Reversing Course:

IBM’s Strategic Recovery in the Flat Panel Display Industry

J.P. EGGERS
New York University, Stern School of Business
Department of Management and Organizations
40 West 4th Street, Tisch 715
New York, NY 10012
Tel: 212-998-0874
jeggers@stern.nyu.edu

Keywords: strategic recovery, renewal, failure, organizational structure, managerial framing

I am indebted to seminar participants at NYU, as well as Danielle Dunne, Roger Dunbar, and Sarah Kaplan, for comments on a prior version of this paper, and to undergraduates Dongmin Kim and Amy Zhou for invaluable research assistance.
Reversing Course:
IBM’s Strategic Recovery in the Flat Panel Display Industry

Abstract:
This study focuses on the process by which IBM transitioned from being a leader in the fledgling but failing plasma display market in the early 1980s to being a leader in the emerging liquid crystal display (LCD) market in the early 1990s. By contrast, nearly all other early plasma supporters failed to capitalize on the emergence of LCD. I call the process by which IBM managed this transition “strategic recovery”, which I view as a specific type of strategic renewal activity. The data reveal six key elements of IBM’s story, of which two are both novel and relatively unique to IBM in this specific industry. First, IBM utilized a hybrid structure for decision-making about early-stage research that allowed the firm to build basic LCD competences despite the organization’s pursuit of plasma. Second, LCD supporters at IBM encouraged a managerial framing that focused executive attention on the business case for flat panel displays and not on technological details, thus minimizing inertia resulting from the failure of the plasma investment. The study offers a two-part model of strategic recovery that provides key insights into how firms can and should attempt to recover from prior strategic failures.
INTRODUCTION

Managers make choices and tradeoffs all the time, whether about supporting one technology over another, or expanding into this country versus that one. Despite the best efforts of managers, some of those choices invariably turn out wrong. What happens next, however, is less clear. In some cases the firm continues its commitment to the failed path despite disconfirming evidence (Guler 2007; Staw 1981). In other cases the experience of failure affects subsequent decision-making in ways that prevent effective strategy-making for the firm (Baumard and Starbuck 2005; Eggers 2009). And in some cases the firm terminates its investment in the failed path and successfully reorients around the new path.

This study focuses on the process of switching from a failed path to a more successful one, a process that I refer to as “strategic recovery.” Strategic recovery is akin to strategic renewal in that it involves the “refreshment or replacement of attributes of an organization that have the potential to substantially affect its long-term prospects” (Agarwal and Helfat 2009, p.282). It differs, or is more specific, in that it deals with the process of recovery from a failed decision, as opposed to a long-term process of decay and inertia (e.g., Kim and Pennings 2009). Much of the work on renewal deals with the perils caused by long-term success, including inertia (Miller 1994; Miller and Chen 1994) and competence traps (Leonard-Barton 1992; Levitt and March 1988). Strategic recovery can be seen as a subset of strategic renewal and the literature on firm-level adaptation, but is different in that the challenges to decision-making come from failure instead of success.

The goal of this paper is to shed light on the organizational characteristics and processes that facilitate recovery from failed decisions. It focuses on IBM’s experience in the flat panel display industry. IBM was one of the earliest industry entrants, investing significantly in R&D and manufacturing for plasma display panels targeting computer monitors. Over time, IBM and other early plasma supporters realized that plasma would not be successful for computers and faced an important decision – to switch to liquid crystal displays (LCDs) or to abandon the flat panel display industry. Unlike most of its plasma-supporting brethren, who either exited or took up peripheral positions as component suppliers, IBM reversed direction in the 1980s and emerged in the 1990s as a world leader in LCD panel manufacturing.
This study identifies six mechanisms that contributed to IBM’s success, and both compares those mechanisms at IBM with those at other industry players and links those mechanisms to existing literature. In so doing, I offer a model of the strategic recovery process that categorizes four mechanisms as “necessary but not sufficient.” The remaining two mechanisms are especially interesting and have the broadest implications for future research. First, managers at IBM maintained a focus on the critical business problem (self-cannibalization of their CRT business and the creation of portable computers) instead of the technical details of LCD versus plasma, and that framing helped overcome inertia created by failure. This finding has implications for literature on managerial framing (Barr, Stimpert and Huff 1992), and specifically for studies suggestion that the orientation of managerial framing is important to innovation and adaptation (Eggers and Kaplan 2009; Tripsas and Gavetti 2000). Second, IBM possessed an R&D structure with mixed decision-making processes. IBM was centralized in that there was a single research group, but it was decentralized in that resource allocation rights were pushed down in the organization to fund exploratory research. This finding has important implications for research on the link between structure and innovation (Dewar and Dutton 1986), as it provides insight into conflicting results supporting centralization (Argyres and Silverman 2004; Siggelkow and Rivkin 2005) versus decentralization (Bower 1970; Burgelman 1991).

This paper is organized as follows. While I reserve most of the theoretical development of the study until after discussing the case, in the following section I briefly explain why strategic recovery is distinct from, but related to, both strategic renewal and learning from failure. After introducing the data and methods, I provide a brief overview of IBM’s experience in the flat panel display industry to demonstrate the uniqueness of IBM’s case. I then dig deeper into the processes behind IBM’s actions, identifying six key factors associated with successful recovery at IBM, and relating those factors to prior research before discussing implications for future work on strategic renewal and innovation.

LOCATING STRATEGIC RECOVERY IN THEORETICAL CONTEXT

Agarwal & Helfat (2009) define strategic renewal as “the process, content, and outcome of refreshment or replacement of attributes of an organization that have the potential to substantially affect
its long-term prospects” (p. 282). There are important differences, however, between general renewal and a specific response to failure. The perspective of strategic renewal is normally at the organizational level, where firm performance has declined and the firm then seeks new solutions (Barr et al. 1992; Crossan and Berdrow 2003). A response to a failed decision is unique for two reasons. First, a failed strategic action initiates organizational momentum, and reversal of direction against this momentum is difficult to manage (Miller and Friesen 1980; Shimizu and Hitt 2004). Second, failure itself is different from an organizational decline (Huff, Huff and Thomas 1992; Kim and Pennings 2009). Research on learning from failure has shown that, despite the theoretic appeal of learning from failure (Sitkin 1992), learning is impaired because of differing beliefs about failure (Cannon and Edmondson 2001) and the desire to place the blame for failure elsewhere (Baumard and Starbuck 2005). Additionally, failure has been shown to lead to risk averse behavior through threat-rigidity (Staw, Sandelands and Dutton 1981) and a heightening of risk aversion (Eggers 2009; Noda and Collis 2001) that inhibits renewal actions. Because of these key differences, the mechanisms that drive recovery will be different from those affecting renewal.

Strategic recovery is also related to learning from failure (Starbuck and Hedberg 2001). Most of the work on learning from failure focuses on how firms take diagnostic information garnered from significant failure and integrates that knowledge into future behavior (Sitkin 1992; Starbuck and Milliken 1988). Research focuses on why firms do not properly utilize this knowledge to make future decisions (Baumard and Starbuck 2005; Cannon and Edmondson 2001). A central issue is the need on the part of managers to admit and accept the causes of failure, and to demonstrate willingness to learn from failure (Cannon and Edmondson 2005; Husted and Michailova 2002). Thus, the literature on learning from failure has largely been concerned with how mistakes can lead to learning improvements that reduce the likelihood of mistakes in the future. Strategic recovery, on the other hand, is less concerned with learning as the goal is not necessarily to improve a process through feedback-based learning. Instead, the view of strategic recovery is that some failures may be random or blameless, a possibility that may be especially likely when considering investments made in an uncertain and evolving new industry. Failure can potentially affect future decision-making (Eggers 2009; Staw et al. 1981), and strategic recovery is about
how to recognize those failures to recover by making intelligent and value-creating decisions in the future. In this respect, strategic recovery starts with failure and looks at how firms recover.

**Using Resource Allocation Literature to Direct Search**

Strategic recovery can be viewed as a series of linked resource allocation decision processes, where a previous unsuccessful decision influences future resource allocation efforts. As such, research on the resource allocation process and related studies can offer ideas concerning what to look for in firms recovering from a failed investment. The three core elements of Bower’s (1970) resource allocation model were definition, impetus and structural context. Definition suggests that organizational goals and, more specifically, how those goals affect managerial incentives and expectations will impact the projects selected for consideration. In thinking about recovery, specific organizational goals as well as how middle and senior managers frame those goals (Barr et al. 1992; Kaplan 2008b) will impact managerial priorities when considering potential recovery projects. Impetus deals with the force with which managers advocate the project, which is linked to the efficacy of the project as well as the manager’s perceptions of the costs and benefits of failure and success. In the case of recovery from failure, it may be that the costs of a second mistake would be seen as significantly higher, especially in terms of managerial reputation. Structural context includes “the formal organization, … the system of information and control, … and the systems used to measure and reward performance of managers (Bower 1970, p. 71).” The three elements of Bower’s original resource allocation model suggest a focus on three specific aspects of IBM’s story – the managerial framing of the firm’s strategic priorities, the ways in which perceptions of the initial failure may affect recovery efforts (including perceptions of risk), and how organizational structure may affect the process by which the second effort is approved or not.

Much of Bower’s (1970) original work focuses on the role played by middle managers in championing projects within a firm. Thus, I pay particular attention to the activities of the middle managers, especially the scientific managers within IBM. Additionally, Burgelman’s (1983, 1996) resource allocation work and a recent reframing from Bower & Gilbert (2005) point out the importance of the strategic context for the resource allocation process, in terms of understanding how managers frame
the strategic imperatives of the firm based on signals from the external environment. Hence I consider carefully the role played by important customers and evolving product market expectations as managers attempt to deal with uncertainty. The key question becomes what external changes occur that may differentially affect the first and second sets of decisions.

**DATA AND METHODS**

This research is an in-depth study of IBM’s involvement in the development of the flat panel display industry. In the 1960s and 1970s, IBM was one of more than a dozen firms with R&D investments in plasma displays. By the early 1980s IBM was the undisputed leader in plasma displays, though sales were small. By the mid-1980s, however, IBM and practically every firm pursuing plasma had abandoned it. The vast majority of early plasma supporters either left the industry or took up peripheral positions in the emerging LCD market. IBM took a different path, and by 1992 had become a world leader in active-matrix LCD manufacturing, less than five years after abandoning plasma displays. This historical trajectory makes IBM a unique case of reorientation after a failed investment. The study uses a grounded theory approach to uncover the process of transition at IBM (Glaser and Strauss 1967/1999; Siggelkow 2007; Yin 1984/2003). The data were obtained from company archives, public sources, and in-depth interviews with informants both inside and outside of IBM, as detailed below.

To collect my data, I reviewed hundreds of internal documents dated 1970s-1990s. The documents ranged from briefing documents for senior executives to technical plans. Other informants provided smaller caches. The mechanisms I suggest to explain why IBM managed its transition are based largely upon these primary documents. I supplemented internal company documents with data from two other sources. First, I collected publicly-available documents, including the full text of the firm’s flat panel patents, a complete set of company annual reports, published scientific articles by IBM employees and others about the history and evolution of the industry (Alt 1998; Brody 1996; Depp and Howard 1993; Howard 1992; Kawamoto 2002; McGroddy 2001), a published case study on IBM’s joint venture with Toshiba (Matsui, West and Bowen 1997), and a book describing the role of governments in the industry (Murtha, Lenway and Hart 2001). Second, I conducted a series of iterative interviews with key
employees at IBM involved in the firm’s plasma and LCD activities between 1970 and 2000. I conducted more than twenty interviews with seven employees that were the researchers and business leaders behind practically every flat panel project that IBM engaged in during the study timeframe. Interviews were initially open-ended with a goal of uncovering the history of the informant’s experiences at IBM, and became more structured for second and subsequent interviews. I also interviewed and collected secondary data about dozens of other flat panel display companies engaged in research on plasma, LCD, and other types of displays. These data are used to build comparisons with IBM’s experience.

The process of data analysis followed the basic tenets of grounded theory building (Glaser and Strauss 1967/1999). Initially, I reviewed primary documents and interview transcripts to identify the core ideas of the story, based on analysis at both the micro (point-by-point) and macro (entire series of documents) levels. Next, I categorized key events based on the underlying processes. For each core factor identified below, I either reinterviewed prior sources or identified new sources to contact to dig into each process. Finally, I discussed the factors and findings in detail with two sources, who provided feedback on factual changes but generally agreed with the central findings presented here.

By focusing on the flat panel industry, this study complements the relatively few industry research studies. Existing research provides details that are especially important for the study of IBM. Spencer (2000, 2003), for example, discussed how firms learned a great deal about the different technological options from other firms, through conferences, published papers, and informal connections. Industry information was readily available, meaning that responding quickly to developments could be an important component of success. Second, managers perceived a great deal of risk in making irreversible commitments and sought out external relationships to reduce firm-specific risk (Hoetker 2005, 2006). Third, prior research on technology evolution shows that firms supporting the losing technology initially had a difficulty switching to the winning one, but that those firms looking to make the switch were not necessarily permanently disadvantaged versus early adopters of the winning technology (Eggers 2009, 2010). Each of these points – the availability of information about the success or failure of the different
technologies, the importance of risk and external firm relationships, and the difficulties posed by
technological trajectory failure – will receive close attention in the study of IBM’s history.

IBM AND THE EVOLUTION OF THE FLAT PANEL DISPLAY INDUSTRY

This section outlines the evolution of the flat panel display industry from the 1960s to the 1990s,
focus ing on IBM and highlighting the fact that the majority of early plasma supporters were unable to
reorient around LCD technology. Figure 1 lays out the key events, most of which are detailed below.

--- INSERT FIGURE 1 ABOUT HERE ---

In 1964, University of Illinois professors Donald Bitzer and Gene Slotto with graduate student
Robert Wilson created the first gas plasma display panel.¹ The goal was a graphics panel for computer
systems. By 1968, Owens-Illinois (a glass manufacturer) licensed the core patents from the University of
Illinois with the goal of making plasma displays for computer terminals. Within a few years, several firms
in the U.S. (IBM, Burroughs, NCR and Control Data), Japan (Fuitsu, NEC and Sony) and Europe
(Philips, Siemens and Thomson) had invested in plasma displays by licensing the University of Illinois
patents, pursuing their own research programs, and/or investing in test manufacturing capacity. In 1971,
Owens-Illinois introduced the first commercial plasma display product, a 12” monochrome graphics
terminal panel. In subsequent years, other early adopters such as IBM and Fujitsu introduced products.

A different technological trajectory also emerged in the 1960s, as researchers at RCA
demonstrated the first liquid crystal display (LCD) in 1968.² Meanwhile, Westinghouse was working on
thin-film transistors (TFTs) that would eventually become a key component of LCDs. Yet both American
firms missed LCD opportunities by slowing development in the early 1970s. Instead, Japanese
manufacturing firms such as Sharp (a calculator in 1973) and Seiko-Epson (a watch in 1973) pushed
forward with LCD products. A number of Japanese firms (e.g., Hitachi and Matsushita) began
manufacturing small LCD products in the 1970s and continued to research higher resolution and larger

¹ A plasma display encloses a mix of gasses in tiny cells between two sheets of glass, and then uses
electricity to create phosphorescent light.
² An LCD uses thin layers of electrodes to control a set of liquid crystals encased between two sheets of
glass. The liquid crystals modulate the light from a backlight to create the image.
applications. In the mid-1970s, firms such as Siemens, Marconi, and Brown Boveri invested in significant LCD research programs targeting displays larger than calculators and watches.

Both technologies – LCD and plasma – were viewed as computer-monitor applications, and most firms saw development of flat panel displays as a key constraint to the creation of portable computers. Thus firms saw the two technologies as direct competitors, creating technological uncertainty.

**IBM Part I – Plasma Displays**

Monitors were an important product supporting IBM’s computer businesses. IBM introduced the first display terminal, the IBM 2260 with an integrated CRT monitor, in 1964 allowing interaction with mainframe computers. The IBM 3270 followed in 1972, and by that point terminals including monitors were a vital strategic and revenue-generating product. IBM identified the yoke, which is the magnetic coil and accompanying electronics that creates the image, as the key value-added element of CRT monitors and outsourced other components to reduce costs. In 1985, display terminals accounted for more than $4 billion of IBM’s annual sales, approximately 10% overall. Forecasts projected strong growth.

Given the importance of the terminal business, IBM’s initial interest in plasma displays was to replace CRT terminal displays. With this aim, IBM licensed the core plasma patents from the University of Illinois in 1969, initiating a research program to build commercial products. IBM introduced their first plasma display product – and the first commercial plasma display with a new magnesium oxide cathode – in 1973 in a line of banking terminal products. The system used multiple panel sizes, from small teller panels to larger (12”) banker panels. With the launch of a commercial product, standard procedures at IBM transferred control of plasma activities from IBM Research to a product division – the Terminals group in Raleigh, NC. IBM maintained leadership in plasma display research, publishing dozens of important scientific papers and receiving 86 plasma patents between 1968 and 1983 (second only to Owens-Illinois with 109). With this momentum and knowledge, IBM built a manufacturing facility in Kingston, NY, in the early 1980s and introduced the first 14” monochrome plasma panel in 1983, a device that displayed four times the information available on CRT terminals at that time.
Despite this progress, one research manager remembered that it was already clear that the plasma panel investment “wasn’t the right answer” for IBM’s flat panel displays. Manufacturing yield rates were consistently under expectations, development took longer than planned, and the high price of panels made the markets for commercial sales relatively limited. The plasma panels were seen as “too expensive compared to the cathode ray tubes … [because] the cost of making the plasma panel was simply higher than people had projected.” Facing similar problems and with a desire to consolidate their business lines, Owens-Illinois abandoned the plasma display market in 1977. Other early plasma adopters followed suit in the late 1970s and early 1980s. The future of plasma displays at IBM came to a head in 1983 when the Terminals division requested $40 million in additional funding for the plasma display program. In response, management convened a cross-functional task force. The task force concluded that the “plasma panel [would be the] clear winner only for large area display” and that “plasma technology should be managed for near term business return” and then discontinued. This marked the unofficial end of IBM Research’s pursuit of plasma technology. As they had already invested in the manufacturing equipment, IBM continued to manufacture plasma displays until finally closing the Kingston plant in 1986. A few key plasma employees joined University of Illinois researcher Larry Weber in 1987 to buy the used equipment and patents and found the startup Plasmaco.

**IBM Part II – Liquid Crystal Displays**

In recommending that IBM abandon plasma, the 1983 task force was not suggesting leaving the flat panel industry. Indeed, the task force called LCD “strategic” and claimed that “LCD will win in the long run” for computer monitors. While IBM had only exploratory research in LCDs underway in the early 1980s, the firm had worked with LCDs previously. While efforts focused on plasma in the 1970s, IBM continued to experiment with different flat panel technologies, including electroluminescent (EL) displays, e-beam addressed displays, electrophoretics, flat CRT, electrochromics, and LCDs. In the mid-1970s, IBM had actively pursued LCDs. A seminal paper by IBM researchers Paul Alt and Peter Pleshko (1974) demonstrated the size limits of passive matrix-addressed displays (including what was then standard for LCDs), suggesting that they would not be appropriate for computer displays. This paper
helped convince IBM to cut back its LCD research. But a series of technological advances, as well as the viability of LCD watches, led to a serious reconsideration in the early 1980s of the potential of LCD.

There were three major impetuses for the increased attention given to LCD. First, one of the task force members from IBM Research had been at the 1983 Society for Information Display conference and seen Seiko-Epson display their prototype for a 2” full-color LCD television. He related: “I went and made a pitch… [T]his could really be the key to the future of flat panels. And IBM needs to start paying attention. And what you should do is give me some money to start a program.” Second, IBM had introduced full-color terminal displays in 1979, and while some at IBM didn’t believe there was a need for color computer displays, the sales success of full-color products convinced managers that full color would be an important ingredient for future flat panel displays. IBM also conducted a number of human factors studies that showed that “you really needed color” to meet user expectations. IBM documents post-1983 list “full TV color” as a “key strategic requirement.” With respect to plasma, a lead display scientist recalled that, “we knew there was probably a road to color but it was going to be difficult.” A 1984 internal report noted that there was “no good color version” of a plasma panel on the horizon. The same was true of EL and every other technology that IBM investigated. LCD, on the other hand, already showed promise. The 2” screen that Seiko had shown was full color, and the technology appeared to have potential for larger screen sizes. Finally, IBM had introduced the personal computer in 1981 and executives were eyeing the potential of “portables” (laptop computers). The potential for portable computers accentuated the importance of weight, durability, and power consumption when considering flat panel displays, and it appeared that LCD would be best positioned to deliver on these criteria.

IBM did not immediately invest in LCD. In 1984, IBM Research hired two LCD-focused scientists, and IBM’s ramp up in LCD patenting began in 1983. Additional task forces were convened to

3 Subsequent research in the 1980s didn’t disprove this “iron law of multiplexing” but instead found different technological configurations that were not subject to the same limits.
4 The major technological advances included work by Peter Brody at Westinghouse in the use of active matrix TFTs for LCDs, and work by Toshiba researchers in the use of amorphous silicon (aSi) as a lower temperature (and therefore lower cost) manufacturing method for LCDs.
consider the issues surrounding flat panel displays. The big move came in 1986 when IBM entered into a two-year joint research alliance with Japanese manufacturer Toshiba focused explicitly on full-color, active matrix (AM) LCD TFTs. IBM initially considered other partners such as GE, Sharp, Matsushita, and Hitachi but settled on Toshiba in part because “they were probably hungrier than others” and in part because, at that point, Toshiba had built the largest prototype. The relationship initially focused on proving that the smaller (2”-3”) LCD televisions could be effectively scaled up to larger sizes, and then moved to the creation of a 14” full color prototype computer display. In 1988 the two firms signed a joint venture agreement to create Display Technologies Inc. (DTI) and build a manufacturing facility in Himeji City in Japan next to an existing Toshiba monochrome LCD plant. By 1991, DTI had created the monitor for the P75 portable and in 1992 for the first IBM ThinkPad. In 1992, DTI produced around 500,000 TFT panels for use by IBM and Toshiba, as well as for sale to other companies. This generated $220 million in sales, 18% market share, and increasing profitability as costs came down.

The patent records shown in Figure 2 demonstrate IBM’s “about-face.” The left axis shows the portion of IBM’s flat panel display patents in plasma (solid line) or LCD (dashed line), the remainder being other technologies. The right axis shows the total count of patents applied for in both plasma (black area) and LCD (grey area) technologies. Through the early 1980s, industry-wide patenting in LCD and plasma were roughly equal. Around 1983, however, firms began investing and patenting in LCD at a rate not mirrored in plasma patenting. The two lines demonstrate both the extreme nature of IBM’s decision-making (the firm was almost completely plasma-focused early and almost completely LCD-focused later) and that the shift for IBM happens around 1982. Thus, even though IBM was late to the LCD game it was able to reorient its focus on LCD with almost no lag to the overall market.

--- INSERT FIGURE 2 ABOUT HERE ---

IBM’s Unique History in Flat Panel Displays

While IBM successfully made the switch from plasma to LCD, the majority of other early plasma supporters did not. Table 1 provides information on the ten firms that licensed plasma patents from the University of Illinois, as well as other firms with significant early patenting in plasma (excluding firms
like Hitachi and Matsushita that had significant plasma patents but had three times as many LCD patents). The table shows a few interesting findings that summarize the key takeaways from this chronological discussion of the evolution of the industry. First, IBM was an early leader in plasma display technology, as evidenced by their dominant patent position and status as the leading manufacturer in the 1980s. Second, of the early plasma supporters only four went on to manufacture LCD panels and one of those (Philips) was a relative latecomer to the LCD after a protracted turnaround while the other two (Fujistu and NEC) never controlled anything like IBM’s market share in LCD manufacturing. Thus, IBM’s story is relatively unique in this industry in terms of its ability to recover from the failed plasma investment, making the firm an excellent subject for further study. Third, IBM was one of the latest firms to abandon plasma displays, ending research in approximately 1983 and closing the manufacturing in 1986. Thus, the secret to IBM’s success was not in recognizing the failure of plasma earlier than other firms (Guler 2007, 2009). Fourth, while some of these firms faced subsequent liquidity constraints (e.g. Burroughs, Control Data, and Thomson) many of them were large and successful companies throughout the entire period, suggesting that IBM was not necessarily successful because of its size or liquidity to fund LCD research. Finally, IBM did investigate LCD technology before 1983, but had largely discarded it for the reasons discussed above. Thus the story at IBM represents a real shift from being a plasma supporter to supporting LCD. With these facts in mind, the following section discusses six mechanisms that contributed to IBM’s successful recovery based on my analysis of the data.

--- INSERT TABLE 1 ABOUT HERE ---

UNDERSTANDING IBM’S SUCCESS

IBM is a unique case. The firm made a seamless transition from full support for plasma to full support for LCD as other firms missed the LCD revolution. Based upon the data, I focus on the search and resource allocation processes. Prior research on behavioral decision-making suggests that failures affect the trajectory of search behavior for most firms (Eggers 2009; Greve 2003; March and Heath 1994; Simon 1947). To facilitate successful strategic recovery, search should be minimally affected by prior failure. In the following subsections, I investigate the relationship between failure and search processes.
for IBM along two dimensions recently suggested as the two primary dimensions of organizational search—alternative generation and alternative evaluation (Knudsen and Levinthal 2007).

Alternative generation is the process by which choice sets are constructed. For IBM, the key question is how the firm was able to continue search in such a way that LCD remained “on the menu” as an option. Central to this process was shifting research resources from plasma to LCD. This switch was important because, by the second half of the 1980s, the ability of IBM researchers to demonstrate working LCD prototypes was a key means of convincing stakeholders. As a senior R&D manager noted later, those prototypes “just melted the execs.” The key factors that helped IBM Research build a technological competence in LCD even after investing in plasma were IBM’s culture, its structure, and the strategic importance of flat panel displays. These factors enabled researchers at IBM to investigate LCD enough that it remained a viable option for future investment.

Alternative evaluation is the process by which one or more choices are selected and resources allocated to support the choice. At IBM, the key question is how LCD supporters convinced IBM senior management to place a significant bet on LCD after the failed investment in plasma. Many informants discussed the hurdles raised by the failure of plasma, exemplified by this quote:

I mean naturally you are always dealing with past failures. “Why is this not like this? And, oh wait, this story sounds good but so did the plasma story. Look what they made us do. Look what they sold us.”… Well [the plasma investment] was basically scrap and move on…. And so the technical management was therefore more skeptical and more demanding of proof because they had been fooled. So that probably raised the bar for us.

While some factors facilitating effective alternative generation also affected alternative evaluation, I identified three additional factors that helped overcome the hurdles mentioned above. These factors include turnover in key personnel, the strategic use of a partner, and the focus on the business problem rather than the technical problem. Each factor is discussed below in greater detail.

**Alternative Generation Process – Building a Competence in LCD at IBM Research**

The most important and theoretically novel reason for IBM’s success at this stage in the process was the hybrid centralized-decentralized structure for early-stage resource allocation. While IBM is often considered centralized with tight control (see the autobiography by Gerstner 2002), the qualitative data
indicate that IBM was decentralized one key aspect – the availability of early-stage research funding. Funding for research work at IBM generally came either from the research department’s internal budget or directly from the product divisions. The research budget was derived from a “tax” on the product divisions and was handed out in very small amounts to facilitate basic research with a few scientists at a time. In addition, IBM corporate required product divisions (semiconductors, terminals, mainframes, etc.) to put aside a portion of their overall budget to fund IBM Research projects that the division believed in and approved. This practice started in the late 1970s with the semiconductor and general products (data storage) divisions. To receive funding, research managers approached product managers and pitched “joint programs” where both research and division funding would be used for specific research efforts. In the case of flat panels, a large portion of the mid-1980s research budget for LCD panels came from “joint programs” with the newly created Personal Computer division. By contrast, other early plasma supporters (namely all of the Japanese firms) had centralized R&D groups with hierarchical budgeting processes that restricted the ability of scientists to get funding without senior executive approval. The presence of a central head of R&D with discretion over research spending at IBM was generally in line with practices at other competing firms in this space. The difference at IBM was the decentralized way in which at least some of the funds was allocated.

The link between organizational structure and innovation is by no means new, but the findings in prior research are mixed. One stream suggests that centralized firms are more innovative, especially in turbulent environments. Argyres & Silverman (2004) showed that organizations with centralized R&D produce more highly cited innovations than ones with decentralized structures. Siggelkow & Rivkin (2005) show that centralized firms are better able to adapt to environmental turbulence. A separate stream links decentralized organizational structure with innovation (Pierce and Delbecq 1977; Shepard 1967), as decentralized firms are better able to leverage specialized knowledge for decision-making (Burgelman 1991; Eisenhardt and Bourgeois 1988). This study’s central finding on structure – that a centralized research center funded in a decentralized manner helped IBM recover from failure and maintain its innovative capabilities – provides an answer that integrates these two perspectives. Studies promoting
centralization either explicitly (Siggelkow and Rivkin 2005) or implicitly (Argyres and Silverman 2004; Lerner and Wulf 2007) focus on search, where the ability to coordinate needs across divisions is beneficial. This perspective aligns with Knudsen & Levinthal (2007) about the alternative generation process. Studies promoting decentralization largely point to the reliance on specialized knowledge from managers in the resource allocation process (Burgelman 1991), which is closely tied to alternative evaluation. Thus, IBM was centralized in terms of alternative generation and decentralized in terms of alternative evaluation. The idea that different structures may be more or less appropriate for different types of innovative activity echoes prior work (Dewar and Dutton 1986) and presents a variation on contingency theory (Lawrence and Lorsch 1967), where a structure is more or less appropriate for a given environment. In this case, the appropriateness of the structure depends on the aspect of the task.

Two other factors played a significant role in IBM’s ability to build competence in LCDs, and both have long roots in existing literature. First, the process of requesting small allocations from the product divisions was made significantly easier by the strategic importance of flat panel displays to IBM’s existing terminal business and emerging personal computer business. In 1985, the terminal business comprised almost 10% of IBM’s total sales ($4.4 billion) and was projected to grow to more than $20 billion by 1987. In 1983, IBM officials became concerned that “[h]igh volume [CRT] products [were] becoming commodities” and that there was a “need to protect IBM’s value-added position.” IBM viewed flat panel displays as both a threat (in terms of cannibalizing their CRT display business) and an opportunity (in terms of creating a new value-added position in the display space). A 1986 document stated that, “recent IBM studies have concluded that a large portion of the current 14” CRT monitor business (2.5M units/year on average 1989-1991) could be exposed if anticipated advances for flat panel devices are achieved.” To the extent that any technology had a chance of replacing CRTs, IBM executives saw it as critically important to play a lead role in that technology. While flat panel displays held strategic importance for some early plasma supporters (e.g. Burroughs, Control Data), flat panel displays were seen as an opportunity to diversify into non-core areas for many of the other firms (e.g. Owens-Illinois).
The strategic priority of establishing a position in the flat panel display industry was complicated by the nature of flat panel displays as opposed to CRTs. In CRTs IBM made only one component (yokes) and outsourced everything else (logic, memory, mechanical, power). The yoke and tube comprised about 30% of the monitor’s cost. In the case of flat panel displays (of any variety), IBM projected that the flat panel module would account for 57% of the overall cost and, if electronic drivers were packaged with the module as expected, that amount increased to 82%. Thus, to protect its existing position as a value-added provider of terminal displays, IBM had to be engaged in manufacturing flat panel modules.\(^5\) Similarly, the internal view was that the flat panel module would be the critical value-added component for portable computers, and portable computers were a clear long-term goal at IBM. Thus, because of the interconnected nature of the flat panel display system (as opposed to CRTs), IBM was faced with the choice of being a technological leader in the winning flat panel technology or losing out on the terminal and PC space completely. Given this level of strategic importance, when IBM’s plasma operations offered hints that plasma might not be the “silver bullet” for flat panel displays, it was seen as important to keep investigating alternatives to plasma. Prior research indicates that markets seen as strategically important are the ones most likely to be entered (Helfat and Lieberman 2002; Mitchell 1989), specifically to protect the value of existing products and complementary assets. IBM’s story supports this assertion and suggests that perceived strategic importance facilitates the process of overcoming inertia from prior mistakes.

The final element that contributed to IBM’s ability to build competence in LCDs was IBM’s culture. This aligns with numerous articles from practitioners (Zien and Buckler 1997) and in the marketing (Deshpande, Farley and Webster 1993; Han, Namwoon and Srivastava 1998) and management (Garud, Dunbar and Bartel forthcoming; Garud and Rappa 1994) literatures that point to corporate culture as key to innovation success. In IBM’s case, the specific element of corporate culture that was vital to success was the organizational attitude towards risk and risky investments. IBM research had a bias towards exploratory investigation of “the next big thing”, and this emphasis was matched with

\(^5\) The technology became more modular over time, with the ability to outsource key components. But, like many emerging technologies, vertical integration was an initial solution for technological uncertainty.
appropriate expectations of the likelihood of success of these investments. While there are many famous stories about former IBM CEO Thomas Watson’s perspective on failure in the 1960s, the following quote from an IBM researcher about an interaction with the VP of Research is most appropriate:

[T]he director of research at that time [1984] was [Ralph] Gomory and he listened to the whole story and then he said, “Ok, let me first explain. I understand my guys can probably make one of these; they can probably make one of anything. But I have a lot of doubts about whether this is commercially reasonable. But the case is pretty good so I would say you’ve got a one in four chance of succeeding.” And we all, I mean, oh my God! [We will never get this funding.] But then he said, “But, you know, for research that is good enough. As long as you understand that you’re putting in yours, then I’m happy with one in four.”

This quote demonstrates that management perceptions of the likelihood of success took account of the hurdles likely to be encountered.\(^6\) By contrast, plasma supporter Owens-Illinois was traditionally a glass bottle company and very unused to high-risk ventures in electronics. When the Owens-Illinois president supporting the firm’s plasma initiative died suddenly, new management looked instantly to reduce risk and uncertainty. A large number of the firm’s investments in electronics were cut, including plasma displays. Owens-Illinois never had any significant conversations about entering LCD, as the technology did not fit the firm’s revised risk profile.

These three factors – the decentralized nature of research resource allocation at IBM, the strategic importance of flat panel displays for the firm, and IBM’s cultural attitudes towards risky investments – all facilitated the ability of IBM Research to build up capabilities in LCD technologies despite the ongoing plasma activities supported by the Terminals division. These decisions to explore LCD were mostly on a small scale, however. Scientists were allowed and encouraged to pursue exploratory LCD projects, and small amounts of money were made available to pursue them. As discussed earlier, these three factors facilitated the ongoing process of alternative generation at IBM. The next step was alternative evaluation – obtaining significant funding for LCD development and manufacturing. While the factors described

\(^6\) Many commentators criticize IBM for being risk-averse and afraid to fail. In the late 1980s, there was a shift toward more applied research in lieu of exploratory projects. Prior to that, research had primarily created potentially commercializable technologies and then “thrown things over the wall” to the product divisions. Lerner & Wolf (2007) document this shift and its implications for centralized R&D.
above likely played a role in a facilitating that part of the transition as well, there were other factors that became important as discussed below.

Alternative Evaluation Process – Building Senior Management Commitment to LCD

If the major accomplishment of 1980-1984 for IBM was moving research from plasma to LCD, then the major accomplishment of the period 1985-1988 was convincing senior managers to allocate significant resources (financial and otherwise) towards a bet on the ultimate success of active-matrix LCD TFTs. Based on a close study of many documents that were circulated among senior management in the 1980s in support of LCDs, I identified three additional reasons why the transition to LCD was successful – the focus on the business case, the turnover in personnel, and the use of Toshiba as a partner.

An interesting finding from a systematic review of internal documents that were presented to senior management by the LCD proponents in the Research and PC divisions was that nearly every presentation led not with the pros and cons of the specific technology but with the importance of the terminal, PC and portable computer markets to the strategic future of IBM and how flat panel displays (regardless of technology) were vital to that success. The best example is a 1985 business case presented to the head of the PC division. The document opens with “Flat Panel Displays” and lists out potential applications such as “TV on the wall, portable TVs, terminals (military), low-bulk desktop terminals, rugged displays, portable computers,” with no mention of specific technologies. The document then lists out key success factors by market segment, and when addressing terminals and personal computers highlights the importance of these markets for IBM with figures on sales and growth rates. The next page lists out technologies, including everything from plasma to LCD to electrochromics. The document then matches each technology to IBM’s key success factors and shows that, for markets vital to IBM, LCD is the only viable option. All of the presentation documents for executives were formatted roughly in this way, with no significant mention of specific technologies until at least halfway through the document.

Thus, instead of focusing on the specific technological issues in trying to persuade executives, LCD proponents kept their senior managers focused on the business case for flat panel displays. One scientist talked about “the laptop problem” and how IBM “wanted to be a laptop company,” while another
noted that the LCD display “was the thing that allowed you to have the laptop in the first place.” When one executive, lamenting the uncertain nature of flat panel technologies and the firm’s failure in plasma, suggested “giving up on the portable business completely,” the argument was made that:

‘If you’re not in portables, you’re not going to be in personal computers.’… And that scared everybody into, ‘Well we better, you know, we can’t fail. We’ve got to make this, this portable computer work because we’re already in the PC business and we don’t want to give it up.’

In summarizing the LCD case made to executives, McGroddy (VP of Research) remembers that, “[i]t was very much a strategic business case. It didn’t even have numbers… A lot of it was not even about the technology at all.” The general point is that LCD proponents focused not on technical or scientific issues, but instead on the product markets the firm wished to serve. This business case focus increased what practitioners call “technology agnosticism” and made managers flexible in their thinking about technologies, thus decreasing the constraining effects of failure in plasma.

Work in the management of innovation focuses on managerial framing and suggests that how managers frame innovation questions has an impact on whether they are endorsed (Barr et al. 1992; Gilbert 2006; Kaplan 2008a, b; Tripsas 2009). Specifically, a managerial focus on existing technologies and routines (Leonard-Barton 1992; Tripsas and Gavetti 2000) restricts firm ability to innovate flexibly. In contrast, managerial focus on the industry affected by the technological change facilitates adaptation (Eggers and Kaplan 2009). Similarly, Furr (2010) shows that an “outward focus” – a managerial frame focused on issues external to the firm such as customers and the industry – increases flexibility and the likelihood of technological change. Managerial framing in general, and framing around the external business problem in lieu of the technological problem in particular, facilitates adaptation. In the case of strategic recovery from failure, the focus of managerial attention on the business problem instead of the

---

7 This importance of business case focus has, on the surface, some links with the marketing concept of “market orientation” (Kohli and Jaworski 1990; Narver and Slater 1990). Market orientation is often conceptualized as a focus on customer needs and competitor actions, and recent work focuses specifically on how market orientation drives innovation (Han et al. 1998; Hurley and Hult 1998; Im and Workman Jr 2004). But market orientation is generally about the extent to which core marketing concepts have diffused throughout the organization, while the focus on the business case in this study is more closely related to concepts in management on managerial framing.
technological problem likely served multiple purposes. First, by focusing away from technological issues, IBM’s LCD proponents would likely diminish the focus on the failed plasma initiative, indirectly decreasing resistance to further investments in flat panel displays. Second, the framing accentuated the downside risk of simply doing nothing by highlighting the stakes at risk (IBM’s terminal and PC businesses). This framing diminishes, without eliminating, the importance of technical considerations.

IBM linked the technical and the product markets by matching key market success factors with technologies able to solve business problems (Dougherty 1992). Thus, one of the major contributions of this research is to suggest that managerial focus on the business problem that the firm seeks to solve increases adaptability in the face of technological evolution. IBM built organizational momentum towards the flat panel display market without necessarily focusing on a specific technological solution, and thus easily switched its technological focus from plasma to LCD while maintaining the same business framing.

While managerial framing was the most relevant explanation for the success of the alternative evaluation process for strategic recovery at IBM, two other elements played key roles as well. First, between the times of the original IBM investment in plasma and the subsequent move to LCD there was significant turnover in the major players on both the research and business sides. In Bower’s (1970) resource allocation research, a key component influencing the process is the reputation built over time by lower level managers that enables senior management to trust their judgment. Conversely, prior failures result in reduced reputation and lowered trust from executives. This stigma attached to failure could have erected a significant hurdle for IBM to overcome when advocating investment in LCD in the 1980s. However, due to IBM’s large size and the time between the key decisions on plasma (1969) and LCD (1986), there was almost a complete turnover in the key personnel on both sides of the decision. Within IBM Research, a group of young scientists that joined IBM in the mid-1970s and had no connection with plasma displays were the driving force behind support for LCD. Additionally, the managers involved in approving resource investments had largely turned over in the time period, including the VP of Research

---

8 In addition to the anecdotal differences in research managers based on my interviews, patent data show that only one IBM researcher had both LCD and plasma patents before 1990.
(originally Arthur G. Anderson in the late 1960s, Ralph Gomory from the 1970s through the mid-1980s, and then Jim McGroddy in the late 1980s) and the CEO (originally Thomas Watson, Jr., and later John Akers). As one informant related, “[t]here is of course a churn of executives and so we didn’t have too much difficulty with people that had been burned with the plasma investment in being too worried about new investments. For one thing it was a different group of people making the investment.” While this key personnel turnover was probably typical of all early plasma supporters since all entered plasma in the late 1960s or early 1970s, and would have been advocating for LCD investment in the early 1980s, there is one distinguishing feature about IBM. At IBM the plasma project was attached to the Terminals division, while the LCD project was attached to the newly created Personal Computing division. At every other firm that I spoke with (e.g. Owens-Illinois, AT&T, NEC, Matsushita) all of the flat panel technologies were considered and funded within the same division, and thus would have been more strongly subject to the reputational damage of the failed plasma investment.

The new personnel involved in advocating for LCD – especially in terms of senior research management (McGroddy), business unit management (Dick Seybold in the PC Division), and executive management (Jack Keeler as Vice Chair of IBM) – proved invaluable to the project’s success. One research manager said, “[w]e had a couple of angels at the senior VP level. That was absolutely important because the kinds of investments now we’re talking about if we move from the development lab to an actual manufacturing line and the commitment it would require was significant.” This is consistent with the extensive literature on product development (Cooper and Kleinschmidt 1986; Zirger and Maidique 1990) and innovation (Kaplan 2008a; Kaplan, Murray and Henderson 2003) that links success to senior management support. By contrast, work on the resource allocation process highlights how managerial reputation mitigates information asymmetries (Bower 1970; Roberts 2005) and how prior failures damage that reputation (Eggers 2009). In the case of IBM’s LCD project, managerial support proved especially important as the final deal to establish the IBM-Toshiba joint manufacturing venture was created as a corporate line-item that would not weigh down the financials of IBM Japan before it became profitable, a deal that required significant support from both the technical and business side and was contingent on
CEO and board of directors approval. By contrast, firms like AT&T used strict “economic value added” guidelines that effectively killed their proposed flat panel investments.

The final critical ingredient affecting IBM’s ability to generate senior management support for the proposed LCD investment was the decision to work with a partner (Toshiba). In 1985, LCD proponents responded to concerns that the proposed internal LCD timelines were too optimistic with the suggestion “[t]o reduce risk and get product out faster, find partner with complementary skills.” There was a strong perception within IBM that while the firm was a research and technology leader, it did not have the mass production manufacturing capabilities to be successful in a highly competitive future market. According to one research manager, “we finally realized that this was a high-tech, low-cost manufacturing issue and as a company IBM needed a partner ... who knew how to do low-cost manufacturing from their other businesses.” The perception was that a Japanese firm with extensive mass production experience would complement IBM’s technical knowledge. More generally, the pursuit of knowledge sharing and capability acquisition between two partners is a well-documented reason for alliance formation (Hagedoorn 1993; Khanna 1998; Khanna, Gulati and Nohria 1998).

IBM also pursued a partnership to reduce its initial capital outlay and risk. After “going it alone” in the initial plasma investment, there was a sentiment at IBM that another major and potentially speculative investment such as LCDs was too risky. One scientist recalled that the “first proposal for [LCD] manufacturing was too much money up front and too long a payback… so they welcomed the chance to reduce their risk by having a partner.” LCD project proponents supported investing with a partner as an acceptable way of handling this risky venture. Sharing risk is also a known driver of alliance formation (Hamel, Doz and Prahalad 1989), especially in emergent technological industries (Eisenhardt and Schoonhoven 1996). These two partner benefits – gaining access to mass production experience and reducing downside financial risk – helped secure approval for the project. Of course, other firms considering transitioning from plasma to LCD could have recruited partners as well, though only Philips (in 1999 with LG) and Matsushita (in 2002 with Toshiba) ever did.
These three factors – the internal focus on the business issues, the turnover in personnel that preserved the internal reputations of key LCD supporters, and the strategic decision to use a partner – clarify how LCD supporters at IBM were able to convince senior executives to reorient around LCD despite both the market uncertainty and the failed investment in plasma. In summarizing the findings of this study, I will address all six forces that have been identified and the extent to which they may be able to explain why IBM was able to reorient around LCDs while most other early plasma supporters were not.

DISCUSSION

This study of IBM’s transition from plasma pioneer to LCD leader offers an important view of a firm’s recovery from a failed investment. The study explores the history of IBM’s flat panel activities against the backdrop of industry, competitive, and technological evolution. It offers three reasons that IBM was initially able to build competence in LCD that was instrumental in crafting the case brought to senior management. First, IBM’s culture recognized the inherent risks in investments in uncertain technologies and pushed researchers to explore alternate technologies. Second, IBM had a decentralized decision-making structure for low-level resource allocation, with money available from both the centralized research budget and product divisions. Third, the strategic importance of flat panel displays for IBM increased the ability to make a compelling case for product divisions to continue to invest in flat panel exploration. Together, these factors allowed bottom-up efforts to build knowledge in LCD.

With this knowledge and the all-important prototypes, LCD proponents convinced senior executives to support this new technology despite the failed investment in plasma. They did so for three additional reasons. First, the time between the initial plasma investment and the subsequent LCD investment, as well as the fact that the supporters of each technology were in different divisions, ensured almost no overlap in personnel between the two decisions so managerial reputations were not affected by the initial failure. Second, IBM sought out a partner in Toshiba, both to share risks and to supply complementary competences in high-volume manufacturing. Finally, LCD supporters kept executives focused on the business case for flat panel displays, which conserved the momentum generated by the plasma project. Below, I integrate these factors into a model of strategic recovery and offer conclusions.
An Integrated View of Strategic Recovery

Borrowing terms from Knudsen & Levinthal (2007), this study suggests two key phases in the strategic recovery process – alternative generation and alternative evaluation. The first phase is about maintaining the ability to search for potential solutions and to build sufficient competence in the core technologies to facilitate subsequent appeals to senior management. According to Cyert and March (1963), the standard response to failure is to cut funding for “activities in the organization for which the connection with major goals is difficult to calculate concretely (e.g. research in many firms)” (p. 171).9 Two commonly suggested reasons why some firms deal better with failure and uncertainty in search processes than others are organizational culture (Garud and Rappa 1994; Han et al. 1998) and the imperative to succeed in the focal industry (Mitchell 1989). This study suggests that while both were part for IBM’s success, neither was sufficient. If these were the only required elements, then other early plasma supporters such as Burroughs and Siemens (computers) or Sony and English Electric (televisions) had both the experience with high-risk projects and the strategic imperative to succeed that should have helped them be more adaptive to the emergence of LCD. Instead, all four firms missed out on the emergence of LCD panels entirely, either contributing to their exit from the product market or forcing them to outsource panel production.

By comparison, IBM’s hybrid resource allocation structure played a key and unique role in facilitating IBM’s recovery from its failed plasma investment. The centralized nature of IBM’s research activities ensured that technologies that did not fit cleanly into a single existing product division still received sufficient support (Argyres and Silverman 2004), and its decentralized resource allocation process prevented the potential biases arising from the prior failed plasma investment (Eggers 2009; March and Heath 1994) from sinking efforts to engage in LCD research. What the model and the case of IBM do not clearly lay out is whether IBM’s decision-making structure is the only one that is successful

9 This does not mean that, after a failure, firms should simply lavish resources on those responsible for the mistake. Indeed, one of the potential reasons why the prior investment failed may be that it was a bad idea promoted by inferior managers.
at avoiding failure-driven inertia. The key elements of IBM’s structure appear to be the centralized research group with decentralized access to funding through internal capital markets. While a great deal of recent research has focused on the role of hybrid structures in strategy, most have dealt with issues related to governance and incentives (Makadok and Coff 2009). In this case, the importance of the hybrid structure is related to decision-making. Research could explore the ways in which hybrid decision-making structures are important for organizational performance and particularly innovation.

The first stage in the strategic recovery process, namely alternative generation, is obviously necessary for a successful recovery but not necessarily sufficient. In the flat panel display industry, early plasma supporters such as Philips, AT&T, Texas Instruments, and NEC all managed to achieve some degree of success in developing technical knowledge on LCDs in the 1980s. These firms had the same opportunity as IBM to emerge from this transitional period as a leader in LCD panel manufacturing (as each was a large and successful firm with both technical resources and market competences). Instead, NEC occupied a relatively small niche in LCD manufacturing, Philips was late to the game through a JV with LG Electronics, and both AT&T and Texas Instruments missed LCDs completely. The story of IBM suggested that the turnover in personnel between the plasma and LCD decisions, as well as the strategic use of a partner, played key roles in IBM’s success, but the same would have been true at all of these other firms. The turnover in personnel was partly driven by the time between the two events and potential partners were available to all firms in the industry. Thus, it appears that neither personnel turnover nor the use of a partner was sufficient to ensure recovery at these firms.

Thus, this study focuses on managerial framing – specifically managerial framing on the business case and industry opportunity, in lieu framing on the specific technological choices – as being the best explanation for IBM’s unique success in the alternative evaluation phase. My interviews with former employees at both NEC and AT&T suggested that internal resistance to switching to LCD was driven by each firm’s failed experience with plasma displays. Prior research has identified managerial framing as a key ingredient to innovative firms (Eggers and Kaplan 2009; Tripsas and Gavetti 2000), but most research has assumed that framing plays a role because it sets an agenda for the organization and is
reflected in the incentives for employees. This study instead suggests that framing alters the perceptions of managers about the value of future projects under consideration. In the parlance of any sort of IRR, NPV or payback period calculation (Damodaran 2010), prior failure has a likelihood of increasing the discount rate applied to future projects, but maintaining framing on the business problem at hand has the ability to mitigate this increased hurdle. While large scale research on managerial framing is difficult, especially with respect to the framing of individual internal decisions (like resource allocation decisions), such research would be very helpful to building a better understanding of exactly what types of framing play important roles in affecting the dynamics of organizational decision-making.

Overall, this study suggests a two-stage model of recovery where the two stages are alternative generation to search for substitutes for the failed investment, and alternative evaluation where the firm is able to overcome potential biases caused by the failed investment. For the first stage, the key to IBM’s success was its hybrid decision-making structure for R&D resource allocation, as the other elements were necessary but not sufficient for success. For the second stage, maintaining a managerial focus on the business problem instead of the technical one appears to have decreased internal resistance to the new course. Again, other elements played important roles but were generally available to all firms in the industry and thus cannot be seen as the dominant explanation for IBM’s success.

Conclusions

This paper uses a case to build theory on the strategic recovery process. The study analyzes IBM’s activities from the late 1960s to the mid-1990s as it transitioned from support for plasma displays to support for liquid crystal displays (LCDs). The study offers six contributors to IBM’s success. Four of these reasons (organizational culture, strategic imperative, use of a partner, and managerial reputation effects) are well recognized in the innovation and adaptation literatures. The other two reasons are more novel. First, while IBM had a centralized R&D function, it was the decentralized nature of its small-scale R&D resource allocation process that allowed the firm to build early LCD capabilities. Second, the firm’s LCD proponents focused on the “business problem” of flat panel displays and downplayed technological aspects in a way that preserved momentum to solve the problem agnostic of the technological solution.
The findings have implications for the literature on strategic renewal (Agarwal and Helfat 2009; Huff et al. 1992) – of which strategic recovery from failure is a special case – as well as the management of innovation (Van de Ven 1986). Both streams of literature often focus on successes, but this paper suggests that how firms deal with past failures are an important aspect of long-term success. Specifically, the findings on the strategic imperative and the framing around the business case for IBM ties strongly to work on the importance of managerial framing of technological uncertainty (Eggers and Kaplan 2009; Tripsas 2009). More research on the phenomenon of “business case framing” for uncertain technological opportunities could help to identify the generality of the effect, and whether it aids all technology-based adaptations or only those that involve recovery from failure. Finally, the findings on the importance of decentralized decision-making for R&D resource allocation suggests the need to reopen the discussion around organizational structure and innovation (a la Argyres and Silverman 2004). In doing so, it would be important to distinguish between the centralization of R&D versus the centralization of the entire firm, the centralization of all R&D functions versus the centralization of the resource allocation activities, and the potential for hybrid structures like IBM – a centralized R&D agency with formal control mechanisms, but also with decentralized pockets of money available to pursue speculative projects.

While the primary objective of the paper is theory building, there are useful implications for managers based solely upon IBM’s experiences and the integration of those experiences with existing theory. Ensuring that a firm demonstrates the “proper” response to a failed technological investment is of significant importance given the likelihood of technological failure. To protect against overly-risk averse responses to failure, managers should consider employing decentralized resources to fund speculative R&D based on the ability to make a compelling product case. When considering how senior managers frame uncertain technological decisions, managers should attempt to focus on the business objectives of technological investments instead of the technology itself (letting the engineers worry about the technologies). Finally, managers should promote an organizational culture that properly understands the likelihood of success and failure in technology investments, and should be prepared to rely on partners to respond quickly to the need to build capabilities and reduce risk exposure.
REFERENCES


Burgelman, R.A. 1983. A process model of internal corporate venturing in the diversified major firm. Admin. Sci. Quart. 28(2) 223-244.


Lawrence, P.R., J.W. Lorsch. 1967. *Organization and Environment: Managing Differentiation and Integration.* Harvard University, Boston, MA.


<table>
<thead>
<tr>
<th>YEAR</th>
<th>OTHER</th>
<th>PLASMA</th>
<th>IBM</th>
<th>External</th>
<th>LCD</th>
<th>IBM</th>
</tr>
</thead>
<tbody>
<tr>
<td>1968</td>
<td>Plasma patents licenses to Owens-Illinois, IBM, Control Data, Fujitsu, NEC, NCR</td>
<td>RCA demos a &quot;crude&quot; LCD prototype</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1969</td>
<td>IBM begins plasma work in earnest</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1970</td>
<td>Owens-Illinois introduces first PDP product (12” display)</td>
<td>First TN (twisted nematic) LCD patent</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1972</td>
<td>Introduce multi-panel banking system</td>
<td>First LCD Calculator (Sharp) and Watch (Seiko)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1974</td>
<td>IBM introduces larger PDP displays</td>
<td>First AM LCD prototype (Westinghouse)</td>
<td>Ai, Pleshko write paper on matrix addressing limitations that effectively kills passive matrix LCD interest</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1975</td>
<td>Owens-Illinois abandons plasma</td>
<td>Dundee group performs aSi doping study that leads to strong aSi interest</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1976</td>
<td>Started small AM LCD research activity in San Jose</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1979</td>
<td>IBM introduces color CRT terminals</td>
<td>aSi in a TFT array for LCDs (U Dundee)</td>
<td>Momentum for LCD research restarts</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1981</td>
<td>IBM introduces first personal computer</td>
<td>IBM builds Kingston plant</td>
<td>First STN (super twisted nematic) LCD patent</td>
<td>First official LCD task force</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1983</td>
<td>Sperry, Control Data, Burroughs, NCR abandon plasma</td>
<td>First 14” monochrome PDP (3290); PDP group requests $30-$40 million more funding; Task force to assess PDP program; IBM unofficially ends PDP research</td>
<td>First color LCD prototype (Seiko-Epson); Seiko introduces 2” full color LCD TV</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1984</td>
<td>Texas Instruments abandons plasma</td>
<td>IBM research hires two scientists specifically to focus on LCD; Internal taskforce labels LCD as “strategic” technology</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1985</td>
<td>IBM ends advanced CRT research</td>
<td>AT&amp;T abandons plasma</td>
<td>First STN display panel (Brown Boverit)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1986</td>
<td>IBM ends PDP manufacturing</td>
<td>Initiation of joint research w/Toshiba (2 year deal)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1987</td>
<td>Plasmaco purchases IBM PDP equipment</td>
<td>Laptops with STN displays hit market</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1988</td>
<td>DTI creates 14.1” prototype</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1989</td>
<td>DTI’s first fab opened at Himeji City (Japan), next to Toshiba STN plant</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1990</td>
<td>P75 portable ($18,000)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1992</td>
<td>First ThinkPad (Model 700C); DTI makes about 500k TFT LCDs</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Figure 2: IBM and Total Industry LCD and Plasma Patents, 1968-1995
Table 1: Early Plasma Supporters

<table>
<thead>
<tr>
<th>Name</th>
<th>Nation</th>
<th>Licensee</th>
<th>Pre-1983 Patents</th>
<th>PDP Exit</th>
<th>Post-1990 LCD Mfg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Owens-Illinois</td>
<td>U.S.</td>
<td>Yes</td>
<td>109</td>
<td>7</td>
<td>1977</td>
</tr>
<tr>
<td>IBM</td>
<td>U.S.</td>
<td>Yes</td>
<td>86</td>
<td>6</td>
<td>1986</td>
</tr>
<tr>
<td>Burroughs</td>
<td>U.S.</td>
<td>Yes</td>
<td>78</td>
<td>1</td>
<td>1983</td>
</tr>
<tr>
<td>Fujitsu</td>
<td>Japan</td>
<td>Yes</td>
<td>67</td>
<td>3</td>
<td>na</td>
</tr>
<tr>
<td>Siemens</td>
<td>Germany</td>
<td></td>
<td>53</td>
<td>36</td>
<td>na</td>
</tr>
<tr>
<td>Philips</td>
<td>Netherlands</td>
<td></td>
<td>41</td>
<td>12</td>
<td>1981</td>
</tr>
<tr>
<td>NEC</td>
<td>Japan</td>
<td>Yes</td>
<td>20</td>
<td>10</td>
<td>na</td>
</tr>
<tr>
<td>NCR</td>
<td>U.S.</td>
<td>Yes</td>
<td>19</td>
<td>2</td>
<td>1983</td>
</tr>
<tr>
<td>AT&amp;T</td>
<td>U.S.</td>
<td>Yes</td>
<td>19</td>
<td>11</td>
<td>1985</td>
</tr>
<tr>
<td>Oki Electric</td>
<td>Japan</td>
<td></td>
<td>15</td>
<td>0</td>
<td>na</td>
</tr>
<tr>
<td>Control Data</td>
<td>U.S.</td>
<td>Yes</td>
<td>13</td>
<td>0</td>
<td>1983</td>
</tr>
<tr>
<td>Sony</td>
<td>Japan</td>
<td></td>
<td>13</td>
<td>6</td>
<td>1984</td>
</tr>
<tr>
<td>English Electric Valve</td>
<td>United Kingdom</td>
<td></td>
<td>12</td>
<td>0</td>
<td>1987</td>
</tr>
<tr>
<td>Thomson</td>
<td>France</td>
<td></td>
<td>12</td>
<td>14</td>
<td>1981</td>
</tr>
<tr>
<td>Ferranti</td>
<td>United Kingdom</td>
<td></td>
<td>11</td>
<td>0</td>
<td>1978</td>
</tr>
<tr>
<td>AEG</td>
<td>Germany</td>
<td></td>
<td>10</td>
<td>15</td>
<td>1984</td>
</tr>
<tr>
<td>Sperry</td>
<td>U.S.</td>
<td>Yes</td>
<td>9</td>
<td>0</td>
<td>1983</td>
</tr>
<tr>
<td>NHK/Japan Broadcasting</td>
<td>Japan</td>
<td></td>
<td>9</td>
<td>0</td>
<td>na</td>
</tr>
<tr>
<td>Texas Instruments</td>
<td>U.S.</td>
<td>Yes</td>
<td>6</td>
<td>15</td>
<td>1984</td>
</tr>
</tbody>
</table>