opposition by insisting that the project would be to seek out “access to access” (meaning identifying potential outsourcing candidates for the technology) rather than developing it fully internally. It wasn’t until much later in the project that the project was reframed as a business unit support effort and succeeded in galvanizing additional support (and neutralizing the opposition). Similarly, when the “technology first” frame didn’t resonate in the early stages of the Multiservice project, Jack attempted to reframe the project as necessary to meet the competitive threat coming from startups in this technical arena. He was more successful later when, teaming up with Edward Fischer, he extended the frame to focus on meeting customer needs. He coupled this with his own version of the business case that demonstrated he had followed the templates required by the Steering Committee. He thus effectively increased the resonance of his own frame about the project and neutralized the opposition.

Table 5-4 gives examples of the different types of framing and counterframing strategies undertaken by actors in the Last Mile and Multiservice projects. These framing strategies tended to move in phases, usually starting with credibility battles over data, moving to legitimacy battles over claims and eventually to realignment of frames. The phases were, however, quite iterative.

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77 Frame bridging, frame amplification, frame extension, and frame transformation.
Legitimacy battles often provoked new analysis of data. Realigning frames was primarily a
search for alternative sources of legitimacy. The framing and counterframing efforts had a
polarizing effect. While often combative, the process helped narrow the points of contention and
made reframing more likely to be effective because it was aimed precisely at these points of
difference.

Table 5-4: Framing (and counterframing) strategies

<table>
<thead>
<tr>
<th>Framing strategy</th>
<th>Credibility</th>
<th>Legitimacy</th>
<th>Alignment</th>
</tr>
</thead>
</table>
| Last Mile        | • Hugh’s 238 page PowerPoint document  
|                  | • Response from technical team to marketing team: ”We think you did good work but we don’t believe it.”  
|                  | • Do the copper analysis to “debunk the debunkers”  
|                  | • Marketing team “circles the wagons” to make sure that individual analyses can’t be picked apart  
|                  | • Edward launches effort to gather more data on “killer apps” that will drive nonlinear demand increases (after Albert argues that he can’t find any data on killer apps)  | • Expertise: claim that those “who spell ‘access’ with a ‘k’” should not have a claim to influence decisions  
|                  | | • Values: Marketing team argues that industry no longer values optics  
|                  | | • Positional: Susannah holds numerous “backroom discussions” with Theresa to force the project through the Steering Committee process  | • Theresa pushes study to focus on “supporting existing businesses” not “new revenue”  
|                  | | • Positional: Hugh walks out of review meeting  
|                  | | • Referent: Hugh attempts to argue that customers require an end to end solution  
|                  | | • Referent: Hermann and Hugh “stage a coup” to seek out support from business unit  | • Hugh claims that he is only doing a study to get “access to access” (rather than building the technology internally  
|                  | | | • Marketing team focuses on requiring a “backhoe free” solution  
|                  | | | • Switch in description of project from “broadband birthright” to “absolute competitive disaster” not to have a presence in access  |
| Multiservice     | • Jack’s initial detailed analysis of Multiservice technologies  
|                  | • When Jack wants unsupportive the business case revisited, George refuses  
|                  | • Jack argues that marketing team uses “linear” thinking and therefore the numbers are not representative of the real opportunity  
|                  | • Jack eventually puts some numbers together to support the case  | • Expertise: Jack argues that technical expertise should dominate marketing views (as it had in the old days)  
|                  | | • Values: Jack makes continual reference to the role of ATG as a technical leader  
|                  | | • Positional: Theresa gets Jack’s boss (Erik) to insist the project follow the Steering Committee process  
|                  | | • Referent: Tom argues that he cannot identify any business unit to support the project  
|                  | | • Referent: Jack and Edward identify a customer (a carrier) to support the project  | • When the technology first frame doesn’t resonate, Jack makes early attempt to sell project as a response to competitive threat  
|                  | | | • Later shift from competitive threat to customer need  
|                  | | | • Theresa attempts to reframe project as “exploratory” so that additional reviews will be required  
|                  | | | • Edward reframes project as radical technology but with implementable incremental steps  |
These framing strategies are not simply about individuals making convenient arguments in order to get their projects approved. People don’t “sell” a particular viewpoint unless they have it at least as a latent element in their frame repertoire. For example, it wasn’t until Edward Fischer was brought on to the Multiservice project that a realignment of frames to focus on customer support was possible. Jack Stafford had continued to push the pure technology frame (and its counterpart which emphasized the lack of relevance of marketing data). Even when he was unsuccessful in getting funding, he did not have the appropriate elements in his repertoire to reframe the project. Adding Edward Fischer and introducing the team to new frame elements had the effect of expanding the frame repertoire of the proposing team.

5.5.3 Frames and framing strategies intertwined with interests and political strategies

This chapter started out with an essential question about the interrelationship of frames, multiple actors and incongruent interests. The framing model that I have developed so far only directly addresses the first two of these questions. Yet, understanding the framing dynamics alone is not sufficient. I argue in this section that the stories of the Last Mile and Multiservice projects show that the framing processes were tightly intertwined with interests and political processes. My observations suggest that framing and political processes operated in a similar fashion: a decision context triggered a set of salient interests from a broader repertoire of interests; the interaction of these interests with others’ provoked political strategies aimed at mobilizing support. But, more than these framing and political processes being parallel, the cases I studied demonstrate that they interacted with each other in a reciprocal manner at every stage of the process. Below, I explore the ways in which the frames and interests were mutually constituting and that framing and political strategies were often inseparable. I will show how they worked together to produce a dominant collective frame that shaped the strategic choice.

First, I argue that pursuit of interests alone cannot explain the actions of individuals in their attempts to shape outcomes of projects. When Hugh stormed out of the second decision meeting for the Last Mile project, it could be argued that he was acting purely on his interests to keep the project alive and not on his belief that this project was the right thing to do. Yet, he got removed as project leader. Was this simply the case that he could not anticipate that the outcome would run so deeply counter to his interests? This would be the kind of argument suggested by Milgrom and Roberts (1988; 1990): influence strategies bring potentially unanticipated costs. In
support of this case, Hugh admitted upon reflection that, “It came to my mind that I am not politically sensitive in this way.” But, the story is more complex than that. This wasn’t the first time Hugh had been removed from managerial responsibilities. Brad had already changed Hugh’s position to that of “individual contributor” in the organization rather than a Director with a team of engineers reporting to him. Hugh may have been revered for his technical contributions to the industry and his impressive record of patenting, but he had been told that he was not as effective in running projects. In an organization where “people are power,” this gave Hugh every incentive to remain at the helm of the Last Mile project. It was also an organization in which dramatic displays of emotion were uncommon and no one could remember a situation when someone had walked out of a meeting in anger. Finally, this took place in the context of multiple rounds of layoffs. Hugh could not personally risk being asked to leave EQUIPCO as the near totality of his retirement savings were invested in EQUIPCO stock which was worth one penny on the dollar at that point. Therefore, the fact that he did take this action speaks to the strength of his belief in the access project in optical solutions.

The notion of interests in the context of ATG strategy-making must be defined rather broadly (well beyond monetary incentives, of which there were very few during the financial crisis that EQUIPCO faced). Much as individuals had a repertoire of frame elements, they also had multiple, sometimes conflicting interests, only some of which got activated by a particular decision context (Table 5-5). Interests ran from the tangibly beneficial (preserving one’s job, getting a promotion, commanding a larger number of resources), to the more intangibly beneficial (being seen as an expert or a truth teller). Some interests had a group aspect to them (contributing to the project team, supporting one’s own functional group, or making ATG look good in the EQUIPCO organization). Sometimes different interests were at odds with each other. When Hugh left the Last Mile decision meeting mid-stream, he was acting on his interest in being a truth teller and expert but against those of commanding more resources. When Tom Rentham refused to support a business case for the Multiservice project, he was seen as a team player by the marketing group but not by the project team.
Table 5-5: Types of interests displayed by members of the ATG organization

<table>
<thead>
<tr>
<th>Interest</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Be seen as an expert</td>
<td>The main “motivator is peer recognition.” “You want to see your idea pursued.” It is the “propagation of intellectual capital...in a school for gifted children.”</td>
</tr>
<tr>
<td>Get a patent</td>
<td>Important award ceremonies to celebrate patent applications and patent grants. Plaques and certificates line the walls of the engineers’ offices or cubicles.</td>
</tr>
<tr>
<td>Preserve job</td>
<td>Many people laid off during the cost cutting. Everyone trying to get on projects that will make them look indispensable. “Right now, the people would likely be laid off if they didn’t have this project to work on.”</td>
</tr>
<tr>
<td>Support own group (project, function or organization)</td>
<td>For people in marketing, “there is probably more value given by individuals to somebody else in the business team thinking what you did is good than somebody in the technology team.”</td>
</tr>
<tr>
<td>Get a promotion</td>
<td>Becoming a director has historically been very high prestige in the ATG (and EQUIPCO Labs) organization.</td>
</tr>
<tr>
<td>Command resources</td>
<td>“People are power in this company...More decisions are made in your favor if you have more people.”</td>
</tr>
<tr>
<td>Work on cool projects</td>
<td>“What motivates people is the ability to work on something, opportunity. Money is secondary to most engineers. We are looking for intellectual stimulation.”</td>
</tr>
</tbody>
</table>

The fact that actors had multiple, sometimes conflicting interests begs the question about how one or another interest became salient in a particular context. In the Last Mile and Multiservice projects, I found that it was the interaction between frames and interests that explained which interests would be salient just as the interaction also affected which frames would be salient in a particular decision context. Individuals’ interests and frames shaped each other. Given that people had multiple interests and multiple potential frames (based on their frame repertoires), the interaction of frames and interests affected salience. Tom’s interest in supporting the values of the marketing group triggered the salience of the “business case” frame for him in the Multiservice project. Reciprocally, his previous experience on a technically credible project that failed due to lack of business unit support produced a “mindset that we’ve got to actively sell this before it is finished” and an interest in only supporting projects with business cases. Given Hermann Meier’s training as an optical engineer, he was more likely to see optically-based solutions as the most appropriate for solutions to broadband access on the Last Mile project. On the other hand, an optical solution for the project would help preserve his
job at a time when investments in optical technologies were decreasing. In Theresa’s case, her initial frame was that there was no market for access ("access pessimist"). However, she had a strong interest in supporting the formal decision-making process that she had helped establish (as head of the Steering Committee). Therefore, once the team was able to meet the key criteria established as part of the Steering Committee process (namely, finding support from a business unit), her later frame was supportive of the project.

A retelling of the Last Mile story could interpret the "pro access"/"pro optical" stance as one about a self-interested desire to preserve jobs and maintain status. At the time of the initiation of the Last Mile project, ATG had just made a substantial cut in another major optical project. As Albert Lee, a member of the marketing team, reflected later,

"The cynical view is that the project got invented because there was nothing else for these [optical] people to do...They asked, 'what question can I construct to preserve my job, my people and my optical playground...?' [But,] the other unsaid piece is that there is a hope that if we save more of the optical people and their expertise, the optical market will come back in a few years. The view is that we will need these people, and we will save the company, because we just completely believe in it. I will not say it is a religious thing, but it is a really intensely felt all-the-way-down-deep-in-the-soul type of thing that this is the right thing to do."

At first glance, these responses would appear to be about raw interests alone: people supported projects if the alternative might not include them and therefore put their jobs at risk. Yet, I argue that much of people’s perceptions of job alternatives were driven by their ability to envision alternative futures. The framing of the environment and the technology got interpreted in terms of personal interests. In an era when layoffs were rife throughout the EQUIPCO organization, people did not want to frame a situation in a way that was inconsistent with individual or group interests. For example, resistance to the previous cuts in the optical program only diminished when the optical engineers saw that new projects, such as Multiservice or Last Mile, would provide other project opportunities that people could fit themselves into, as Terrence Smith suggested:

"Within the technical team, we have a lot of very smart guys that could be deployed in a number of different ways. They resisted closing down the Lightwave project, but we only laid off four people from that group. So, it is not like we trashed half the people. We have a handful of world class photonics people, so now we ask, 'what would you really like to do?'"

Different framings supported different factions or different interests.
Second, I suggest that framing strategies were tightly intertwined with political strategies. Consistent with research on issue selling (Dutton and Ashford 1993; Dutton, Ashford, O'Neill, Hayes, and Wierba 1997), promoting an idea in an organization has important political considerations for the individuals involved. Political strategies for influencing outcomes took very much the same form as the framing strategies – credibility, legitimacy and realignment (Eisenhardt and Bourgeois 1988; Stevenson and Greenberg 2000) (see Table 5-6 for a comparison for both projects). Hugh’s “trust me, I’m right” strategy at the initiation of the Last Mile project was seen as much an attempt to “bulldoze” the project through as it was to influence the way others saw the opportunity. His early data gathering effort that produced a 238-page PowerPoint document was both an attempt to convince people with data and to overwhelm challengers with information to the point where they would be incapable of responding. Using data to convince often came up against challengers who found that the data were not convincing. The facts were “slippery” in the hands of different people with different interpretations. Frustrated that the framing strategies were meeting with overpowering resistance from challengers, proposers turned to more overtly political actions such as subverting the process, lobbying decision makers or seeking side deals.  

In the Last Mile project, the “coup” staged by Hugh Collins and Hermann Meier not only had the effect of giving them time to build their case that access technologies had a business logic but also pushed the marketing team at least temporarily out of the decision process. In addition, it brought in the trump card of direct business unit support for the project. On the Multiservice project, Jack Stafford gave up on getting approval through the normal decision channels and instead focused his attention on getting support from a customer. He ultimately resorted to a side deal with his boss when he could not get formal approval through normal decision-making channels. These actions were primarily about locating a higher source of power to support the project. This power could come from a business unit (as in the Last Mile project) or a customer (as in the Multiservice project).

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78 Using Eisenhardt and Bourgeois’ definition of politics in strategy-making… “Politics are the observable, but often covert, actions by which executives enhance their power to influence a decision. These actions include behind-the-scenes coalition formation, offline lobbying and cooptation attempts, withholding information and controlling agendas. Politics contrast with the straightforward influence tactics of open and forthright discussion, with full sharing of information, in settings open to all decision makers.” (Eisenhardt and Bourgeois 1988)
Table 5-6: Examples of framing strategies and their political aspects

**LAST MILE**

<table>
<thead>
<tr>
<th>Framing strategy</th>
<th>Example activity</th>
<th>Framing aspect</th>
<th>Political aspect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Credibility</td>
<td>At start of project, Hugh develops 200+ PowerPoint deck of data</td>
<td>Provides detailed data supporting his view</td>
<td>Makes it difficult for challengers to argue against him unless they invest substantial time in “debunking”</td>
</tr>
<tr>
<td>Legitimacy</td>
<td>Hugh argues that he knows access better than others</td>
<td>Lends credibility to his position that EQUIPCO needs an access offering and that ATG can develop one</td>
<td>“Trust me, I’m right” seen as a bullying tactic of a senior scientist</td>
</tr>
<tr>
<td>Alignment</td>
<td>Before Decision 3, Hugh and Hermann “stage a coup”</td>
<td>Gives them time to develop a new way of framing the project (business unit needs)</td>
<td>Avoids the input of the marketing subteam</td>
</tr>
</tbody>
</table>

**MULTISERVICE**

<table>
<thead>
<tr>
<th>Framing strategy</th>
<th>Example activity</th>
<th>Framing aspect</th>
<th>Political aspect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Credibility</td>
<td>Tom does not develop a business case document for the project</td>
<td>Supports his view that there is not business unit demand and that a project should not be approved unless a business case exists.</td>
<td>Reinforces the power of the Steering Committee. Supports Tom’s position as a neutral arbiter.</td>
</tr>
<tr>
<td>Legitimacy</td>
<td>Jack meets with Brad to explain the technology and show its potential.</td>
<td>Builds enthusiasm for Multiservice as “the next big thing.”</td>
<td>Brings in support from the head of the group.</td>
</tr>
<tr>
<td>Alignment</td>
<td>Seeking out support from an EQUIPCO customer</td>
<td>Reframes the project as meeting an important customer need</td>
<td>Makes it difficult to reject project given visibility with a customer</td>
</tr>
</tbody>
</table>

Where disputes in meaning occurred, they often led to an escalation of commitment in which team members became increasingly intransigent. Escalation of commitment was also tightly linked to interests as it resulted from attempts at self justification or preservation of position (Staw 1976; Staw 1981). Polarization in frames increased the likelihood of side deals where the decisions often got made. For those at the headquarters location, this meant circling the halls of the building where the senior executives sat with the explicit plan of catching the eye of one of them through the glass walled offices and getting a minute to pitch a case. Disagreements about frames did not tend to occur in productive debates but instead were personalized. People in the organization talked about decisions against projects that they had championed as personal embarrassments. It was easy to tell who "owned" a project by how defensive they were when it was discussed in a group. The attacks on viewpoints were often perceived as “vitiolic.” In the Last Mile project, Hugh Collins got so angry at the challenges...
and questions that he stormed out of the room in a critical decision meeting. One of the senior business executives who was challenging the proposal described it this way: “suffice it to say, he walked out on me.”

In summary, the framing of a project shaped and was shaped by the interests of the various actors. Different frames activated different interests. Interests not only shaped the frames that people brought to a situation but were also the outcome of the framing process itself in which interest formation was itself a sensemaking activity. Reaction (either support or challenge) to a proposal was regulated by the effect that the proposal could have on the interests of the individuals involved. While it is true that individuals and groups on the Last Mile and Multiservice projects acted to advance their interests, the evidence suggests that these interests were interpreted through their frames.

This process was recursive. Not only did frames set the stage for framing contests, but the outcome of the contests in turn shaped the frames held by the participants (Hunt et al. 1994). For example, after the main decision emerged in the Last Mile project (in which only a limited budget was provided but “Widgets” were included as a potential solution) each side claimed to have gotten what it wanted. The business team members claimed that they were never “anti-Widget” per se, and just wanted the size of the investment to be in line with the size of the opportunity (even though they explicitly stated anti-Widget sentiments at earlier stages). The technical team said that they had been proposing this focus all along, even though a review of earlier documents revealed that they had initially requested a much larger scope with large in-house development. Once the outcome was known, they adjusted their frames to be consistent. Susannah Watts of the marketing team claimed, “We boxed them into this box. It is basically... three full time resources for three months. I do not even give a damn if they build a Widget at this stage, we have prevented them from starting out another all-singing-all-dancing stealth project that is another optical program by any other name, which was the objective that we went in with.” Hugh Collins claimed, “They finally went where I wanted to go six months ago.”

In Figure 5-8, I present the full model of framing contests that integrates frames and interests in the process of making strategic choices about technical investments.
In this model, cognition matters not as a static “frames” but rather as social process of framing. Individuals have repertoires of both frames and interests, elements of which are made salient in the particular decision context. These frames and interests are mutually constituting. Individuals and groups engage in influence strategies (both framing and political strategies) based on the degree of congruence with the frames and interests of others. Different influence strategies can be undertaken for both framing and political purposes, and often these are empirically inseparable. The ability of influence strategies to get frames to resonate and to mobilize action determines which collective frame and set of interests predominate as the choice is made. This process is recursive at all stages: influence strategies can reshape the decision question posed or alter the salience of frames and interests. Similarly, the decision outcome alters the future questions, frame and interest repertoires and influence strategies used.

The framing contests that took place over the course of the Last Mile and Multiservice projects were often full of conflict and emotion. This led to longer decision making processes than many felt were desirable. Research in strategic management has suggested that fast
decision speeds lead to better performance (Baum and Wally 2003; Eisenhardt 1989b). But, Brad’s perspective as the head of the ATG organization was that the conflict was necessary. Just after Hugh stormed out of the second Last Mile decision meeting, Brad said,

*This is not easy. It’s hard. Access is catalytic to the success of the company. So, if there was an easy decision and no pushback, I would be very concerned. But, the fact that there is such emotion and such variety of opinion is a clear and positive indicator that this is an absolutely critical deliverable for the company. I would be worried if [the tension] were not there.*

The conflict appeared to be a vital part of the strategy-making process when frames about the future differed and the stakes were high. While it will likely be many years before it can be known if the decision to invest in Last Mile enhanced EQUIPCO performance or not, from the perspective of the participants, the longer decision-making process that resulted from the resolution of conflicts in frames was essential.

5.6 Conclusion

In this chapter, I have attempted to explore the role that cognitive and collective frames played in shaping strategic choices in the case of two ATG technology projects. I have pursued this task by addressing the ways in which interpretations (frames) of information ambiguities and potentially incongruent interests were interrelated and how this played out across multiple actors (with different frames and interests). I have elaborated a model of framing contests in which these factors operate interdependently. This model was built on six observations. First, actors have a repertoire of knowledge accumulations (frame elements) based on their experiences across multiple different contexts. Second, frames are enacted by individuals in particular decision contexts (projects) drawing on these frame repertoires. Third, to the extent that there is incongruence in frames related to a project, individuals engage in framing strategies with the objective of increasing the resonance of their own frame in the organization. Fourth, frames and interests shape each other. Understanding either frames or interests alone is not satisfactory. The framing and political strategies in which individuals engaged to pursue these frames and interests were analytically but not always empirically separable. Fifth, as a result of these framing activities, the salience of different frames changed over time in the context of a particular project or across projects. Sixth, and most importantly, this process resulted in the enactment of a predominant collective frame at a particular time and place.
This study of EQUIPCO’s strategy-making is limited in its scope. Because it focused on one firm over the short period of eight months during the particularly extreme situation of a complete market crash, any generalizations should be made carefully. ATG’s relatively democratic decision making process, the high stakes nature of the decisions at hand and the highly uncertain market with the accompanying widely diverging interpretations of it, likely made the framing contests I investigated particularly dramatic. Yet, taken together, the six observations above suggest some extensions and clarifications of our understanding of managerial cognition and of strategy-making.

This perspective frames and framing is a significant departure from the way cognition has been construed in the managerial cognition literature. The results from this study move beyond the unidimensional, social psychological sense of cognition as an aggregation of individual views to an interactive and dynamic process of meaning construction (Gamson 1992). Looking at strategy-making in this way opens up the possibility for examining cognition not simply as “frames” nor even as a situated process of “framing,” where cognition is collective in that it is the product of interactions among people (Kogut and Zander 1992; Lave 1988; Lave and Wenger 1991; Orlikowski and Gash 1994) but as a politically charged and self-conscious process for negotiating meaning (Gamson 1992; Hall 1982). The frames that I measure in the frame analysis are simply “snapshots” that are an artifice required for analysis but do not capture the dynamic of the actual framing process (Oliver and Johnston 2000). Any representation of a firm-level construct measuring cognition would only be the product of the negotiated outcome from the diverse internal views leading to a collective frame. Framing is purposeful in the sense that individuals and groups develop implicit or explicit framing strategies to shape the outcomes of investment decisions, and it is contested in the sense that the frames of different groups often come into conflict (Benford and Snow 2000). This view contrasts with the pure cognitivist approach in which knowledge is a context-free, “factual” construct and bounded rationality is based only on the technical limits of the mind (Simon 1947). In this setting, frames about the diagnosis of the challenges, the nature of the solution and the governance of the decision were contested. Projects became the locus in which these framing contests played out. Framing contests are the means by which conflicts in individuals’ cognitive frames are resolved to produce a predominant collective frame.
The role of cognitive framing can only be understood by connecting it to multiple actors and their interests. In the Last Mile and Multiservice projects, many people were relevant in producing strategic choices, and groups of proposers and challengers coalesced to advance their own perceived interests and frames. They engaged in political and framing strategies to influence the decision outcome. Power was based on the ability to control the construction of the frames that would predominate as strategic choices were made. These choices then “resignify which set of collective beliefs are salient, and alter the meaning of actors’ interests” (Ellingson 1995). This process is not just about senior management engaging in both “sensemaking” and “sensegiving” (Gioia and Chittipeddi 1991) but instead about people at multiple levels of the organization enacting frames in framing contests in which the “sensegiving” process itself is problematized. This model of framing contests adds a sense of purposeful action to cognitive frames that is absent in all but the social movements literature on framing. Further explorations might focus on understanding the specific ways individuals deploy frames depending on the audience, forum or other larger contextual issues (Creed, Langstraat, and Scully 2002) and also examine how much difference in frames creates enough incongruence to trigger a framing contest (Orlikowski and Gash 1994).

The work of the Carnegie School deserves a special note here, as it is a natural alternative explanation for strategy-making under uncertainty. This stream of research introduced bounded rationality (March and Simon 1958) and its relationship to strategic choice in conditions of ambiguity (March and Olsen 1976). Their model of strategic choice-making is one of shifting coalitions of individuals pursuing their own interests (in a boundedly rational way) through processes of bargaining and negotiation. Indeed, there are several similarities between the portrayal of framing contests in this chapter and the garbage can model in which choices look for problems, issues look for decision situations, solutions look to be an answer, and decision makers look for action (Cohen, March, and Olsen 1972). In the Last Mile and Multiservice projects, it is the case that individuals shifted frames in order to achieve desired objectives, and individuals acted based on the accumulations of their whole previous histories. Interests were ill-defined. In some cases, people had solutions looking for projects (Hugh’s interest in the “Widget” technology is a case in point). Projects for making strategic decisions were also somewhat fuzzy in character in that there were no clear beginning or end points (as they all had long provenances and often continued on into other projects over time).
Yet, the Carnegie School’s models do not satisfactorily account for the purposeful action of individual agents and groups, the strategic nature of their interactions nor the rich characteristics of the frames. This tradition has in fact been criticized previously for “a notion of the human actor so impoverished as to preclude any possibility of independent agency” (Whittington 1988: 530) and for the abstraction of the actor from social dynamics (Whitley 1977). In the garbage can model, actors are not strategic about their interests. And, while the model does recognize that differences of interpretation exist, it ignores the potential conflict among the agents (Eisenhardt and Zbaracki 1992). The stories of the Last Mile and Multiservice projects are rife with actors deliberately acting to pursue their interests in ways that reshaped their own frames and others, often in highly conflictual processes. While the garbage can model does account for accumulations of experience, this is deployed in a ‘stimulus-response’ mechanism rather than in the social process of meaning negotiation that I observed.

Eisenhardt and Zbaracki (1992) point out that the patterns described by the garbage can model are more evident over longer time frames and with fewer deadlines. In that case, the eight month study at EQUIPICO in a context where deadlines mattered tremendously may not provide an adequate test of this alternative hypothesis. This study of EQUIPICO strategy-making was not designed to address the garbage can model explicitly, and thus, while the findings indicate that this model would not accommodate the dynamics observed, it remains an open empirical question to see exactly how the models – of the garbage can and of framing contests – are related.

This study of the day-to-day practices of strategy-making is an empirical contribution to the emerging literature on strategy as practice. There have been many recent calls to explore the work of strategy makers (Johnson et al. 2003; Whittington 1996; Whittington 2003) but few empirical studies. This movement in the strategy field has been partly triggered by a dissatisfaction with strategy process research. Though studies of strategy process (Bower and Doz 1979; Bower 1970; Burgelman 1983; Mintzberg et al. 1976; Mintzberg 1973; Pettigrew 1985) have made substantial contributions by opening up the black box of strategy, humanizing strategy and legitimating in-depth, small sample studies, it often has produced disembodied stage models that are abstracted from the individuals doing the work and has neglected their agency in
the process. As a result, practice scholars are calling for greater focus on the work of strategists (Johnson et al. 2003).

This study, and the framing contests model that is the product of my observations, raises a number of issues for the strategy literature. First, it suggests that the project is an important locus for understanding strategy. Even while studying individual practices, it was crucial to locate them in a particular context. While frame repertoires span settings and time, frames are enacted in specific settings. The results from this study show that this setting is most appropriately viewed as the project or initiative rather than the firm. By focusing on the practices of strategy-making, the firm recedes as the predominant social structure for strategy and the project or initiative comes into view as the critical locus (Obstfeld 2004). Looking only at the work of the individuals without locating it in a unique decision context may not be adequate to the task. It may be essential to place the project front and center as the unit of observation or analysis in order to consider the larger (macro) structures and individual (micro) actions that interact to produce strategic choices. Second, linking framing and politics to understand strategy at a micro level bridges the divide between content and process in the study of strategy. The strategy field has traditionally been divided between content studies which treat firms as macro-level wholes and process studies that focus inside the firm. By taking the practice perspective, I am able to incorporate the content of the frames and the organizational dynamics that shape them.

This research has been couched in the broader question about how firms respond to discontinuities. The framing contests model could be extended to offer several insights about the underlying dynamics shaping firm response. The observations suggest that framing contests only arise to the extent that there is an incongruence of frames within the organization. In the case of successful incumbent firms, it could be the case that a particular set of frames gets enacted across enough people and decision contexts that it becomes institutionalized and thus is the only one that is salient. Firms therefore might not be able to respond adequately because an outmoded frame continues to predominate. In cases where alternative views do surface (usually, as in the case of EQUIPCO, as a result of external crisis), the framing contests model suggests that firms may not succeed in responding because it is difficult for them to reach internal agreement on the nature of the threat. Yet, the model also suggests that firms do not have to be
victims of predominant frames. Purposeful action on the part of actors within the firm to shape the frames of others can lead new collective frames to predominate in new sets of strategic choices. One means through which many firms have accomplished this is by changing out senior management (Tushman and Rosenkopf 1996; Virany, Tushman, and Romanelli 1996) or by allowing autonomous decision-making in various levels of the organization (Burgelman 1994). These efforts have the effect of expanding the frame repertoires of management and thus enabling alternative frames to be enacted. But, the model suggests that this kind of change would also be possible through entrepreneurial action in the organization. Actors could choose to enact different frames by drawing differently on their frame repertoires.

In summary, the stories of the investment decisions in the Last Mile and Multiservice projects provide some insight into the mechanisms through which cognitive and collective frames influence strategic choice. My observations suggest a new understanding of framing in the context of technical change. Information ambiguity is the linchpin of strategic decision making during discontinuities, and framing is a key mechanism for explaining how managers cope with it. Firm response to technical change is therefore enacted through the conflicts in frames where outcomes are determined through a political process. The articulation of this dynamic suggests that the framing processes within firms could be a more proximal explanation of heterogeneous firm response to discontinuous technical change.
Appendix to Chapter Five – description of frame analysis

Focusing specifically on the frames of the individuals in each project and for each decision, I used the multiple sources of data (observations from meetings, interviews, e-mails and documents) to generate a description of the salient frame in each context. These descriptions included detailed elements of the frames as well as the sources to which the viewpoints could be attributed (industry level, EQUIPCO, ATG, functional and capability-based norms). Based on these detailed descriptions, I generated a list of frame elements by type of element and source. I then coded each individual according to which elements were in their repertoire based on their demographics. Table 5-7 summarizes this data for the elements that were relevant for at least one individual for the Last Mile and Multiservice projects. This list is not comprehensive in the sense that it does not include any frame element that was never activated by any individual on any decision for these two projects. An analysis of more projects and decisions would likely expand the list of elements.

Table 5-7: Frame elements by type

<table>
<thead>
<tr>
<th>SOURCE</th>
<th>TYPE</th>
<th>ELEMENT</th>
</tr>
</thead>
</table>
| Industry       | Diagnosis   | • Carriers have no funds for capital expenditures; will not invest in new infrastructure ("no backhoe")
|                |             | • Carriers will invest in new technologies if they are carefully targeted, don't cannibalize revenues, create ST sales
|                |             | • Demand for bandwidth will increase exponentially (potential for killer apps)
|                |             | • No killer apps on the horizon; demand for bandwidth will increase slowly
| Solution       |             | • Access is the current rate limiter in the industry. Solve the bottleneck by solving access.
|                |             | • Any new technologies will have to take advantage of existing infrastructure (e.g., copper)
|                |             | • Any new technologies will have to be low risk, and able to be implemented incrementally.
| Governance     |             | • Industry crisis due to faulty economic calculus; therefore more rigorous economic analysis required for investment.
| EQUIPCO        | Diagnosis   | • EQUIPCO should not be in the access business.
| (corporate)    |             | • EQUIPCO needs an end-to-end solution for the customer.
|                |             | • EQUIPCO's competence is in high end, low volume network equipment; cannot manage low margin businesses.
|                |             | • EQUIPCO should only put limited focus on long haul optical technologies, emphasize other technological thrusts.
| Solution       |             | • EQUIPCO should be a technical leader in the industry, respond to competitive threats.
|                |             | • Build projects internally rather than source externally.
|                |             | • EQUIPCO needs to be more customer facing.
| Governance     |             | • Need to focus on short term cash flow producing projects.
| ATG (division) | Diagnosis   | • Given the change in the market, ATG needs to reorient its priorities (no more "lab" mindset)
|                |             | • ATG needs to prove its value added to the corporation (no overlap with the business unit)
| Solution       |             | • ATG needs to support the business unit needs
|                |             | • ATG needs to think ahead of the business units, research should be forward thinking, independent of day-to-day
| Governance     |             | • Passion for an idea, despite the odds, may carry the day in decision-making (a way to deal with uncertainty)
| Functional -   | Diagnosis   | • Pessimistic about market demand prospects.
| business       |             | • Technical proposals are likely to not be practical, not to take into consideration market needs, likely pet projects
|                |             | • Our role is to help tech teams come up with meaningful business cases
|                |             | • Our role is to quash technical projects that do not have realistic business cases
|                |             | • We need to make sure that every project is supported by at least one business unit

Chapter 5: framing contests - 233 -
I then coded each individual according to which elements were in his or her repertoire based on their demographics. Thus, all project members could accumulate the industry, EQUIPCO and ATG elements. Only technical people could accumulate functional-technical frame elements, and marketing/business people to functional-business elements. Based on individual background and experience, I noted which individual had the potential to accumulate each capability-based frame element. For example, those with academic and project backgrounds in optical technologies had the optical frame elements in their repertoires. I coded the frame elements that were the most salient for each individual for each decision in each project. I grouped the various frame elements into common combinations found among the informants. I first identified which elements appeared grouped together on a consistent basis across informants and across decisions. Based on the general topics represented by the elements,
I derived a representative theme for each frame. In Table 5-8, I provide an example of the groupings of frame elements for the Last Mile project.

Table 5-8: Groupings of frame elements for the Last Mile project

<table>
<thead>
<tr>
<th>Cluster Name</th>
<th>Type</th>
<th>Source</th>
<th>Specific Frame Element</th>
</tr>
</thead>
<tbody>
<tr>
<td>Access optimists</td>
<td>Diagnostic</td>
<td>EQUIPCO</td>
<td>Access: access technologies require a low-cost, high-volume economic model that EQUIPCO can’t manage.</td>
</tr>
<tr>
<td>Access optimists</td>
<td>Diagnostic</td>
<td>Function-tech</td>
<td>Access: EQUIPCO needs to be in access.</td>
</tr>
<tr>
<td>Access optimists</td>
<td>Diagnostic</td>
<td>Capability</td>
<td>EQUIPCO needs an end-to-end solution for the customer.</td>
</tr>
<tr>
<td>Access optimists</td>
<td>Diagnostic</td>
<td>Capability</td>
<td>The technical people are the experts and should be trusted to pursue the right projects.</td>
</tr>
<tr>
<td>Access optimists</td>
<td>Solution</td>
<td>Function-tech</td>
<td>Access: access is the bottleneck in the communications system.</td>
</tr>
<tr>
<td>Access optimists</td>
<td>Solution</td>
<td>Capability</td>
<td>EQUIPCO competence in high end, low volume network equipment; can’t manage low margin businesses.</td>
</tr>
<tr>
<td>Access optimists</td>
<td>Solution</td>
<td>Capability</td>
<td>Optimistic about market demand</td>
</tr>
<tr>
<td>Access optimists</td>
<td>Solution</td>
<td>Capability</td>
<td>Marketing/business unit people are linear thinkers; technical people understand future needs better than others (are more able to be visionary)</td>
</tr>
<tr>
<td>Access optimists</td>
<td>Solution</td>
<td>Capability</td>
<td>Access is the current rate limiter in the industry. Solve the bottleneck by solving access.</td>
</tr>
<tr>
<td>Access optimists</td>
<td>Governance</td>
<td>Function-tech</td>
<td>EQUIPCO should be a technical leader in the industry, and respond to competitive threats to this leadership.</td>
</tr>
<tr>
<td>Pro-optical</td>
<td>Solution</td>
<td>Industry</td>
<td>Optical: optical technologies have broad application beyond long haul.</td>
</tr>
<tr>
<td>Pro-optical</td>
<td>Solution</td>
<td>EQUIPCO</td>
<td>Optical: market downturn in optical demand is temporary/short-lived.</td>
</tr>
<tr>
<td>Pro-optical</td>
<td>Solution</td>
<td>Function-tech</td>
<td>Optical: need to continue developing optical technologies to prepare for return of market.</td>
</tr>
<tr>
<td>Tech first</td>
<td>Solution</td>
<td>EQUIPCO</td>
<td>We should be building cool stuff</td>
</tr>
<tr>
<td>Tech first</td>
<td>Solution</td>
<td>Function-tech</td>
<td>The push to make business cases on all projects is eroding the creativity of the technical group</td>
</tr>
<tr>
<td>Tech first</td>
<td>Solution</td>
<td>Capability</td>
<td>Build projects internally rather than source externally.</td>
</tr>
<tr>
<td>Tech first</td>
<td>Governance</td>
<td>ATG</td>
<td>Technology driven solutions should win in the decision-making process</td>
</tr>
<tr>
<td>Tech first</td>
<td>Governance</td>
<td>Function-tech</td>
<td>Devices: most solutions will involved building a device.</td>
</tr>
<tr>
<td>Access pessimists</td>
<td>Diagnostic</td>
<td>Industry</td>
<td>Carriers have no funds for capital expenditures and will not invest in new infrastructure (&quot;no backhaul&quot;).</td>
</tr>
<tr>
<td>Access pessimists</td>
<td>Diagnostic</td>
<td>Industry</td>
<td>No killer apps on the horizon; demand for bandwidth will increase slowly</td>
</tr>
<tr>
<td>Access pessimists</td>
<td>Diagnostic</td>
<td>EQUIPCO</td>
<td>EQUIPCO should put only limited focus on long haul optical technologies and emphasize other technical thrusts.</td>
</tr>
<tr>
<td>Access pessimists</td>
<td>Diagnostic</td>
<td>Function-business</td>
<td>Pessimistic about market demand trends</td>
</tr>
<tr>
<td>Access pessimists</td>
<td>Diagnostic</td>
<td>Capability</td>
<td>Non-optical: optical is saturated for a long time to come.</td>
</tr>
<tr>
<td>Access pessimists</td>
<td>Solution</td>
<td>Industry</td>
<td>Any new technologies will have to be low risk, and able to be implemented incrementally.</td>
</tr>
<tr>
<td>Access pessimists</td>
<td>Solution</td>
<td>Industry</td>
<td>Any new technologies will have to take advantage of existing infrastructure (e.g., copper)</td>
</tr>
<tr>
<td>Access pessimists</td>
<td>Solution</td>
<td>Capability</td>
<td>Non-optical: not everything needs an optical solution</td>
</tr>
<tr>
<td>Business case</td>
<td>Diagnostic</td>
<td>Industry</td>
<td>Carriers will only invest in new technologies if they are carefully targeted, don’t cannibalize existing revenues and create short term revenues.</td>
</tr>
<tr>
<td>Business case</td>
<td>Solution</td>
<td>ATG</td>
<td>ATG needs to think ahead of the business units, research should be forward thinking and independent of the day-to-day business.</td>
</tr>
<tr>
<td>Business case</td>
<td>Solution</td>
<td>Capability</td>
<td>Non-device (architecture/software): solutions may not require building a device.</td>
</tr>
<tr>
<td>Business case</td>
<td>Solution</td>
<td>Capability</td>
<td>Outside experience; more likely to appreciate need for business case, not technology for its own sake; less likely to be attached to overarching EQUIPCO frames</td>
</tr>
<tr>
<td>Business case</td>
<td>Solution</td>
<td>EQUIPCO</td>
<td>EQUIPCO needs to be more customer facing.</td>
</tr>
<tr>
<td>Business case</td>
<td>Solution</td>
<td>Function-business</td>
<td>Our role is to quash technical projects that do not have realistic business cases.</td>
</tr>
<tr>
<td>Business case</td>
<td>Solution</td>
<td>Function-business</td>
<td>Technical proposals are likely to not be practical, not to take into consideration market needs, likely to be pet projects</td>
</tr>
<tr>
<td>Business case</td>
<td>Governance</td>
<td>Function-business</td>
<td>All projects should be vetted through the Steering Committee process in order to assure a good business case</td>
</tr>
<tr>
<td>Cluster Name</td>
<td>Type</td>
<td>Source</td>
<td>Specific Frame Element</td>
</tr>
<tr>
<td>----------------------</td>
<td>------------</td>
<td>--------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Business case</td>
<td>Governance</td>
<td>Role</td>
<td>Steering Committee member: make sure the project will get approved by the Review Board</td>
</tr>
<tr>
<td>Analytical rigor</td>
<td>Diagnostic</td>
<td>EQUIPCO</td>
<td>Engineer: belief in value of &quot;rational, objective&quot; analysis</td>
</tr>
<tr>
<td>Analytical rigor</td>
<td>Governance</td>
<td>Capability</td>
<td>Industry crisis due to faulty economic calculus; therefore more rigorous economic analysis required for investment.</td>
</tr>
<tr>
<td>Analytical rigor</td>
<td>Governance</td>
<td>Industry</td>
<td>Passion for an idea, despite the odds, may carry the day in decision-making (a way to deal with uncertainty)</td>
</tr>
<tr>
<td>Business unit focus</td>
<td>Diagnostic</td>
<td>ATG</td>
<td>ATG needs to prove its value added to the corporation (no overlap with the business unit)</td>
</tr>
<tr>
<td>Business unit focus</td>
<td>Diagnostic</td>
<td>ATG</td>
<td>ATG needs to support the business unit needs</td>
</tr>
<tr>
<td>Business unit focus</td>
<td>Diagnostic</td>
<td>EQUIPCO</td>
<td>EQUIPCO should no longer in the access business.</td>
</tr>
<tr>
<td>Business unit focus</td>
<td>Solution</td>
<td>ATG</td>
<td>Given the change in the market, ATG needs to reorient its priorities (no more “lab” mindset)</td>
</tr>
<tr>
<td>Business unit focus</td>
<td>Solution</td>
<td>Capability</td>
<td>Non-ATG EQUIPCO experience: more likely to appreciate need for business case, not technology for its own sake</td>
</tr>
<tr>
<td>Business unit focus</td>
<td>Solution</td>
<td>Function-business</td>
<td>Our role is to help tech teams come up with meaningful business cases</td>
</tr>
<tr>
<td>Business unit focus</td>
<td>Solution</td>
<td>Function-business</td>
<td>We need to make sure that every project is supported by at least one business unit</td>
</tr>
<tr>
<td>Business unit focus</td>
<td>Governance</td>
<td>EQUIPCO</td>
<td>Need to focus on projects with a short term, cash flow orientation</td>
</tr>
<tr>
<td>Business unit focus</td>
<td>Governance</td>
<td>Function-business</td>
<td>All projects need to have a clear market-based business case. Must be evaluated on economic as well as technical merits.</td>
</tr>
</tbody>
</table>

I also grouped the informants into categories of proposers, challengers and Review Board. I then calculated what percent of the potential frame elements in the repertoires in any particular area were salient for that group of people for a particular decision. This allowed me to depict the major differences between the groups and show how they evolved over time.
Chapter Six

Integrating insights: a structurational model of framing

6.1 Introduction
6.2 Revisiting the empirical studies
6.3 Theoretical wellsprings from structurational models
   6.3.1 Giddens and structurational models
   6.3.2 Some critiques and extensions of structuration theory
6.4 Constructing a structurational model of framing
   6.4.1 Research context – discontinuity as “critical situation”
   6.4.2 Frame repertoires and cognitive frames as modalities
   6.4.3 Collective frames as structures
   6.4.4 Framing strategies (agency)
   6.4.5 Summary of structurational model of framing
6.5 Implications for theory and research
   6.5.1 Firm response to technical change
   6.5.2 Role of managerial cognition in strategy
   6.5.3 Strategy-making
6.6 Conclusion

6.1 Introduction

The promise of this dissertation lies in the potential for integrating insights from the two different studies – large-sample and field-based – of strategic choice in the face of the fiber-optic revolution. In this chapter, I use the findings from the empirical studies as stepping stones towards a model of the role of frames in making strategic choice under uncertainty. The stories that emerge from these different empirical settings and different analytical approaches complement each other in building a broader understanding of the organizational dynamics that produce strategic outcomes. While the large-sample study suggests that there is a significant and economically important association between managerial cognitive frames and subsequent
strategic action, it leaves open the question about the mechanisms that might lead a particular frame to become predominant in an organization. The field study permits a deeper understanding of precisely these mechanisms: individual actors with different interpretations of the information environment engage in framing contests, the outcome of which are the collective frames that predominate as strategic choices are made.

In putting these two studies together, my goal is to develop a more nuanced conception of the role of frames in strategic choice and to suggest ways in which this view might affect the current understanding of firm response to technical change, the role of managerial cognition in shaping organizational outcomes and the dynamics of strategy-making. This chapter represents one particular experiment in integration which I ground in Giddens’ (1979; 1984) structuration theory. Using structuration theory makes sense for several reasons. First, I find the three dimensions of structuration theory (structure, agency and the modalities that are the medium between them) to be congenial to the dimensionalized notion of framing that has emerged from the empirical research reported in earlier chapters. I argue that by mapping frames, framing strategies and frame repertoires onto the structurational model, I can provide a more robust explanation of the relationships between these factors. Second, Giddens’ structurational model makes an unequivocal connection between meaning generation and power. He suggests that these modes are separable only analytically and are coinvolved in the production of outcomes. This will become particularly important in helping to unpack the associations between framing and politics that I found in my empirical work. Third, Giddens comments explicitly about the appropriateness of structuration theory for linking quantitative with qualitative research (which he notes echoes the macro-micro divide). He argues that while these perspectives tend to be viewed as hostile to each other – macro researchers see micro work as purely descriptive and atheoretical, micro researchers see macro work as imposing a fixity that social life does not actually have – they should instead be seen as complementary (Giddens 1984: 329). Using structuration theory to look across the findings from my own quantitative, large-sample study and qualitative, field study is a way to shed light on the dynamics that connect the insights about framing from each.

In this chapter, I first revisit the empirical studies and summarize the insights from each. I then explore the precepts of structuration theory and suggest a way that they might relate to
understanding the role of frames in strategic choice. Subsequently, I draw out the interfaces between the theoretical principles and the findings from the empirical work to develop a structurational model of framing. Finally, I discuss the implications of this model for questions of strategic management, including firm response to technical change, managerial cognition research, and the practice of strategy.

6.2 Revisiting the empirical studies

The two empirical studies covered in Chapters 3, 4 and 5 above bring different optics to the understanding of the role of cognition in strategic choice and action.

The quantitative, large-sample study (Chapter 3), aimed to understand the patterns and consequences of the relationship between managers’ frames and strategic action as companies faced the fiber-optic revolution over the past 20 years. The specific test was of the association between top managers’ frames about the relative importance of optics (as measured by normalized optical words in the Letter to Shareholders) and strategic action in the form of optical patenting relative to total patenting efforts. Several important themes emerge from this study:

- Given the information ambiguity associated with the fiber-optic revolution, multiple interpretations existed. During a period of discontinuity, the top management teams of different firms had different frames about the importance of optical technologies.

- Top managers’ frames connect to action. Even when controlling for a number of plausible alternative explanations, top managers’ collective frames about the relative importance of optics had a critical influence on strategic actions.

- Frames have important consequences. Not only did different interpretations exist in different firms, but these differences had tangible effects on outcomes. A standard deviation change in frames leads to an 80 percent change in subsequent optical patenting rates (at the mean).

- In addition, a substantial portion of strategic action can be explained by prior experience (e.g., past patenting or CEO technical background).

- Frames appear to be embedded in organizations to a greater or lesser degree depending on such factors as the age of the organization. The effects of top managers’ frames are
much more important for incumbents than for entrants. This suggests that, for entrants, the top managers’ frames have not had the same amount of time to become institutionalized into the practices of the organization. Frames in newer firms may not be as deeply embedded as in older incumbents.

While the quantitative study suggested an important relationship between frames and strategic outcomes, it left open the question about the mechanisms that might connect them. The purpose of the field study was precisely to explore these mechanisms at the micro level. Drawing on framing theory in the social movements literature, I developed a model of the role of cognitive frames in strategy-making dynamics as they are produced in the course of situated action which is summarized in Figure 6-1.

Figure 6-1: Model of framing contests

Several important themes emerged from this study.

- Because of information ambiguity in the situation, there were multiple, contested interpretations of the internal and external environment, the solution and the means for arriving at a decision.

- These frames were enacted by actors in particular decision contexts based on their frame repertoires. A particular frame was made salient in the context of a specific project and in interaction with other actors in the organization.
• **Knowledge accumulated** in frame repertoires that accrued from an actor’s multiple histories and experiences.

• Individual actors were not simply victims of their own frames. There was a possibility for **purposeful action** as actors attempted to get their own frames to predominate as choices were made (in what can be seen as a political process). This purposeful action had both intended and unintended consequences.

• **Frames and interests were mutually constituting.** The framing and political strategies actors engaged in to influence strategic choices were analytically though often not empirically separable.

• The framing contest process resulted in the enactment of a **predominant collective frame** in a particular time and place.

Combining the themes from each of the two studies suggests that a model of frames in strategic choice during periods of discontinuity should incorporate the following: information ambiguities and the resulting potential for contested interpretations; accumulations in the form of frame repertoires; frames enacted in a particular decision context; different degrees of embeddedness of frames; and purposeful action by actors to shape frames and interests; and collective enactment of the predominant frame. To develop this model theoretically, I will make use of Giddens’ (1979; 1984) structurational model and more recent extensions of it. In the next section, I will outline the features of structuration theory that are particularly salient for this interpretation and then use them to develop a structurational model of frames in strategic choice.

### 6.3 Theoretical wellsprings from structurational models

To amplify the theoretical dimensions of this model, I will draw heavily from Giddens’ (1979; 1984) work on structuration and more recent critiques and extensions of it by Sewell (1992) and Emirbayer and Mische (1998).

#### 6.3.1 Giddens and structurational models

The core notion of structuration theory is that structures shape and are shaped by individuals acting in a social context. In an attempt to transcend the dichotomies posed by determinist, static notions of structure and subjective, dynamic views of agency, Giddens
explores how structure and agency are interrelated. For him, structures only exist to the extent that they are enacted by actors in a social context. Practices that are reproduced consistently across actors and over time can develop structural properties. In developing a model that attempts to link macro and micro empirical perspectives, it is quite natural to turn to Giddens because his theory of structuration is founded essentially on the point that social life is neither wholly determined by macro-level social forms nor is it simply a collection of micro-level actions.

The structurational model (reproduced from Giddens in Figure 6-2) depends on the interrelationship between three different modes: structure, agency and the “modalities of structuration” (Giddens 1984: 28). Structure and agency are mutually constituting through the influence of modalities.

**Figure 6-2: Giddens' structurational model**

![Diagram of Giddens' structurational model]

Actors draw on the modalities as they interact. This model applies across three different but interrelated dimensions, those of meaning (codes and interpretations), power (resource allocation and authorization) and normative elements (regulation). Giddens also emphasizes the role of "rules" and "resources." These are another way of thinking about the dimensions of structure. Rules essentially are the aspects that shape what gets done while the resources shape the ability
to get it done. For my purposes, this distinction is the more useful one. Rules incorporate the idea of interpretive schemes and therefore are akin to an actor’s enactment of collective frames. Resources incorporate power and therefore are akin to the dominant politics and interests enacted within a particular setting. Using structuration theory, the link between frames and interests that I observed in my field study can be read more broadly as the link between rules and resources.

The structurational model operates in the following way. Modalities are interpretive schemes, norms and facilities (sources of power) that actors draw upon in their recurrent interactions, the act of which then constitutes the structures. Rather than reifying structures as exogenous forces on social action, Giddens emphasizes the role of human agency in enacting structures over time. Yet, at the same time, he admits that structures can be extremely persistent if they are continually reproduced. These structures can be deeply encoded in the actors’ habits and thus become powerful shapers of their subsequent choices and actions. Thus, structure and agency are not antithetical constructs but rather interconnected and equally essential to understanding the organization of society. It is this reciprocal relationship between structure and agency (through modalities) that makes the structurational model attractive for understanding the dynamics of framing that I observed in my empirical studies. The theory suggests that structures are enacted and thus have the potential for change built into them. Because structures are dependent on their reproduction through the actions of actors, they can be changed when these actors disregard, substitute or alter their reproduction of them.

My theoretical move to use structuration theory in an organizational context is inspired by the stream of scholarship by Barley and Orlikowski (Barley 1986; Barley 1990; Orlikowski 2000; Orlikowski 1992) who have developed a structurational model of technology. The general principles of this technology-oriented model rest on the duality of technology: technology is both a product and medium of human action. Because technologies are subject to interpretive flexibility, these scholars argue that the duality can lead to both intended and unintended consequences. These structurational models of technology have tended to focus on explaining situations where new technologies are introduced to organizations. Orlikowski’s work looks at the development and introduction of information technologies into a large

79 Orlikowski (1992) provides a detailed theoretical treatment and empirical demonstration of this model.
consulting organization. Barley examines the introduction of CT scanners for diagnostic purposes in various hospital settings. As such, the analyses tend to focus on the relationship between institutions (which both condition and are influenced by interaction with technology) and technologies (which are both a product and medium of human action).

My use of structuration theory will take a different trajectory in two important ways. First, I will focus specifically on the structures of signification (one of the three dimensions of the structurational model). While Giddens’ (1984) argues that “structures of signification always have to be grasped in connection with domination and legitimation” (p. 31), for the purposes of an analysis of frames in organizations, it will be most useful to focus on the dimension of meaning in the structurational model. At the same time, the value of structuration theory in this analysis is precisely that even while focusing on one dimension one must consider the others. Meaning cannot be truly separated from questions of power. I suggest that focusing on meaning generation allows me to understand the ways that this connection occurs.

My field research identified three aspects of framing: the frame repertoires of actors which represent accumulations of knowledge based on prior experiences in various contexts; the collective frames as they are enacted in particular decision contexts; and the framing strategies that actors engage in to make their frames predominate as strategic choices are made. These empirically driven aspects of framing map on to the three dimensions of the structurational model (see Table 6-1). By doing this mapping, I can expand the understanding of the interrelationships between these three dimensions of framing and also develop more precise terminology.

From the standpoint of meaning, the modalities are interpretive schemes that actors draw on (parallel in construct to frame repertoires). These repertoires consist of knowledge accumulations based on individual experiences. These accumulations create elements that can be combined into cognitive frames. They also include cognitive frames of individuals which are, in Giddens’ words, “modes of typification,” or regularized combinations of frame elements. One means of explaining the presence of these cognitive frames is through the mechanism of bounded rationality (March and Simon 1958) in which different combinations of elements (e.g., about the nature of the environment and the right strategic solution) get codified into a cognitive frame as a way of simplifying the cognitive processing required. These cognitive frames can
become routinized if reinforced through application over time and develop a habitual, taken-for-granted character. These routinized cognitive frames are often the first frames that an actor might draw upon in a particular situation, but the presence of the underlying elements in the repertoire means that it is always possible to combine them differently to produce an alternative cognitive frame about the situation.

Table 6-1: Mapping frame repertoires, frames and framing strategies to the structurational model

<table>
<thead>
<tr>
<th>Giddens’ structurational model relative to meaning</th>
<th>Empirically driven aspects of framing from field study</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Modalities/interpretive schemes:</strong> interpretive schemes that actors draw upon in their recurrent interaction</td>
<td><strong>Frame repertoires:</strong> accumulations of knowledge based on experiences that actors draw upon (includes frame elements and cognitive frames)</td>
</tr>
<tr>
<td><strong>Structures/signification:</strong> reproduction of situated practices. Focus on routinized signification. (Rules and resources).</td>
<td><strong>Collective frames:</strong> enacted in particular decision contexts. Different degrees of embeddedness. (Set of rules).</td>
</tr>
<tr>
<td><strong>Agency/communication:</strong> self-reflexive action based both on intentions and capabilities</td>
<td><strong>Framing:</strong> purposeful action to shape the collective frame</td>
</tr>
</tbody>
</table>

Agency comprises the communications that people engage in to transmit meaning (parallel to framing strategies). Communication is a process of meaning constitution. Actors draw on their accumulations of knowledge, most typically in the form of pre-existing cognitive frames, to shape their interactions. In doing so, they reproduce structures of signification in their situated practice. These structures do not exist outside of the actions of individual actors seeking to constitute meaning. However, to the extent that they are reproduced over time and across a number of actors, they can develop what Giddens calls, “structural properties” or institutionalized features that are reproduced across time and space. As I develop the structurational model of framing, I will make an important distinction between the actor’s cognitive frame and the shared collective frame that may come to predominate as strategic choices are made.
The focus on the meaning dimension of the structurational model is not intended to exclude the other dimensions. The nice feature of Giddens’ argument is that, by insisting that signification cannot truly be separated from structures of domination and legitimation (or separated only analytically but not empirically), he provides a theoretical explanation for the tight linkage between framing and political action that I observed in my field work. In Chapter 5, I argued that frames and interests were mutually constituting and framing was essentially a political process where power was the ability to get one’s frame to predominate as strategic choices were made. From a structuration perspective, this should not be surprising precisely because structures of signification cannot be separated from other dynamics. Therefore, even as I focus on the structures of signification, I will need to draw on the other dimensions to explain outcomes.

In attempting to develop a theoretical model of the role of frames in strategic choice about technology, it seems more useful to focus on all three modes of the structurational model, not just structure and agency, but also the modalities that inform and mediate the interaction between the two, as this will help explain the interconnection between frame repertoires, frames and framing strategies. Typically, when scholars in strategic management draw on structuration theory, they tend to do so solely to make the point that both structure and agency matter (Pozzebon 2004).\textsuperscript{80} In this model, by contrast, I attempt to take Giddens more seriously in the sense that I want to focus on the underlying mechanisms that connect structure and agency (in the particular context of understanding the role of frames in strategic choice). To do this, I draw on more recent extensions of theory about both structure (by Sewell 1992) and agency (by Emirbayer and Mische 1998).

\textsuperscript{80} While structuration theory has not made major inroads in scholarship on strategic management, there have been several efforts to incorporate Giddens into strategy research questions. Pozzebon (2004) conducted a review of articles on strategic management using structuration theory published during 1995-2000 and identified 19 different attempts. These articles were mainly published in Organization Studies, Journal of Management Studies, Academy of Management Review and International Studies of Management & Organization. In most cases, the unit of analysis was the strategy process itself rather than strategic choices. Also, most used structuration theory primarily as a theoretical hook to overcome the dichotomy between structure and agency and, as such, combined it with other theories such as social constructivism, institutionalism or sensemaking. In this chapter, I am not simply drawing on Giddens to get around the polarities of structure and agency. Rather, I will attempt to use structuration theory to generate insights about the mechanisms that connect frames to strategic choice. Chapter 9 in Huff, Huff and Barr (2000) written with Larry Stimpert develops the structuration model more fully at multiple levels of analysis (industry, firm group and individual) but focuses primarily on the structures of signification, domination and legitimation and not on the modalities or interactions. They use their model to explain new entry into industries.
6.3.2 Some critiques and extensions of structuration theory

While Giddens’ structuration theory has been incredibly generative for scholars in a wide diversity of fields, his writing and theorizing has tended to be somewhat opaque. At critical moments, he leaves the reader wondering about the specific nature of the mechanisms at work. Recent articles by Sewell (1992) and Emirbayer and Mische (1998) have attempted to extend structuration theory by filling some of these gaps.\textsuperscript{81} Sewell focuses on ways to build the potential for change more explicitly into structure. Emirbayer and Mische examine how agency can be both entrained and purposeful by focusing on the temporality of agency.

Sewell’s (1992) critique of Giddens is that he underspecifies of the notion of structure itself. Sewell objects to the notion of “rules” and “resources.” He asserts that Giddens doesn’t go far enough in articulating the nature of structures (in particular, in identifying the content of what people know) and suggests that it might be more useful to conceptualize “rules” as “schemas” instead. This definition may be more granular than that of Giddens, but it also impoverishes the structuration theory that Giddens puts forth. For Giddens, schemas are the modalities from which actors draw to shape action in particular circumstances. These actions then enact rules over time. By collapsing rules and schema, Sewell risks losing one of the crucial insights of structuration theory.

Yet, it is not his attempt to clarify the definition of structure that is the most useful or compelling aspect of this theoretical work. Instead, Sewell gains the most traction when he explores the possibility that structures might embody forces for continuity and change simultaneously. Dissatisfied with the strong “reproductive bias” that he perceives in Giddens’ conceptualizations of structure and with the idea that change therefore has to be seen as entirely exogenous, he proposes a more “multiple, contingent and fractured” notion of society (Sewell 1992: 16).

To do this, he proposes five axioms that “show how the ordinary operations of structures can generate transformations” (p. 16): multiplicity (actors have multiple, potentially conflicting,

\textsuperscript{81} Both of these articles have a focus that is broader than a critique of Giddens’ structuration theory. They both work with Bourdieu’s theories (and others) as well. While there are very important differences between Giddens and Bourdieu, both place structure and agency (the objective and subjective) in dialectic. Therefore, the critiques and extensions offered by Sewell and Emirbayer and Mische are useful because they explore this interface.
schemas in their repertoires), transposability (schemas can be applied in a wide range of situations, including familiar and new contexts), unpredictability (there will be intended and unintended consequences of schema application), polysemy (multiple meanings are possible), and intersection of structures (different schemas can be claimed by different actors and they can be appropriated from one situation to another) (Sewell 1992: 17-19). These factors will be extremely helpful in developing an understanding of the underlying mechanisms of a model of frames in strategic choice. As I build up the structurational model of framing in the next section, I will use these concepts to demonstrate how framing has the potential to lead to either continuity or change depending on how frames are enacted in the moment.

Emirbayer and Mische’s (1998) critique of Giddens, on the other hand, is focused on the overemphasis on the routine, habitual and taken-for-granted notion of agency. While the structurational model builds in the potential for change in structures (when agents disregard, change or enact them differently), Giddens focuses more on how structures get reproduced than on the conscious efforts of agents to change structures. Emirbayer and Mische, in contrast, argue that agency involves not just routine but also purpose and judgment. In their view, a more useful approach to agency would be one that incorporates all of these different components equally. In particular, in applying structuration theory to questions of strategy, I argue that a focus on more purposive actions is essential. Emirbayer and Mische bring Mead’s (1932) theorization on temporality to bear in fleshing out the potential for purposeful action by individuals. Agency in their conceptualization is not just about the notion that actors “could have acted otherwise” (Giddens 1979: 56) but that they can “critically shape their own responsiveness to problematic situations” (Emirbayer and Mische 1998: 971).

They solve the problem they identify in Giddens’ work by focusing on three aspects of agency: its past, future and present. The past is what they call the iterational element: "It refers to the selective reactivation by actors of past patterns of thought and action, as routinely

82 Giddens, in fact, anticipates this issue in a later discussion in The Constitution of Society in which he explains that there are two ways to bracket structure and agency. In studying institutions, he suggests that “structural properties are treated as chronically reproduced features of social systems,” while in the analysis of strategic conduct, “the focus is placed upon modes in which the actors draw upon structural properties in the constitution of social relations…” (Giddens 1984: 288). I follow this latter path in applying structuration theory to questions of strategic management. Work by scholars who have applied structuration theory to organizational phenomena have tended to focus more on the former path (c.f., Barley and Tolbert 1997)
incorporated in practical activity, thereby giving stability and order to social universes and helping to sustain identities, interactions, and institutions over time." The future is the projective element: "Projectivity encompasses the imaginative generation by actors of possible future trajectories of action, in which received structures of thought and action may be creatively reconfigured in relation to actors' hopes, fears, and desires for the future." And, the present is the practical-evaluative element: "It entails the capacity of actors to make practical and normative judgments among alternative possible trajectories of action, in response to the emerging demands, dilemmas, and ambiguities of presently evolving situations" (Emirbayer and Mische 1998: all quotes from p. 971). The past, future and present aspects of agency all condition action in the moment.

Thinking of the temporal nature of agency is particularly useful in developing a model that explains how strategy is made in a rapidly changing environment whose discontinuous nature has disrupted many pre-existing collective frames. Actors enact particular cognitive frames by drawing on their own prior experience, projecting into the future desirable outcomes and responding in the situated moment to the frames and actions of others. These enacted frames only obtain structural properties to the extent that they are reproduced in further interactions by multiple people and over time (becoming collective frames). In stable times, the emphasis is more on the past. But, in periods of discontinuity, the balance between the past and the future must shift. Where interpretations are up for grabs, actors have to draw more on projections of the future, as the past is no longer an adequate guide.

These two extensions of Giddens’ work deepen the understanding of both structure and agency and provide additional theoretical traction for conceptualizing the role of frames in strategic choices about technology. Sewell's five axioms of structure and Emirbayer and Mische’s three temporal dimensions of agency help explain the potential for purposeful as well as routinized action in the face of discontinuous change. Routinization occurs as actors draw on the past to enact structures in the present. But the inherent flexibility of structures and the potential to project into the future enable purposeful action to break routines or enact new structures. In the following section, I build the details of the model, drawing on the insights from the empirical studies reported in earlier chapters.
6.4 Constructing a structurational model of framing

I draw on the empirical data from both the macro and micro studies to develop the three modes of a structurational model of framing in strategy. This model is the product of grounded theory building, in which I have brought the structuration theory of Giddens and others to bear on a pattern of relationships I observed in the data (Dougherty 2002; Glaser and Strauss 1967; Strauss and Corbin 1997).

6.4.1 Research context – discontinuity as “critical situation”

Before I turn to the model, it is important to comment on the empirical context of the research from which the model was developed. Setting the research in a period of discontinuity in the communications technology industry was a deliberate choice based on the phenomenological puzzle about the difficulties firms have in responding to technical change. This setting turns out to be particularly useful as an empirical strategy for two reasons.

First, discontinuity creates an ambiguous information environment for the actors involved (both firms and managers). Here, the information environment can be understood to be any information that could be salient for a strategic decision, both from within the firm (about own resources, for example) and from outside (e.g., about the relevant competitive set). It should also include information about technologies (both developed internally or externally to the firm). The ambiguity of this environment opens up the possibility for multiple interpretations of events and trends and thus invites framing-based explanations of strategic choice and action. In this setting, the information environment does not transmit clear and easily recognizable signals to firms and managers. Both of the empirical studies reported in earlier chapters demonstrate that interpretations of the nature of the environment differed substantially both across firms and within them. It is not possible to consider the “signals” or “messages” from the environment as unproblematic. Uncertainty exists about the performance trajectory of the technologies, the cost of developing them, their ultimate uses, and the size of the potential market, among other things. It is typical, both in the managerial cognition literature and among my informants to think of this
problem as one of accuracy in which differences in perception reflect some failure to ‘get it right.’

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The structurational model of technology (Barley 1986; Orlikowski 2000; Orlikowski 1992), drawing on the social constructionist literature (Bijker, Hughes, and Pinch 1987), suggests that technology is subject to interpretive flexibility (to a greater or lesser degree). Sewell (1992) describes this as the “polysemy” (p. 19) of information where a multiplicity of meanings is possible. Technologies, even material objects, are not constrained to be interpreted and used in one particular way. This notion is particularly important in the context of understanding strategic choice about technology in a period of discontinuity because the space of interpretation is very broad, including interpretations of not just technologies, but markets, competitive action, and even internal capabilities. Indeed, it is this very uncertainty that invites an explanation based in framing because, at its heart, framing is about the way actors perceive, filter and conceptualize information (Tenbrunsel et al. 1996; Weick 1990) in order to form decisions and take action (Daft and Weick 1984; Goffman 1974).

Second, a discontinuity creates precisely the “critical situations” (Giddens 1984: 60) that shatter current routines and provide an analytical opportunity to see the forces of structuration at work. As the President and Chairman of PerkinElmer wrote in the company’s annual Letter to Shareholders, managers are often at a loss for approaches to making strategy at these moments.

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83 The ontological debate in the managerial cognition field focuses on what the researcher can know relative to the informants or research subjects. By arguing that the cognitive frame more or less accurately interprets information, most managerial cognition scholars are making the implicit assumption that the mapping process “distorts” some objective reality that can be known by the researcher (Hambrick and Mason 1984; Prahalad and Bettis 1986; Sutcliffe 1994). On the other hand, social constructionists take issue with this more deterministic view, arguing that cognitive maps don’t represent a underlying reality but rather construct it (Bougon 1992; von Krogh and Roos 1996). In an attempt to resolve these tensions, Porac (1997) has suggested a middle ground that may be the most relevant in studies of technology. If we cannot argue that there are global realities, he says, it is possible to localize frames within a time and place. The observable frame represents the consensus in the moment (Garud and Rappa 1994; Porac 1997). For the purposes of this analysis, I focus on what the managers perceive and how this affects their choices and actions and not on what the researcher can know somehow independently or analytically. Therefore, the “accuracy” perspective is not salient.
While management's role must be to anticipate and plan for change, there are few reliable
guidelines for developing consistent strategies during periods of uncertainty. (Gaynor Kelley,
President, and Horace McDonell, Chairman of PerkinElmer, Letter to Shareholders, 1986)

These uncertainties in the market and within firms can, at the extremes, create a great
deal of anxiety for strategic decision makers. In 2001, the new CEO of Optical Fiber Corp.
indicated as much after the market crash led to a turnover of management.

These events have caused a great deal of shock, uncertainty and anxiety. Shareholders became
anxious about their investment. Some customers became nervous about the viability of the
Company. Employees became concerned as to the future ownership of the Company. Having
joined the Company on September 1, I will admit that I too was shocked and anxious. (Neil
Wilkin, CEO of Optical Fiber Corp., Letter to Shareholders, 2001)

This is the kind of “critical situation” that Giddens characterized as a set of “circumstances of
radical disjuncture of an unpredictable kind which affect substantial numbers of actors, situations
that threaten or destroy the certitudes of institutionalized routines” (1984: 61). Drawing on
Bettelheim’s account of the effects of concentration camps on individuals, Giddens noted that
actors lost their feeling of autonomy that the routines of day-to-day life had provided, where “the
disruption and the deliberately sustained attack upon the ordinary routines of life produce a high
degree of anxiety” (1984: 63). These critical situations allow the scholar to probe the specific
nature of routinization, and in the case of the research presented here, of the mutability of
frames. It is in this context that I am able to surface empirically the three aspects of a
structurational model of framing that includes frame repertoires (modalities), collective frames
(structures) and framing strategies (agency). This context makes visible what might normally be
invisible.

6.4.2 Frame repertoires and cognitive frames as modalities

I start the explanation of the model with frame repertoires. These function much as the
interpretive scheme modality does in Giddens’ structurational model. Individual actors draw
from these repertoires to make interpretations in the moment. Frame repertoires are “stocks of
knowledge” (Giddens 1984: 29) that accumulate through individual experiences in multiple
contexts. Cognitive frames are bundles of elements made salient in particular decision contexts.
This notion is similar to Swidler’s (1986: 277) concept of cultural repertoires or “tool kits” from
which people construct “strategies of action.” Yet, because these repertoires contain multiple,
potentially conflicting, elements, it is possible that different frames could be enacted (as different
elements in the repertoire are made salient). The accumulations come from experiences in
multiple arenas, from participation in projects, training in a particular technical area, affiliation with a functional area, belonging to a particular division within the corporation, inculcation into corporate norms, experience outside the firm (in another firm with other norms), and absorbing industry institutional beliefs.

Some experiences could come from projects, such as particular project experiences with certain technologies or experiences of success or failure in certain kinds of projects. For example, in the Multiservice project at EQUIPCO, Tom Rentham’s (a member of the marketing team) cognitive frame was that no project should be supported, no matter how interesting the technology, if specific business unit support could not be identified. The strength of his conviction came from prior project experience where he had invested a great deal of effort to see the project go nowhere because of a lack of connection to the business units. And on the Last Mile project, Hugh Collins had a tremendous amount of knowledge accumulated from previous work in access technology projects which shaped his cognitive frame about the importance of the access market and the desirability of “Widget” technologies.

Other experiences are generated from an individual’s training. For example, at EQUIPCO, on the Lightwave and Last Mile projects, the critical divide was between optical and electrical engineers. For the Module project, support was largely determined by whether “you are […] a hardware person or you are a software person” according to Stephen Merton, the junior engineer on the project.

“There is always a pull between, a tug-of-war, between the two and when you talk [about the Module project] then you are talking about replacing some of the software with hardware. And sometimes there is still some push back because it is something that the software person does not know.” (Stephen Merton)

Functional affiliation also leads to knowledge accumulation. In EQUIPCO, individuals in the marketing and economic analysis groups had access to particular ways of interpreting the market and technologies that those in the technical areas did not (this despite the fact that most of the people in the market and economic analysis functions were trained in technical areas). The view that cognitive frames are shaped by functional affiliation is captured in the research on “thought worlds” (Carlile 2002; Dougherty 1992). Thought worlds are defined as deriving from participation in different functional groups (such as R&D or marketing) and have been used to explain conflicts of interpretations during new product development projects. In EQUIPCO’s
ATG group, people talked about the strong differences in views between “The Tower” (the location of marketing staff) and “The Lab” (where the technical staff worked). Similarly, in the large-sample study, I found a significant effect on strategic actions for many of the CEO demographic measures, including the presence or absence of technical background for the CEO and years tenure in the job.

Knowledge accumulations can be generated through experience in a particular organizational context. For example, in EQUIPCO, many of the participants had spent the vast majority of their careers in the Advanced Technologies Group (ATG) and its precursor, EQUIPCO Lab division. When people seemed too positive about a technology investment, they were often accused of having a “Lab division” mentality. Repertoires could also be informed by firm norms as these are experienced by the actor. In the Last Mile project, Hugh Collins argued that opposition stemmed from a corporate level belief that “EQUIPCO’s economic model seemed to be a very sophisticated system of high cost, high price, high margin, and limited production runs.” But, as he countered, “that does not match access; it does require a different mindset.” In addition, those actors who had worked in different divisions of the organization or different firms accumulated various beliefs from these multiple contexts. Susannah Watts often noted that her experience working in the business units was the source of her regular skepticism about major technology proposals. The more varied the actors’ experiences, the more potential elements in their frame repertoires.

Industry level beliefs could also provide additional frame elements. The “bubble mindset” was something shared across the entire telecommunications industry. It was absorbed throughout EQUIPCO as well and was influential in project dynamics even after the bubble burst. According to Susannah, the enthusiasm for the Last Mile project was misplaced.

*It generally comes down to urban myth. It’s the belief set that the people have gained over the last five years based on the pre-bubble and the bubble time. When I put some figures together that demonstrated there was no need for optical access technologies, that generated a lot of arguments and discussion. It does not tie up with their belief that everybody will pay for bandwidth and that there are oodles of money to spend everywhere."

In my analyses of strategic choice making, I focused on categories of frame elements associated with taking a position on a particular strategic direction: the diagnosis of the situation, the solution (or prognosis) proposed and the governance (or criteria) for the decision. In the appendix to Chapter 5, I listed the kinds of elements identified in the projects I analyzed at
EQUIPCO. These include views about the customers, the growth of the market, the nature of EQUIPCO capabilities, the types of technologies that might be viable, the kinds of data that would be credible and the decision-making criteria.

Frame repertoires exist only at the individual level of analysis. However, because some experiences that are accumulated are shared, there will likely be elements in the repertoires that are common across actors. Frame repertoires are both constraining and enabling. If cognitive frames are combinations of frame elements in the repertoire, then the repertoire constrains the interpretations possible for that actor. On the other hand, new frames might be enabled from novel recombinations of elements in the repertoire.

These repertoires have a number of properties that will ultimately help explain forces for inertia and adaptation in the face of technical change. First, it is quite possible that people will have multiple, conflicting elements in their repertoires. As Sewell (1992) argues, this multiplicity of schemas means that "social actors are capable of applying a wide range of different and even incompatible schemas" (p. 17). It might be that a particular bundle of elements has been enacted consistently enough over time that it becomes routinized. As a result, it might appear that an actor does not have the potential to frame a situation differently. However, the concept of multiplicity of schemas is built on an implicit potential for change. If there are multiple elements in the frame repertoire, then alternative draws on the repertoire are possible. Similarly, repertoire elements and cognitive frames can be applied across a wide range of decision contexts – what Sewell calls “transposability of schemas” (Sewell 1992: 18). It is, in fact, this quality of frame repertoires (and modalities more broadly) that opens up a space for agency which is, in essence, the ability to extend frames across time and space.

For example, at EQUIPCO, Theresa Veneto had multiple, often conflicting elements in her repertoire. In the context of the Last Mile project, this led to a shifting of frames over time. Given that she was trained in electronics, not optics, she was predisposed to think that optical solutions (such as the ones proposed in the project) were suspect. Her initial cognitive frame led her to oppose the investment. However, as head of the Steering Committee, she also felt that the formal process should be the final arbiter of strategic choices. As such, when Hugh and later Hermann were able to get through the required steps outlined as part of the Steering Committee process and garner general support from other senior managers within ATG, she enacted a
cognitive frame focused on the value of the Steering Committee process. As a result, she moved from opposition to support.

6.4.3 Collective frames as structures

Collective frames are the equivalent to structures in a structurational model. They only exist as they are enacted by multiple actors. Actors draw from their repertoire of frame elements to construct cognitive frames in particular decision contexts. The extent to which these cognitive frames are collectively enacted (and thus shared) within the organization determines if they become collective frames. In the way that Giddens conceptualizes structures, the focus is on the routinized, reproduced nature that makes them appear to be fixed. An insight that comes from studies of firms in periods of discontinuous change is that not all frames possess this same routinized quality. In the decision-making processes at EQUIPCO, the frame that would predominate as choices were made was contested. And, even a frame that was enacted in a particular decision context might not predominate for all decisions. The cognitive frames of a particular actor in a decision context are drawn from the actor’s frame repertoire. As discussed extensively in Chapter 5 on framing contests, actors then engage in framing strategies aimed at getting their own cognitive frames to predominate in the collective as choices are made.

A collective frame remains context specific. Enacted once, it is only provisional. It may or may not get reproduced over time and space (different contexts). If an actor wins the framing contest and his or her cognitive frame comes to predominate in one decision context, it is more likely to be enacted again in other settings. To the extent it is reproduced over time, it attains what Giddens calls “structural properties.” He suggests that there is a hierarchy of embeddedness based on the degree to which practices are extended across time and space. The more that structural properties are reproduced, the more they become “structural principles” that guide a broad set of social action. And, those practices with the greatest time-space extension become institutions (Giddens 1984: 17). Turning back to Giddens’ distinction between rules and resources (power over things and people), I suggest that these collective frames are sets of rules. Resources are akin to interests as they enacted in the organization. Giddens points out that one cannot consider rules separate from resources. This suggests that collective frames must be coinvolved with interest structures (sources of power). And, the degree to which a particular collective frame is linked to a particular set of resources also determines its degree of
embeddedness. As frames and interests get more strongly intertwined, it becomes a system with strong structural properties. When collective frames are reproduced over a longer period of time and are embraced by more people in more decision contexts, they become embedded. Giddens calls the patterning of these social relationships over time-space a system (Giddens 1984: 36). The degree of “systemness” (or embeddedness) of the frame determines the probability that it will be reproduced in the next decision context.

It is in this sense that collective frames tend to take on a life of their own in organizations. If enough actors reproduce a particular collective frame across enough situations, it may become the only frame that is salient in any decision context. At that point, framing contests may not occur because a common frame gets enacted by all participants. Because strategic choices do not occur on a daily basis (for example, I only observed 15 critical decisions across the five projects I studied over eight months), the data from my field work cannot shed light with much specificity on these institutionalization processes. It was clear, however, that certain frames that had been relatively latent (enacted infrequently) in the EQUIPCO Advanced Technologies Group – such as the importance of a business case – became much more salient over the course of the several months of my observations. The hotly contested process for cutting the budget for the Lightwave photonic switch project was the first major investment choice where the “business case” frame was collectively enacted. As a result, actors found this frame salient in decision-making processes in subsequent project decisions. While it did not always win, it had to be encountered and countered by people proposing new technology investments. I speculate that this represents the early steps of institutionalization.

Similarly, embedded frames may not remain so forever. This was particularly important in my field study where the critical situation of the telecoms crash had discredited the “bubble mindset” and the related “pro optical” viewpoint. While that view was enacted in the large majority of decisions in the late 1990’s, it was no longer salient for all participants by 2002 when I conducted my study. This was mirrored in the large-sample study, where the mentions of optics declined in 2001 after a strong rise in the prior period.

An essential question in the context of understanding strategic choice in the face of technical change is the mutability of frames. I argue that collective frames as structures have two mechanisms for stasis or change built in to them: depth of embeddedness and
unpredictability of routinization. The degree of embeddedness (in some sense, the depth of the collective frame) is one dimension along which mutability could be established. One can understand the depth of a collective frame in terms of the degree of its implication in the other dimensions of the structurational model (power and legitimation). The more a collective frame is implicated in the resources (power structure) of the organization, the deeper the structure will be.84 If enacting an alternative collective frame would imply a change in that power structure (with resulting gains in power from some and loss of power of others), then it is more likely to be a deeply embedded collective frame. A similar argument can be made for sources of legitimation. If, for example, actors are been successful over the years in enacting a particular collective frame about the business, their identities may become tightly linked to the collective frame. Efforts by other actors to enact new collective frames will then be perceived as threats to these identities.

Change is possible if actors enact new collective frames (which is more likely to take place if the existing collective frames are not as deeply embedded). For example, at EQUIPCO, the pro-optical “bubble mindset” was quite sticky even as the depth of the crisis in telecommunications made itself apparent. It had been consistently collectively enacted over a wide range of decisions over a period of years. Many of the technical leaders had ascended to their positions on the coattails of the optical revolution. Their power and identities were tied up in the collective frame that optical technologies were essential to the future of EQUIPCO. The change in salience of this collective frame only came as their power bases were eroded (through layoffs of their staff) and as they were able to reconstruct new sources of power that related to alternative beliefs. For example, Hugh Collins only stopped fighting for the pro-optical frame when he could get involved in new projects by repositioning himself as a lead innovator rather than as an optical guru.

84 The power structure of the organization should for these purposes have quite a broad definition, including multiple sources of power. The power structure itself defines the nature of the sources of power. French and Raven (1968) identify five sources of power: reward and coercion (these two might be combined into a notion of positional power), expert, legitimacy, and referent. In EQUIPCO, hierarchy (position) is one obvious source, however there are many others. Individuals may exercise power due to their expertise (think of Hugh Collins’ experience as a senior scientist that gave him credibility in the decision-making process in a way that he wouldn’t have otherwise). The existing economic model for the business also confers power by defining how the firm makes money and who can play a critical role in producing profits (this is a form of legitimacy power). Referent power often comes from close identification with a powerful customer or business unit within the corporation. Giddens calls these sources of power “facilities.”
On the other hand, as Sewell points out, routinization itself is unpredictable and thus a source of change in and of itself: "schemas will be differentially validated when they are put into action" (Sewell 1992: 18). Enacting collective frames results in both intended and unintended consequences and thus the process of extending collective frames over time and space does not necessarily mean that the collective frame doesn’t change as it is reproduced. For example, in EQUIPCO, the “business case” frame was enacted more frequently as the telecoms crash forced fiscal restraint. This new view did not resonate with the technical people because they did not have much to draw on in their frame repertoires. However, one aspect of a business case was the ability to garner business unit support. The technical people, who had always been engaged in getting others to appreciate their “cool technologies,” began to repurpose the “business case” frame as a “business unit support” frame. By enacting this revised collective frame, they were able to get it to predominate in subsequent decisions (e.g., for Multiservice, Last Mile and Module).

This view of collective frames stands in stark contrast to more traditional conceptualizations of cognition in the strategy literature which have tended to depict management interpretation as a purely cognitive, psychological process in which viewpoints are immutable (Huff 1990b; Porac and Thomas 2002; Walsh 1995). As a result, actors are portrayed as victims of their own frames. The more sociological, structurational rendering of frames that I propose here opens up space for human agency. Even deeply embedded collective frames can be changed. Actors can enact new collective frames or repurpose old ones.

6.4.4 Framing strategies (agency)

The third feature of the structurational model of framing is agency. The importance of Giddens’ structuration theory is the incorporation of structure and agency into a model of society. Yet, Giddens’ notion of agency focuses primarily on the routinization of structures. While he argues that this routinization occurs on the basis that things could have been otherwise, in his model, agency seems primarily to function in reinforcing established routines. Even in the “critical situations” when past routines are dramatically disrupted, actors are portrayed by Giddens as functioning primarily to reestablish routines in the new context (Giddens 1979: 123-8; 1984: 60-62). This interpretation of agency does not seem robust enough for understanding strategic choice and action in organizations because it overemphasizes the routine and under
emphasizes the creation of new structures. Giddens focuses little attention on explaining how new patterns might emerge.

This is where Emirbayer and Mische’s (1998) extension of structuration is particularly useful. They point out that agency involves purpose and judgment as well as routine. Applying their temporal notion of agency to framing (integrating past, future and present aspects of human action), suggests that actors enact frames by drawing on the past (their frame repertoires), projecting into the future their desired outcomes and responding in the situated moment to the decision context and the frames and actions of others. In this sense, frames do not have to be “psychic prisons” (Bolman and Deal 1991/2003). In periods of relative stability, actors may draw primarily on the past. But, when existing frames and routines are disrupted, the past is no longer a useful signpost. Therefore, actors must shift their focus to projections of the future. This will likely cause them to draw differently on the past, perhaps combining frame elements in new ways (different from their pre-existing cognitive frames).

Actors not only see the world according to their own frames but engage in purposeful action to shape the frames of others. As a result, power is based in the ability to influence the construction of the collective frames that predominate as strategic choices are made. The act of projecting into the future involves the generation of possible frames that respond to actors’ interests (described by Emirbayer and Mische [1998] as “hopes, fears and desires for the future” p. 971). This occurs in the present when actors judge among their potential cognitive frames to respond to the contingencies of the moment. These contingencies involve not just the specific project or technical question, but also the interactions with other actors who are engaging in a similar process. Agency is not just about establishing one’s own cognitive frame but engaging in purposeful action to shape the collective frame. Actors attempt to shape the collective frame through deliberate framing strategies.

As I explored in depth in Chapter 5 on framing contests, framing processes are tightly intertwined with political processes for pursing interests. Giddens emphasizes that interpretive schemes and sources of power are inseparable in a model of structuration. While I have proposed to take a vertical slice on the mode of signification (rules) in the structurational model, when considering the framing strategies of actors (agency), it is particularly clear that this dimension cannot be separated from the sources of power (in Giddens’ words, “facilities”). The
field work in EQUIPCO demonstrated that frames and interests were mutually constituting. Thus, the framing of a project shaped and was shaped by the interests of the various actors. Different cognitive and collective frames activated different interests. Interests not only shaped the frames that people engaged within a situation but were also the outcome of the framing process itself in which interest formation was itself a sensemaking activity.

Sewell (1992) gives us a clue about how to build politics and the pursuit of interests into a theory of framing by suggesting that the underlying nature of the structures are likely to create the potential for political dynamics. The implication of his conception of multiplicity of meanings is that any situation can be interpreted in various ways and each of the different meanings can empower different actors. Similarly, his notion of “intersection of structures” implies that different actors can enact frames from one context and apply them in another in order to claim a territory (p. 19). In the Last Mile project, when Hugh and Hermann “staged a coup,” their purpose was to find support from a business unit for their project. In essence, they were enacting the “business case” frame to support a project that had been opposed by people whose cognitive frames were focused on the importance of the business case. They were able to mobilize support by co-opting a frame that had been used to oppose them.

Ultimately, however, I find it useful to turn to more political models of framing to build out the mechanisms of purposeful action that connect frames and interests. In particular, theories of framing from social movements research (a starting point of a great deal of the theoretical insights in Chapter 5 on framing contests) sheds particular light on the dynamics of framing when actors purposefully attempt to make changes to the predominant or embedded frames (Benford and Snow 2000). This stream of research suggests that making the choice not to enact the predominant collective frame (or once the predominant collective frame has been disrupted) will be an inherently political action. One can’t simply enact an alternative frame without engaging in political action to legitimate it. In the Savior project, Vince Weston recognized that the vision he was proposing would be a radical departure for the ATG group and EQUIPCO more broadly. He assiduously avoided bringing the project forward to the Steering Committee because he knew he would face tremendous opposition with the likely result that the project would be shut down. Instead, thinking that support from the boss would be an essential first step, he engaged in the political process of getting Brad on board.
Understanding the link between framing and political action is particularly important in the case of strategic choice (or any area where outcomes are organizational). Where no single person’s action will suffice to shape the collective frame, the decision process will be inherently political. It is precisely when meanings are contested that the interlacing of frames and political action will be most evident. This means that actors’ political pursuits of their own interests will shape which meanings will be salient and simultaneously that these actors can change the power balance by engaging in particular framing strategies. These dynamics occur in a process I termed “framing contests” in Chapter 5. The macro study reported in Chapter 3 demonstrates that these collective frames have real consequences for organizations. Top managers’ frames are associated with strategic action across a large number of firms. And, changes in frames lead to important changes in firm actions. It also suggests that these effects exist for a wide variety of firms and across time.

6.4.5 Summary of structurational model of framing

In this section, I have developed a structurational model of framing that responds to the findings from my macro large-sample study and my micro field study. I have used Giddens’ theory of structuration along with some important extensions by Sewell and Emirbayer and Mische to elucidate the dynamics of framing as they relate to strategic choice making in organizations. Several themes of the model are important:

- **Frame repertoires** are accumulations of knowledge based on the experiences of each individual actor. Different elements of the repertoire can be enacted in a particular cognitive frame about a situation. These repertoires both constrain and enable the construction of cognitive frames: the kinds of frames that can be produced must draw on those knowledge accumulations in the repertoire. At the same time, the repertoires enable myriad potential recombinations of those elements into new frames.

- **Cognitive frames** are enacted by actors based on their own frame repertoires and taking into account the frames and actions of others. Cognitive frames will become **collective frames** when they are collectively enacted, that is, when individual actors are successful in getting a group to enact a particular frame in a particular context. Collective frames attain structural properties through their continued reproduction over time and across
actors and contexts. The more implicated frames are in the sources of power (interests), the deeper their embeddedness and the harder they will be to change.

- Individual agency exists, not just in the reproduction of existing collective frames, but in purposeful framing strategies. Actors can enact new cognitive frames in the organization and attempt to get these frames to predominate collectively as strategic choices are made. As strategic choice making occurs in organizations (i.e., collectives of people), this purposeful action is inherently political.

- Frames and framing cannot be considered absent an understanding of the sources of power in which they are implicated. Cognitive frames and sources of power ("facilities") are modalities. Collective frames (sets of rules) and resources (power over things and people) are structures. The degree to which specific collective frames and specific resources are linked determines the degree of embeddedness of the collective frame.

- The more embedded a collective frame, the more difficult it will be to enact alternative collective frames. Yet, because of the multiplicity property of frames, the potential to enact alternatives always exists. And, it is this understanding that provides insight into patterns of continuity and change within organizations.

This structurational model of framing is an attempt to link history, interaction and agency as a way of coming to terms with the macro-micro split common in analysis of strategic choice (Hall 1995).\(^8\)\(^5\) It is a process rather than variance theory of framing in strategic choice.\(^8\)\(^6\) This type of theorizing is particularly suited to understanding events as they unfold over time,

\(^8\)\(^5\) Hall (1995) argues that this kind of approach is about analysis of the "mesodomain" (p. 399) (the space in which the macro and micro domains interact). It is at this level of analysis that one can understand structure to "provide conditions that shape but do not determine activity" (p. 399). Thus, it is in the mesodomain that the internal and external environment matter as they are interpreted by actors and as those frames then play out in organizational framing processes.

\(^8\)\(^6\) Markus and Robey (1988) provide a good discussion of the distinction between these two types (process and variance) of theorizing. In contrast to variance theories that put forward a static relationship between causal factors and outcome variables, process theories recognize the complexity and emergent nature of organizational phenomena. Yet, at the same time, process theories have as their goal the recognition and articulation of regularities in observed phenomena.
investigating changes in meaning, and exploring the conflicts and dynamics in a way not possible with variance theories (Orlikowski and Gash 1994).

6.5 Implications for theory and research

Using the structurational model of framing developed in this chapter, I now turn to its potential application for questions of strategic management. I start by exploring how a structurational model of framing can add insight to our understanding of firm response to technical change. Subsequently, I comment on the implications for research on theories of managerial cognition and of the practices of strategy-making. I suggest that this model offers a set of underlying mechanisms that can explain some of the varied (and often conflicting) empirical results reported by scholars in the field. I summarize the insights in a set of propositions that articulate the connection between frames and strategic choice and action.

6.5.1 Firm response to technical change

What motivates much of the explorations in this dissertation is the continued challenge of understanding heterogenous firm response to technical change. As mentioned in Chapter 2, scholars have produced many competing explanations, few of which have considered the notion of framing explicitly. Where the concepts of frames or cognition have been mobilized, they have primarily been seen as inertial factors that explain firm resistance to change (c.f., Huff et al. 2000). How might the structurational model of framing explain the inertial behavior we see in so many firms in the face of technical change? First, the modalities or, specifically, the frame repertoires can be a source of inertia. If frame repertoires are actors’ accumulations of knowledge based on experiences, changes in frames are limited by what accumulations are present in the repertoires of people involved in the decision-making. To the extent that the decision makers are a relatively homogeneous group, and particularly if they have been in the firm for a long time, they will not have the opportunity to encounter alternative frames about a situation and therefore will be unlikely to understand new things. Second, to the extent that a particular collective frame has been enacted consistently over time in an organization and has therefore become institutionalized, it can prevent a firm from adopting an alternative interpretation of the market or technology even as these environmental factors change. This will be truer as collective frames become more deeply embedded through tighter links with resources.
These notions could explain why we see so many firms changing their senior management team in periods of discontinuity (Tushman and Rosenkopf 1996; Virany et al. 1996). It might also explain why, for example, Burgelman found that Intel was only able to shift away from DRAM technology through an autonomous strategy-making process that involved multiple levels of management (Burgelman 1994). In his telling of the Intel story, the senior management team was locked into thinking that DRAMs were an essential part of the corporate portfolio. However, the autonomous process allowed them to expand the frame repertoires from which to enact frames of the business by involving more people in the decision-making process.

Where research on firm response to technical change has posited cognition as an explanatory factor, it has tended to be descriptive of the phenomenon without providing a sense of the causal mechanisms. The structurational model of framing provides some insight into what those mechanisms might be. Tripsas and Gavetti (2000), for example, demonstrate that Polaroid’s difficulty in responding to the emergence of digital photography was due to the inability of management to change its frame about the desired economics of the business (away from the traditional razor-and-razorblade model). The technical organization had been at the cutting edge in exploring these new digital technologies even though they were very different from the core technical competencies that had made the company successful in the instant film photography business. Despite the technical leadership achieved through research, the firm was unable to capitalize on developments in digital technology, even after hiring new people to undertake the effort. There are two puzzles here. First, why was the technical organization able to engage in research in these new digital technologies? And, second, why were senior managers incapable of thinking about the business in a way that would allow them to capitalize on the technical developments? Tripsas and Gavetti’s evocative description of these phenomena can be supplemented by a theory that captures the underlying mechanisms that would explain both dynamics.

The authors point out that one of the collective frames in the organization focused on technical primacy. In this sense, technical development that moved well beyond the bounds of

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87 The “razor and razorblade” economic model is one based on selling a more durable good (a razor handle, an instant camera) at cost or a reduced price and making money on the disposable items required for its use (razor blades, instant film).
instant film into the realm of digital imaging was not surprising. Yet, this search was constrained by other collective frames that may have been even more deeply and broadly embedded in the sources of power in the organization. Possession of technical capabilities was not sufficient to change Polaroid’s strategic direction. The inertial force of the razor-and-razorblade frame can be attributed to the resources with which it was intertwined. It was not enough for Polaroid’s top managers to hire new people to develop digital imagery if the incompatible collective frames (both about the economic model as well as the value of having a product that required film as an input) were connected with the sources of power in the organization. The senior team had achieved their positional power by collectively enacting these frames over time. And, the roles and relative sources of power of such groups as manufacturing (experts in disposable items) and sales (experts in positioning razor-and-razorblade products) were dependent on the existing collective frames. The new hires, who had accumulated quite different frame repertoires because of their experiences outside of Polaroid, enacted cognitive frames that could not help but contrast with those of the existing senior managers. These new members of the organization were not effective in getting these cognitive frames to predominate as collective frames when choices about investment were made. As a result, the frames did not develop any kind of structural properties that could shape outcomes over time. Thus, while Tripsas and Gavetti establish convincingly that, in the case of Polaroid, cognition matters for outcomes, the structurational model of framing can suggest a set of dynamics to explain why this might be the case.

The structurational model of framing provides a set of mechanisms that can explain the patterns in other studies of firm response to technical change even where they have not put cognition front and center in the interpretation of the data. To illustrate this point, I will take two seminal examples from the management of technology literature, those of Henderson and Clark’s (1990) study of photolithography firms and Christensen and Bower’s (Christensen and Bower 1996; Christensen 1997) study of computer disk drive firms. Henderson and Clark (1990) demonstrate that, at least in the case of the photolithography industry, firms have difficulty responding to architectural innovations because they destroy the usefulness of existing knowledge. They define architectural innovations as ones that require new connections between relatively unchanging components. They argue that making these kinds of reconnections (or even recognizing the need for this type of innovation) is particularly difficult because this
architectural knowledge becomes embedded in the structure and information-processing procedures of the organization.

A structurational model of framing provides an understanding for why this phenomenon might exist. Henderson and Clark focus on disruptions to architectural knowledge. In the structurational model, cognitive frames are enacted from accumulations of knowledge (frame repertoires). These frames can become deeply embedded to the extent they are enacted collectively and implicated in the sources of power of the organization. In the case of photolithography firms, the predominant collective frame implied a particular organization structure, hierarchy of expertise and value in production. Architectural innovations were essentially the products of alternative frames (and would have required new collective frames to conceive of and implement them). However, for incumbents, this new frame would have disrupted the tight links between the existing collective frame and resources. Thus, it is not the architectural nature of the innovation per se that creates the problem. Through the lens of the structurational model of framing, architectural innovations are a specific case of situations that challenge the links between collective frames and resources. If an alternative frame has implications for the balance of power in the organization, it is less likely to be enacted by those in power positions.

A comparable argument could apply to Christensen and Bower’s (Christensen and Bower 1996; Christensen 1997) story of the impact of innovation on incumbents in the disk drive industry. They found that firms could respond to any type of innovative change if that change involved existing customers but did poorly when innovations were initially developed for other customer sets. They argue that resources are allocated to programs targeting powerful customers. The structurational model of framing suggests that particular collective frames about the right customers to target and the required technologies were so embedded in the sources of power in the organization, that they were difficult to dislodge. “Disruptive innovations” are disruptive of the collective frame-resource linkage. In another study, Christensen and colleagues find that firms in the disk drive industry that entered well in advance of the establishment of a dominant design were more likely to fail than those firms that entered just as the dominant design was coalescing (Christensen et al. 1998). They argue that the early entrants locked in on the wrong technologies and found it hard to make the switch when the winning version emerged.
The structurational model would suggest that the mechanism explaining the lock-in is the link between collective frames and resources. If a firm makes a bet on the wrong technology well in advance of the formation of the dominant design, then it is more likely the underlying collective frame that led to the investment choice will become embedded as resources such as incentive structures are enacted in concert with this view. Once embedded, the organizations might find it harder to enact an alternative frame once the dominant design became apparent.

The structurational model of framing offers an explanation for the underlying causes of the dynamics observed in each of these studies. The inertial effects can be attributed to the depth of embeddedness of frames. More deeply embedded collective frames are tightly intertwined with resources, and it is this linkage that proves difficult to change. These studies thus provide insight into the dimensions of collective frames and resources that explain outcomes. Product architecture, customer demands and dominant designs are all types of collective frame-resource linkages. Each of these studies I have highlighted makes a compelling case for the relationship between these specific factors and inertial response. The structurational model does not replace these explanations. Rather, it helps explain why the effects occur.

In all of these cases, agency was depicted as being tightly conscribed. Alternative views were not heard or had trouble gaining any kind of legitimacy within the incumbent organizations. Existing embedded collective frames continued to be reproduced. Yet, I believe that this demonstration of the role of framing in inertial responses to technical change only tells half the story. While the view that frames or cognition would be a force of stasis is consistent with many of the accounts of cognition and technical change, there are others who suggest that managerial interpretation can also be a force for adaptation. In the management of technology field, there is an emerging stream of research on the evolution of technology trajectories (Garud and Karnoe 2001; Garud and Karnoe 2003; Van de Ven and Hargrave 2003)\(^8\) that suggests purposeful action is an essential part of the explanation for what shapes technical change at the industry level. The

\(^8\) Garud and Karnoe (2001; 2003) contrast the notions of path dependence and path creation. They argue that actors purposively manipulate circumstances, either to reproduce existing structures or to disengage from these structures and pursue different trajectories. While they bring agency back into the technology evolution story, they neglect power. For them, all options are open and the outcomes are just a matter of path creation. Van de Ven and Hargrave (2003) as well as others who are bringing social movements theory into analyses of technical change (Wade, Swaminathan, and Dowell 2002; Zald, Morrill, and Rao 2002) focus explicitly on the political dimensions which both constrain and enable agency.
findings from my field study reflect similar insights at an intra- rather than inter-firm level. These studies are consistent with a view that agency does not exist simply as a notion that things could have been otherwise (à la Giddens) but that purposeful, often political, action can take place.

As I discussed in Chapter 2, the research on firm response to technical change has for the most part taken on a deterministic flavor. Technical change occurs and firms, typically, fail to adapt. By incorporating notions of modalities, structure and agency, the model I develop in this chapter suggest how frames and framing can be forces for adaptation or change. In particular, the model suggests the conditions under which adaptation or inertia might be more likely. The key hinges on the idea that collective frames cannot be considered absent an understanding of the other structures with which they are implicated. Even while the structurational model of framing that I propose focuses on the structure of signification, the value of structuration theory is not only in pointing out the recursive nature of structure and agency but in highlighting the way frames (sets of rules) are intertwined with resources. As such, inertial response will be more likely when the frames are more deeply embedded. Change will be more likely when these interconnections are disturbed (and therefore more likely to be reshaped).

**Proposition 1:** Inertial firm response to technical change will be more likely when the collective frames in the organization are more deeply embedded (where the degree of embeddedness is determined by the tightness of the links between collective frames and resources and by how much these frames have been enacted across time and space).

**Proposition 2:** The likelihood of firm adaptive response to technical change will increase to the extent that the collective frame-resource linkages are disturbed, thus creating a space for new collective frames to be enacted.

A disturbance in the interconnections of structures can occur in two ways. The first source of disruption is an exogenous force. In the case of my observations at EQUIPCO, the crash in the communications market can be taken as an exogenous shock to the Advanced Technologies Group. These kinds of changes, if powerful enough, can disrupt the connections between sets of rules (collective frames) and resources. Once these connections are broken,

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89 Of course, what is exogenous is highly dependent on the level of analysis. An exogenous disruption to an individual firm (e.g., a major technical change introduced into the industry) might be endogenous at the level of the industry itself. Therefore, these distinctions between exogenous and endogenous are relative. Depending on the level of analysis, different forces will serve as exogenous.
people are more likely to enact alternative frames. The second source of disruption can come from the political action of individuals or groups within the organization to get a new collective frame to predominate. The social movements literature on framing (Benford 1997; Benford and Snow 2000) has demonstrated that actors can purposefully break and remake the connections between collective frames and resources by mobilizing a powerful enough group around an alternative collective frame. These two sources can be interrelated. As suggested in Chapter 5 on framing contests, while the crash in optical communications created fertile ground for change, it was the action of individuals and groups engaging in framing contests within the organization that caused the change in collective frames, and ultimately in strategic direction, to occur. An exogenous change can create what the social movements theorists call a “political opportunity” (Gamson and Mayer 1996) that opens up a space for the purposeful action of actors.

**Proposition 3:** The disturbance of the collective frame-resource linkage can occur through an exogenous shock and/or collective action within the organization. Purposeful action of individuals within the organization is essential to create and/or respond to these disturbances.

The structurational model of framing does appear, therefore, to have some power in explaining organizational outcomes in the face of technical change. It opens the door to a series of questions that further research could attempt to answer. What are the different types of collective frame-resource links that contribute to inertial responses to technical change? What contributes to embeddedness of frames? Under what conditions is purposeful action that disrupts collective frames more likely? What characteristics might a non-inertial firm possess?

6.5.2 Role of managerial cognition in strategy

The structurational model of framing is a very different take on managerial cognition than the one that predominates in the literature today. It is both more social and more political than the psychological constructs used by most scholars in the field. Research on frames and their role in strategy has mainly taken place in the domain known as managerial cognition. I point out in Chapter 2 that there is an extensive and growing literature on this topic. Indeed, the examination of cognition in the managerial arena goes back at least to March and Simon (1958) who argued that everyone in a firm brings a certain cognitive foundation, a set of “givens” to any management decision – assumptions about the future, knowledge about alternatives and a view of the consequences of pursuing each alternative. This is an essentially psychological view of cognition where the cognitive foundation forms the basis of simplified representations of the
information environment. These simplified representations must be made because of cognitive limits in the face of an information environment that cannot be known in all of its complexities.

Using this concept of bounded rationality, scholars in strategic management have argued that frames are the basis of strategic action directed by management (Huff 1990a; Kiesler and Sproull 1982; Porac et al. 1989; Prahalad and Bettis 1986). While frames have their origin in the cognitive psychology of the individual, these scholars have found it useful to conceptualize frames as the property of both individuals and collectives (Carroll 1993; Kogut and Zander 1992) such as groups or coalitions (Peteraf and Shanley 1997; Reger and Huff 1993), firms (Prahalad and Bettis 1986) and industries (Porac et al. 1989). And, they have analyzed a whole host of different kinds of frames: frames about the nature of the technical change (incremental or radical); whether the change is a threat or opportunity (Dutton and Jackson 1987; Gilbert 2002; Jackson and Dutton 1988); the relevant dimensions of merit to evaluate the technology (Das and Das 2001); the scope of the impact, including how the technology is envisioned to evolve and how it should be incorporated into the firm (Prahalad and Bettis 1986); and the nature of the competitive set (e.g., Baum and Lant 2003; Lant and Baum 1995; Peteraf and Shanley 1997; Porac et al. 1989; Reger and Huff 1993), to name a few. These studies essentially demonstrate that collective frames of different sorts do exist in organizations.

Yet, when faced with the challenge of explaining firm response to technical change, I found this literature lacking in three important ways. First, most of this research is based on relative static views of frames. It tends to be descriptive, identifying frames but not studying them in a situated process of framing. In his seminal review piece on managerial cognition, Walsh (1995) highlighted more than 70 different terms for cognition nearly all of which were focused on the fixed notion of the frame rather than the dynamic notion of framing. For example, the stream of research on cognitive competitive sets identifies managerial categorizations of competitors and assesses their “accuracy” relative to an analytically defined categories established by the researchers (Baum and Lant 2003; and Porac et al. 1989 are good examples of this). These studies tend to be cross-sectional and therefore do not analyze how these frames might change over time. In addition, they often do not connect the frames to strategic outcomes. The structurational model of framing focuses less on accuracy and more on the meaning as experienced by the actors themselves. And, it suggest that collective frames are

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inherently the product of a dynamic process of framing and become embedded only to the extent they are reproduced over time.

Second, when group or organizational level frames are considered in this literature, the focus has been on the central tendency rather than on differences of views within the organization. For example, in her use of survey data to examine top managers’ frames, Sutcliffe takes an average of survey responses by management team to establish the collective view. She focuses her efforts on establishing a high degree of commonality of frames across members of a management team (Sutcliffe and Huber 1998; Sutcliffe 1994). There is less explanation in this work about the processes by which a frame comes to be collectively reproduced over time, nor about how potential differences in cognitive frames of the actors get resolved. The structurational model of framing suggests that differences in cognitive frames can easily arise because of different accumulations in the frame repertoires of actors. The collective frames may appear to be relatively fixed and “shared” across a wide set of actors in the organization to the extent that they are deeply embedded. Again, because this research has tended to be cross sectional, it has not focused as much on potential differences in frames within the organization.

Third, by foregrounding cognition, much work in this arena tends to push politics and interests to the background. This kind of research approach can say little either about conflicting views or about potentially political processes for producing collective meaning. Where frames are considered at other than the individual level, this stream of research has focused on the relatively apolitical notion of “shared” frames. There is little sense of the political and contested processes necessary for producing a collective frame. Managerial cognition research attributes firm inertia to individual cognitive inertia (an entirely psychological perspective). My model suggests that people can “change their minds” but this potential can only be understood in a social context and in interaction with interests. The stickiness of frames is not so much about individual cognitive inertia but about embeddedness and linkages with resources. The psychological approach seems more able to explain inertia than change. When change is considered, this view on cognition simply notes that “inner models will eventually conform to the new reality” (Horowitz 1979: 249; as cited in Huff et al. 2000). The only lesson from this work about change in frames is that it takes time, but this approach doesn’t take into account the process of negotiating how the new reality may be understood. These scholars argue that change
can take place if actors can plausibly challenge the shared cognition but don’t describe how this would happen or what makes this kind of challenge possible. There is little to suggest the mechanisms by which embedded collective frames can be changed.

The structurational model of framing, on the other hand, suggests that our understanding of cognition needs to be expanded in the context of strategic management, moving beyond the unidimensional, social psychological sense of cognition as an aggregation of individual views to an interactive, dynamic and political process of meaning construction (Gamson 1992). This model is the product of having taken cognition “outdoors.” Vaughan (1996) notes that this type of research approach naturally leads to a more sociological, rather than psychological notion of cognitive frames. By taking cognition “outdoors,” I show that questions of accuracy of frames may be less relevant to an understanding of strategic choice. Rather, it appears to be more useful to understand how the collective frames that shape strategic choice are produced and reproduced within the organization. It also provides a means for understanding how purposeful action can shift existing embedded collective frames.

This route naturally demands a more longitudinal rather than cross-sectional approach to research. The structurational model of framing suggests that it is difficult to understand collective frames without understanding the resources with which they are implicated. It also suggests that there is a strong distinction between cognitive frames and collective frames, and also that these collective frames can be embedded to different degrees depending on the tightness of the collective frame-resource linkage. As such, research on frames would require an examination of collective frames in their context rather than in the brains of the individual managers.

**Proposition 4:** Collective frames are not simply cognitive constructs but rather are established through contested, political process within the organization. They only have a sustained effect on organizational outcomes to the extent they are reproduced over time. Changing embedded frames requires a similar contested, political process.

6.5.3 **Strategy-making**

The exploration of strategy-making in this dissertation was done in the service of developing an understanding of how firms respond to technical change. Studying strategic choice was the most fertile terrain for making the connection between frames and organizational action. Yet, the empirical findings and the structurational model of framing developed from
them have reciprocal implications for an understanding of how strategy gets made in firms. Within the field of strategic management, the vast majority of research has focused on the content rather than the process of strategy (Langley 1989; Mintzberg and Lampel 1999). Where research has focused on the process, it has been more likely to produce stage models (c.f., Bower 1970; Burgelman 1983; Burgelman 1994; Fredrickson and Mitchell 1984; Mintzberg et al. 1976; Nutt 1993; Nutt 1984; Pettigrew 1985) that are in some sense disembodied from the agency of the individual actors. The Bower-Burgelman model (Bower and Doz 1979; Bower 1970; Burgelman 1996; Burgelman 1983), for example, identifies three key stages in strategy-making: definition, impetus and context. The important insight from their model is that different levels of management may be involved to a greater or lesser extent in each of the stages, and in particular, that senior management may not be the key driver of many strategic outcomes.

These process models are longitudinal and therefore add a richness to understanding how strategy is produced that content-based, cross-sectional models cannot. However, they lack the ability to make sense of the frictions present in the day-to-day practice of making strategy (of the kind that I observed in my study of EQUIPCO). It is for these reasons that the calls for more practice-based models of strategy-making have been amplified in recent years (Hendry 2000a; Johnson et al. 2003; Whittington 1996; Whittington 2003). These scholars have urged a focus on strategists and strategizing rather than on organizations and strategies. Empirical scholarship in this area has been sparse. The European Group on Organization Studies (EGOS) conference has had a track on micro-strategizing for the past three years and the Strategic Management Society has introduced a theme on the practice of strategy in its upcoming annual meeting (2004). In addition, a recent Journal of Management Studies volume provides some emerging empirical work from Europe.

90 This view is consistent with scholarship on situated action (e.g., Suchman 1987) that suggests that individual knowledge about what to do is highly situated. What someone is capable of thinking or doing in one context they are not capable of thinking or doing in another setting. In application to the field of strategic management, the ideas is that scholars will not be able to understand strategic choice without understanding the work of strategists in strategizing activities.

91 Journal of Management Studies, Volume 40, Issue 1. It includes an introduction by some of the major proponents of strategy as practice in Europe (Gerry Johnson, Leif Meilin and Richard Whittington) and a few empirical papers on strategic change, the roles of center and periphery in organizational innovation, routines and the resource based view, the failure to make strategy, and the discourse of boardroom strategists. None of the articles includes an examination of managerial frames per se.
Like scholars in this emerging field of strategy-as-practice, I argue that an examination of strategic practices is more useful than the development of stage-based models of process disembodied from the individual actors. Yet, in contrast to these scholars, I suggest that the use of the strategists as the unit of analysis abstracts actions too far from the context and constraints in which they take place. The structurational model of framing implies that strategy-making is best studied through the lens of the projects and decisions that are produced.

This stream of research on micro-strategizing is admittedly in its infancy and therefore it would be inappropriate to make strong critiques of the work to date. However, the usual critiques of micro level studies in general can be made of this work specifically: there tends to be an over-emphasis on the agency of the individuals with less ability to analyze the structures that constrain or entrain their actions. The design of the research in this dissertation was intended to overcome this limitation. By integrating both macro and micro perspectives in the structurational model of framing, my goal has been to avoid some of the limitations of the purely micro approach. While the model demonstrates the essential role human agency plays in making strategic choices, it also highlights the power of embedded frames to shape action.

A structurational model of framing forces a shift in focus to the interactions that produce strategic choice. While collective frames may be enacted recurrently over settings and time, the actions that produce (and reproduce) them are localized to a specific setting. The results from the micro field study show that this setting is most appropriately viewed as the project rather than the firm. I take an expansive definition of “project” to include any type of strategic initiative around which actors coalesce in order to make a strategic choice. The term “project” should not be understood as simply a middle-management or front-line activity. A project or initiative is any case where a question about strategic direction is posed and people engage in a process to reach an answer. By focusing on the practices of strategy-making, the firm recedes as the predominant social structure for strategy and the project or initiative comes into view as the critical locus (Obstfeld 2004). Most strategy research treats firms or business units as macro-level wholes. Some research has demonstrated that strategy should instead be analyzed at the program level (Cockburn and Henderson 1994), but there has been less work that has identified the project as the focal point. As a result, suggestions by scholars in the emerging strategy-as-practice stream of research to focus on the strategists as the level of analysis and their work may
be incomplete. The structurational model of framing suggests that the terrain is critically important for understanding interaction. As a result, it may be appropriate to place the project/initiative front and center as the level of analysis in order to consider the larger (macro) structures and individual (micro) actions that interact to produce strategic choices.

**Proposition 5.** The strategic initiative or project broadly defined is the terrain in which framing processes take place. It is the interactions of actors in these specific contexts that shape the collective frame that will predominate as strategic choices are made.

This encourages further multi-method work in strategy. By triangulating across different optics of the same phenomenon, the researcher can simultaneously capture salient macro and micro perspectives. This is therefore primarily a call for more field work in the area of strategy since much has been done at the macro level. The structurational model of framing also suggests the need for longitudinal data which can allow researchers to assess institutionalized structures (such as collective frames) that are enacted over settings and time as well as actions (such as framing) that are specific to a local setting (Barley and Tolbert 1997: 99).

### 6.6 Conclusion

The goal of this chapter has been to develop a model of framing in strategic choice that is sensitive to macro and micro dimensions of the problem. This model is both grounded deeply in an empirical context and informed by social theory. This iteration between data and theory has led me to push the boundaries of both. I sought out the structuration theory of Giddens to help integrate the results from my macro, quantitative large-sample study and my micro, qualitative field study. And, I was interested in Giddens, not just for the purposes of arguing that structure and agency (in my case, collective frames and framing) both matter for outcomes but rather to explore the mechanisms that underlie this interrelationship. This has led me to draw on theoretical work that has amplified Giddens’ notions of both structure and agency and to make my own amplifications of the theory as well. The result is a model that emphasizes the highly social and interactional nature of both cognitive and collective frames in the context of such a complex, multi-person, organizational process as strategy-making.

The model takes history(ies) seriously as a shaper of outcomes but identifies the mechanisms for that effect as the frame repertoire of each actor. These repertoires are accumulations of knowledge from the multiple contexts in which the actor participates. The
repertoires are the source of the frames that are enacted in particular decision situations. Cognitive frames are constrained and enabled by the repertoires themselves. History matters, but it matters in ways different than those attributed to it in evolutionary theories of path dependence. In the structurational model, the weight of history is not deterministic. Path dependence is an achieved result that comes from the ways that actors enact frames over time.

The model offers a way of thinking about inertia and adaptation in organizations. Much of what the management of technology literature focuses on explaining is the inertial response of firms to technical change. While that research has produced many alternative explanations, the structurational model of framing identifies a common underpinning mechanism common across many of them. Inertia is the product of the depth of the embeddedness of frames (about the technology, about capabilities, about target customers, etc.) and their implication in the resources of the organization. Simultaneously, this model offers more hope than many of the other theories do. Because of the potential of actors to exert agency by enacting alternative cognitive frames and working to get them to predominate as the collective frame when choices are made, the fate of the firm is not wholly determined by the pre-existing frames. The model makes it clear why this kind of change is hard, but it also points the way. These kinds of changes are more possible when exogenous shocks disrupt the links between existing collective frames and resources (think of economic shocks, technical change, or even the replacement of top management by the Board of Directors). They are more likely to succeed if actors appreciate the complex and political processes required to get an alternative frame to become collective.

The model highlights the importance of the depth of an embedded frame in dealing with change. The less embedded a frame is, the more likely that alternative collective frames will emerge to predominate in strategic choices. Yet, the advantage of a deeply embedded collective frame is that it can smooth the decision-making process and the implementation of strategic actions. This is, of course, the “essential tension” of which Kuhn (1977) wrote: “Very often the successful scientist must simultaneously display the characteristics of the traditionalist and of the iconoclast.” The structurational model of framing suggests that both are possible. Forces for tradition only exist to the extent that actors reproduce them. Yet, the iconoclastic effort to change collective frames is only possible to the extent that it can reshape the links between collective frames and resources.

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