Fading Memories: A Process Theory of Strategic Business Exit in Dynamic Environments

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This comparative study of the evolution of Intel Corporation's strategic position in two semiconductor memory businesses and in the microprocessor business provides insight into the forces that drive strategic business exit in dynamic environments. Inertial forces caused Intel's distinctive competence to diverge from the evolving basis of competitive advantage in the memory business. Inertial forces also caused Intel's corporate strategy to diverge from strategic actions taken by middle-level managers. Intel's internal selection environment played a key role in the strategic business exit process by causing it to shift the allocation of scarce manufacturing resources from the memory business to the emerging microprocessor business before corporate strategy was officially changed. The paper contributes to the development of theory about the role of strategy in firm evolution by offering insight into how the internal selection environment mediates the coevolution of industry-level sources of competitive advantage and firm-level sources of distinctive competence and into the link between corporate strategy and strategic action.•

INTRODUCTION

Why do some firms continue to survive while others do not? Arguments based on the study of evolutionary processes applied at the firm level posit that long-term survival depends, in part, on the firm's ability to use intraorganizational ecological processes to cope with external selection pressures (e.g., Burgelman, 1991; Van de Ven, 1992). Intraorganizational ecological processes allow firms to generate new businesses based on distinctive competencies and, through internal selection and retention processes, to change the mix of businesses in which they compete. Intraorganizational ecological processes thus allow firms to reduce their dependency on the vagaries of the competitive environment associated with any given business. But this also raises the question of how firms strategically exit from some existing businesses and how they redeploy or shed competencies associated with these.

Not much systematic research has focused on the intraorganizational processes leading to business exit. Organizational theorists have offered insights into the processes associated with organizational decline (Sutton, 1990), permanently failing organizations (Meyer and Zucker, 1989), and disbandings (Hannan and Freeman, 1989) but have not documented the processes leading to strategic business exit. Research in industrial organization economics has discussed exit primarily in the context of declining industries and has focused on capacity divestment decisions, using stylized models of competitive interaction (e.g., Ghemawat and Nalebuff, 1985, 1990) or cross-sectional research (e.g., Harrigan, 1981; Baden-Fuller, 1989; Lieberman, 1989). Strategic management research has focused on business exit primarily in the context of product-market positioning (e.g., Porter, 1980), portfolio planning, or corporate restructuring (e.g., Gilmour, 1973; Snow and Hambrick, 1980; Bower, 1986).

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Focusing on the intraorganizational processes associated with strategic business exit offers the opportunity to examine from the inside out how the dynamics of firm-level distinctive competence match, or fail to match, the dynamics of the basis of competition in the industry. The issue of dynamically matching firm-level distinctive competence and industry-level sources of competitive advantage is particularly salient for firms facing technological change that is competence destroying (Tushman and Anderson, 1986) or that affects the relative importance of different technical competencies within the firm (Henderson and Clark, 1990). More generally, the issue is important for all firms facing structural industry change that causes shifts in the basis of competition.

Theory about the matching of firm-level distinctive competence and industry-level sources of competitive advantage remains underdeveloped in strategic management. Received theory has a prescriptive adaptive orientation and pays little attention to the possibility that the processes involved may be coevolutionary, at least in part. Building on Barnard (1938) and Selznick (1957), Andrews (1980) has argued that the task of top management is to match distinctive competence with business opportunities. In the same line of thought, Prahalad and Hamel (1990) have explained the success of companies such as Canon, NEC, and Ericsson in terms of the development of core competence. Their explanation depends to a large extent on strategic intent based on the chief executive officer's (CEO's) superior foresight. Such post hoc vision or grand strategy explanations beg important questions, from the perspective of an evolutionary theory of the firm (e.g., Winter, 1990; Burgelman, 1991; Nelson, 1991; Van de Ven, 1992). This sort of explanation also does not sufficiently take into account the fact that strategy making in large, complex firms simultaneously involves multiple levels of management (e.g., Bower and Doz, 1979; Burgelman, 1983a).

This paper reports longitudinal field research on the processes leading to strategic business exit. The paper documents the processes leading Intel Corporation to exit from dynamic random access memory (DRAM) design and manufacturing in 1984–1985, to halt capacity expansion for erasable programmable read only memory (EPROM) manufacturing in 1991, and to transform itself from a "memory" company into a "microcomputer" company. The paper examines why Intel's distinctive competence was deployed and developed in ways that diverged from the evolving basis of competition in the DRAM industry and why it took top management several years to come to the conclusion that Intel's strategic position in the DRAM business was no longer viable and that exit was necessary. It also examines why middle-level managers were able to shift scarce manufacturing resources gradually from the DRAM business to new, more profitable opportunities in the microprocessor business without a preceding reconsideration of the official corporate strategy. Finally, the paper elucidates further the role played by internal selection processes in maintaining Intel's ability to make viable strategic decisions while its official corporate strategy was in flux.

METHOD

This study is part of an ongoing research project that tracks the evolution of Intel Corporation's corporate strategy. Intel was founded by Robert Noyce and Gordon Moore, who left Fairchild in the summer of 1968. Andy Grove, who had been Moore's assistant director of research at Fairchild, also left to join Intel, completing what the company's historians have called the "triumvirate." Intel was the first company to specialize in making large-scale integrated circuit memory products. The company's strategy in 1968 was to build semiconductor memory products for mainframe computers in competition with the "core memory" standard of the day. In 1991, Intel was a leading microcomputer company that had survived for more than twenty years as an independent company in an extremely dynamic industry. The firm grew from $1 million in sales in 1968 to $4.8 billion in 1991. Profits rose from a loss of $2 million in 1969 to over $800 million in 1991.

Research Design

The research was based on a longitudinal, two-stage, nested case study design within one corporate setting (e.g., Yin, 1984; Leonard-Barton, 1990). Archival and interview data were collected on the evolution of two semiconductor memory businesses—DRAM and EPROM—and the microprocessor business at Intel. These cases were selected for theoretical reasons as an intentional sample (Glaser and Strauss, 1967; Eisenhardt, 1989b). The selection criterion was strategic importance to the firm. DRAMs was the business that had made Intel successful during the 1970s. EPROMs, during the mid-1980s, still accounted for about 15 percent of Intel's business. Microprocessors had become Intel's largest source of revenue by 1982 and grew rapidly during the mid-1980s.

The research was carried out in two stages. The first stage, from fall 1988 through spring 1989, focused on the decision to exit DRAMs during 1984–1985. The second stage of the research, from fall 1990 through spring 1991, focused on the implementation of the DRAM exit decision. It sought to document the difficulties that Intel encountered in getting the organization to stop all activity in DRAMs. During this stage of the research, Intel top management also made important decisions regarding EPROMs and microprocessors.

Data Collection

Interview and archival data were collected. All data collection was longitudinal. For DRAM, data were historical, covering the period 1971–1985. For EPROMs and microprocessors, historical data were combined with current data obtained during the research period.

Interview data. Twenty-seven key Intel managers were formally interviewed, many of them repeatedly, yielding close to 200 pages of written interview notes. Seventeen of these managers were interviewed during the first stage of the research. Some top managers who had previously left the company were included as well. Managers from different levels, different functional groups, and different businesses who had been involved in or affected by the decision were asked to discuss the causes of Intel's exit decision. Ten additional managers, most of whom were at lower and middle levels in the organization in the mid-1980s, were formally interviewed during the second stage of the research. These interviews provided a more detailed account of how the DRAM exit decision was perceived and experienced by front-line managers. Many of the managers previously interviewed were contacted again to clarify differences and discrepancies. Throughout the research period, informal discussions with current and former Intel employees were used to corroborate data obtained from the formal interviews. The head of R&D of one of the leading Japanese photolithography equipment suppliers was also interviewed. This company had had an important impact on the evolution of the DRAM industry, and the interviewee had had significant experience with DRAMs in another major U.S. semiconductor company earlier in his career. Table 1 lists the managers who were formally interviewed, with the job they held in 1984–1986 and the number of times they were interviewed.

Table 1

Interviewees

Job in 1984–86 period (except as stated)	Number of interviews
1. Chief Executive Officer	2
2. Chief Operating Officer	4
3. Chief Financial Officer	1
4. Senior VP and General Manager (GM), Components Division	2
5. Senior VP and GM, Systems Division	2
6. Director, Assembly/Test	3
7. Director, Technology Development (TD)	3
8. Director, Memory Components Division (early 1980s)	2
9. Director, Memory Components Division (July '83 to early '85)	1
10. Head, DRAM Memory Operations; supervised design, marketing/sales, and customer support	1
11. Head, Fabrication Facility (Fab) 5 TD (DRAM)	3
12. Head, Fab 3TD (Logic/SRAM)	1
13. Head, Fabs 4,5,8 Manufacturing	1
14. Head, Fab 5 Manufacturing	1
15. Project Manager, Fab 5TD—1 micron DRAM	1
16. Supervisor, Fab 3, of TD and manufacturing group leaders; brought in to make TD and manufacturing integrate efforts for the 1.5 micron 80386 microprocessor	1
17. Fab 3 Manufacturing (group leader)	1
18. Fab 3 Manufacturing group leader; associated with Component Contracting in 1991	1
19. Head, Component Contracting in 1991	1
20. DRAM designer	1
21. Responsible for closing Barbados assembly and Puerto Rico test facilities in 1986	1
22. General Manager, Application Specific Integrated Circuits in the Microcomputer Division in 1988	1
23. Development Manager, Microcomputer Division in 1988	1
24. Responsible for Intel's Computer Aided Design group throughout the 1980s	1
25. Product Development Manager for the i860 (RISC) microprocessor in 1988	1
26. Manager assigned to study and make strategic recommendations for Intel's memory businesses in the mid 1980s	1
27. Personal assistant to Andy Grove in 1988	2
28. Senior VP and Chief Technical Officer, Nikon Precision Inc. in 1991	2

The interviews lasted between one and two hours and were open-ended. Follow-up interviews were semistructured, for clarification about key events, people, and issues that had been identified. Key events centered primarily around the introduction of successive generations of products in each of the businesses, because these introductions drove and were driven by the competitive dynamics in the industry. Key people were individuals or groups from different functional areas or different hierarchical levels who made critical decisions or made proposals that, while not necessarily implemented, triggered high-level reconsideration of strategic issues. Key issues included the importance of DRAMs as a technology driver at Intel; the importance of DRAMs in Intel's product market strategy; the allocation of scarce manufacturing capacity; the allocation of R&D resources to different businesses; the integration of process technology development and manufacturing; the retention and deployment of key talent, and, more generally, Intel's ability to compete in commodity businesses. No tape recorder was used, but the interviewers made extensive notes. I conducted fifteen of the interviews with a research associate. Transcripts of the research associate's notes, when compared with mine showed consistent agreement on the substantive content of the interview. This provided some confidence that the data were valid and reliable.

Archival data. Archival data, such as documents describing the company's history, annual reports, and reports to financial analysts, were obtained from Intel. The company also provided a statement on the evolution of Intel's approach to the development of computer-aided-design tools throughout the 1980s, written specifically for this research. Additional archival data were obtained from Dataquest and from written materials, such as industry publications and financial analysts' reports and business press articles about Intel and the semiconductor industry. These archival data made it possible to construct a quantitative picture of the evolution of the semiconductor industry and Intel's evolving strategic position in major segments. The archival data could be juxtaposed to the interview data to check for potential systematic biases in retrospective accounts of past strategy (Golden, 1992). Discrepancies between interview data and archival data discovered in the course of the research raised a number of questions that guided further data collection and analysis. Jelinek and Schoonhoven's (1990) study of the innovation process at Intel was a fortuitous source of additional data as well as a validity check for the new data collected in this study. Data collection was concluded when a level of saturation was reached (Glaser and Strauss, 1967).

Limitations

The study is subject to the general limitations associated with field research but also has some specific limitations. First, the research concerns a single and successful corporation in the semiconductor industry that is still run by some of its founders. While it would be useful to study a larger sample that includes failing organizations, few in-depth studies of strategy-making processes of semiconductor firms exist. By concentrating on one organization with more than twenty years of continuity in leadership, the researchers had access to sources with intimate knowledge of the details of the firm's evolution and could examine in depth how the organization had dealt with potential failure. Having excellent access made it possible for the researchers to put themselves into "the manager's temporal and contextual frame of reference" (Van de Ven, 1992: 181). Excellent access also made it possible to reconstruct the strategic business exit with input from people at the different levels of management involved in the process. This provided a basis for triangulation and may alleviate some of the concerns associated with retrospective data (e.g., Golden, 1992). Second, the semiconductor industry is extremely cyclical and expansive (Webbink, 1977; Brittain and Freeman, 1980; Jelinek and Schoonhoven, 1990; Eisenhardt and Schoonhoven, 1990) and of the high-velocity type (Eisenhardt, 1989a). Hence, some of the phenomena documented in this study may not be generalizable to companies operating in less rapidly changing environments (Williams, 1992).

Conceptual Framework

Stages of strategic business exit. Data analysis and conceptualization were iterative (Glaser and Strauss, 1967; Burgelman, 1983a; Eisenhardt, 1989b). The analysis of the DRAM case data suggested that the exit process comprised several partly overlapping stages that bracketed key events: (1) Intel's initial success in the DRAM industry, (2) the emergence of external competition and Intel's competitive responses, (3) internal competition for resources between Intel's memory and microprocessor businesses, (4) growing doubts among Intel's top management about the viability of the DRAM business, (5) Intel's strategic decision to exit from DRAMs and its implementation, and (6) articulation of new official corporate strategy and internal "creative destruction" of obsolete routines associated with Intel's early success. Cross-case analysis suggested that the stages were roughly the same for DRAMs and EPROMs but that the time taken by each stage was generally longer for EPROMs.

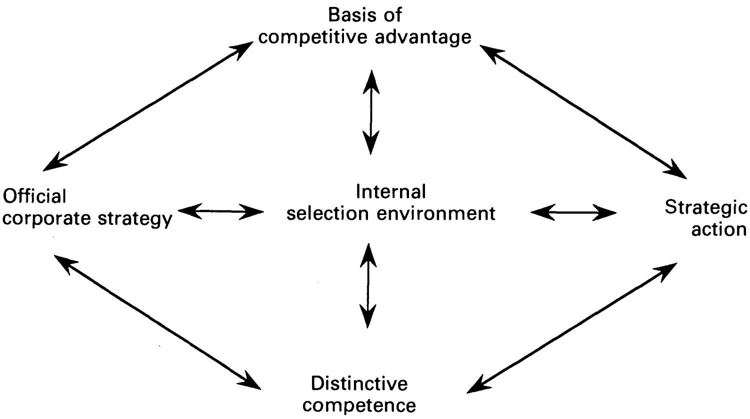
Questions raised in data collection. Several questions emerged in the course of the longitudinal data collection and were brought into sharper focus by the stages framework. The first question—Why did Intel, the first successful mover in DRAMs, fail to capitalize on and defend its early lead?—focused attention on the changing industry structure and Intel's evolving strategy in DRAMs. It required examining why Intel, a company well suited to developing, marketing, and profiting from innovative products, would not or could not effectively compete in commodity businesses. This, in turn, required examining how inertial forces associated with Intel's distinctive competence affected its competitive responses.

The second question—How did it happen that the bulk of Intel's business had shifted away from DRAMs and DRAM market share was allowed to dwindle while top management, even in 1984, was still thinking of DRAMs as a strategic business for the company?—directed attention to sources of inertia in official corporate strategy and to actions by middle-level managers that were not in line with the professed corporate strategy of Intel, the "memory company." It also directed attention to the fact that top management viewed DRAMs not only as a product but also as a core technology of the firm. The third question—How was it possible that middle-level managers could take actions that were not in line with the official corporate strategy?—directed attention to the role played by Intel's internal selection environment, constituted, in part, by its organization structure, its resource allocation process, and its culture of constructive confrontation. The fourth question—If not planned by top management, how did microprocessors and EPROMs come about at Intel in the first place?—focused attention on the evolution of Intel's distinctive competence, which produced unanticipated innovations, and on the role played by top management in the internal selection processes in supporting these innovations.

The fifth question—If Intel exited from DRAMs because they had become a commodity business, how would that affect the future of EPROMs, which had also become a commodity business by 1988?—was answered during the second stage of the research (1990–1991): Intel decided to halt expansion of manufacturing capacity in EPROMs in 1991. This question focused attention on the organizational learning processes associated with strategic business exit. Finally, the sixth question—Why did it take Intel's top management almost a year to complete the exit from DRAMs after the November 1984 decision not to market 1 Meg(abit) DRAMs?—helped determine that Intel was not simply "harvesting" the DRAM business and helped clarify further the intricacies top management faced in determining which key elements of distinctive competence associated with DRAMs to retain and how to do so.

Forces driving strategic business exit. Addressing these questions suggested that the stages in the strategic business exit process could be explained in terms of interplays between dynamic, mostly exogenous, industry-level and dynamic, mostly endogenous, firm-level forces. Five categories of forces were identified: (1) The *basis of competitive advantage* in the semiconductor memory business was determined by evolving industry-level forces, including those identified by Porter (1980), as well as the emergence of dominant designs (Utterback and Abernathy, 1975) and changing appropriability regimes (Teece, 1986). (2) *Distinctive competence* concerned the differentiated skills, complementary assets, and routines Intel evolved to create sustainable competitive advantage in the memory and microprocessor businesses (Selznick, 1957; Teece, Pisano, and Shuen, 1990). (3) *Official corporate strategy* reflected top management's beliefs about the basis of the firm's past and current success (Burgelman, 1983a, 1991; Donaldson and Lorsch, 1983; Weick, 1987). Key beliefs concerned the core business of the firm (Intel the "memory company") and the relative importance of particular technological competencies for competitive advantage (DRAMs as "technology driver"). (4) *Strategic action* was what Intel actually did. In principle, official corporate strategy and strategic action should be closely related; however, strategic action depended on initiatives taken by middle-level managers who responded more to external and internal selection pressures than to official corporate strategy (e.g., Mintzberg, 1978; Quinn, 1980; Burgelman, 1983a, 1991; Mintzberg and McHugh, 1985). (5) Intel's *internal selection environment* mediated the link between corporate strategy and strategic action as well as the coevolution of industry-level sources of competitive advantage and firm-level sources of distinctive competence. It encompassed the structural and strategic contexts shaping the strategic actions of middle-level managers (Bower, 1970; Burgelman, 1983a). The conceptual framework constituted by these five categories of forces and their interplays is illustrated in Figure 1 and served to organize the discussion of the key findings.

Figure 1. Forces driving the strategic business-exit process.



FINDINGS: PROCESSES LEADING TO INTEL'S STRATEGIC EXIT FROM MEMORIES

From the perspective of Intel, the relationships among the five categories of forces evolved through states of relative harmony, when the forces were mutually supportive and consistent with each other, and disharmony, when they were not. Strategic harmony was associated with Intel's initial success in the DRAM industry in the early to mid-1970s. Strategic disharmony characterized the late 1970s and early 1980s and culminated in the November 1984 decision not to put the 1 Meg DRAM into production. New harmony came about as the DRAM exit decision was implemented during 1985.

The Basis of Competitive Advantage

In 1969, Intel established itself as a leader in semiconductor memories by pioneering a new semiconductor process technology called metal-on-silicon (MOS). This process technology allowed Intel to increase the number of circuits on a chip while simultaneously reducing its production cost. In 1970, Intel introduced the world's first DRAM into the market. While other companies, notably Advanced Memory Systems, had been able to design a working DRAM, they had failed to develop a process technology to manufacture the new device successfully (Gilder, 1989). Intel became the first successful mover in DRAMs because its new MOS process technology pushed DRAM manufacturing processing yields above the threshold for viability in the market against the core memory standard of the day. Over the next three years, DRAMs replaced magnetic cores as the standard technology used by computers to store instructions and data as they executed programs.

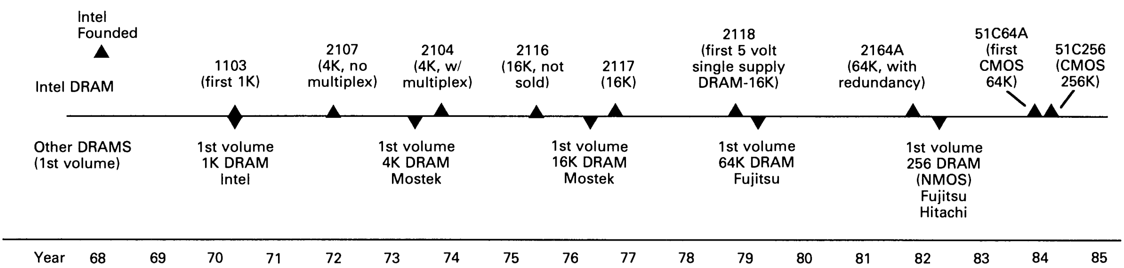
There were three major types of technological competencies involved in semiconductor products: (1) circuit design (Can we design it?), (2) process technology development, called TD (Can we make it?), and (3) manufacturing engineering (Can we manufacture it in large volumes with high yields?). TD was a silicon-based competence: It involved the sequence of physical steps necessary to put multiple layers of masks on a chip. Circuit design was not a silicon-based competence. It referred to the ability to define patterns on each layer of mask. DRAMs required a very tight relationship between circuit design and TD. According to a former director of Intel's Memory Components Division, "The DRAM designer . . . focuses on the memory cell and has to understand where every electron in the structure is. . . . The design and the process are developed together. In contrast, a logic [microprocessor] designer is not as concerned with the details of a transistor's operation. The process is critical, but not as interactive with the design" (Cogan and Burgelman, 1990: 9). TD was also significantly different from manufacturing engineering, which was primarily concerned with reaching high yields of functioning chips (Graham and Burgelman, 1991). TD activities involved device physics and materials science. TD scientists asked questions such as "Can this material carry enough current?" By defining the process technology, the TD scientists limited the degrees of freedom available to the manufacturing engineers. They set the parameters—e.g., deposition pressure, exposure energy, etch gas mixtures—within which the manufacturing engineers could adjust their process equipment. Manufacturing engineers needed to characterize the product's performance in terms of these parameters. They asked questions such as "How often does this lithography tool need to be realigned?" Or, "How many wafers can be processed in this etch bath before device performance or yield degrades?" And, "What is the mechanism that causes the degradation? How can this mechanism be monitored?"

In the early stage of the DRAM industry, when production volumes and minimum acceptable yield levels were relatively low, the difference between the activities and concerns of TD and manufacturing engineering was not very salient. Intel naturally viewed TD as its distinctive competence because TD made the difference in its initial success (Selznick, 1957). Intel also developed a distinctive competence in integrating TD and manufacturing (Cogan and Burgelman, 1990; Jelinek and Schoonhoven, 1990). From the start, Intel's founders perceived this integration to depend on geographic proximity. They decided to keep the TD and manufacturing activities together at a fabrication facility (fab) and to perform all process technology research directly on the production line. This approach resulted initially in the ability to make rapid incremental process changes and to stay ahead of competition using TD. Intel also developed a distinctive marketing competence early on (Davidow, 1986). Top management understood the need to educate customers to help them use the new semiconductor memories in their product development. Intel formed the Memory Systems Operation, which assembled DRAM chips with the required peripheral controller circuitry for sales to original equipment manufacturers (OEMs). OEMs bought these assemblies and put them together into complex systems for end-users.

At the time of founding, Intel's official strategy was to offer replacement parts for mainframe computer memories (Gilder, 1989). By 1972, Intel's original DRAM was the world's largest selling semiconductor product, accounting for over 90 percent of Intel's sales revenues, and DRAMs remained Intel's core business throughout the 1970s and early 1980s. Intel emphasized being first to market with premium-priced products and first to move into new markets as existing ones matured (Jelinek and Schoonhoven, 1990). As the largest volume product, DRAMs were viewed as the "technology driver" on which Intel's learning curve depended, and the company routinely allocated resources to its successful and fast-growing DRAM business.

Shifting basis of competitive advantage. Figure 2 shows a time line of important competitive product introductions in DRAMs. Texas Instruments and Mostek were early entrants. Mostek, a start-up, pioneered "multiplexing," which allowed a smaller number of output pins to address the entire memory and thereby increased DRAMs' user-friendliness as of the 4K generation. This reduced the usefulness of Intel's Memory Systems Operation. Also, large, vertically integrated Japanese firms targeted the semiconductor memory industry as strategic and entered as of the 64K generation with the intention to dominate. The Japanese companies' determination to dominate led to aggressive capacity expansion and price competition (Prestowitz, 1988).

Figure 2. DRAM product introduction timeline, 1968–1985.



Source: Intel documents, Dataquest

The difference between competitors' product offerings quickly disappeared. Beginning with the 4K generation, Intel's DRAM became the basis for a dominant design. This moved the pattern of innovation from "fluid" to "specific" (Utterback and Abernathy, 1975), with competitors (initially Mostek) now focusing on optimizing the dominant DRAM design. New DRAM generations followed each other in highly predictable two- to three-year cycles (see Figure 2). Personnel migration between semiconductor companies in the U.S. led to diffusion of the DRAM technology and further leveling of technical competencies. These developments changed the appropriability regime (Teece, 1986), so that it was more difficult for companies to profit from the intellectual value added in DRAMs.

As the DRAM industry matured, customers demanded tens of thousands of units of a single product. Large numbers of "wafers" (circular slices of silicon containing a number of DRAM chips determined by its diameter) were needed to satisfy OEM customers. These customers moved from a willingness to accept any batch with a reasonable number of functioning DRAMs to demanding high quantities of DRAMs with guaranteed performance, reliability, and price. This, in turn, shifted the basis of competition in the industry toward the large-scale, precision manufacturing competence necessary to achieve very high yields for each new DRAM generation immediately. And this shift favored the tightly managed manufacturing-oriented firms, such as Texas Instruments and the Japanese, over the more innovative but less disciplined TD-oriented Intel (Prestowitz, 1988; Jelinek and Schoonhoven, 1990).

Semiconductor equipment suppliers, in particular, the photolithography equipment suppliers, became an important source of innovations in manufacturing and the key to increasing yields (e.g., Henderson and Clark, 1990). Japanese suppliers began to offer superior equipment. Nikon's chief technical officer explained that Nikon's photolithography equipment had a mean-time-to-failure that was an order of magnitude better than that of U.S. equipment suppliers, but Nikon's equipment was not available in the U.S. until 1986. In the meantime, large Japanese DRAM manufacturers, such as Fujitsu, NEC, and Hitachi, focused on establishing strong relationships with Japanese equipment suppliers. By involving equipment suppliers in continuous improvement of the manufacturing process in each DRAM generation, top Japanese DRAM producers were able to reach yields that were sometimes 40 percent higher than those of top U.S. companies (Prestowitz, 1988). As a result of these various industry-level forces, DRAMs became a commodity product. The new key factor determining profitability in the DRAM market was manufacturing capacity. To be a viable competitor, a company needed to be willing to commit increasingly large capital investments to DRAM capacity and to develop the necessary discipline in manufacturing to obtain high initial yields and continuous yield improvements quickly for each DRAM generation.

The changing basis of competition in the memory business strained the relationships between Intel's TD and manufacturing groups and called into question the company's routines for integrating the two groups. The changes made the difference between TD and manufacturing engineering activities salient and important as production volumes in DRAMs increased dramatically between the early 1970s and early 1980s (see Figure 2). TD scientists continued to see their task in terms of process innovation, revolutionary change, and technical elegance. Manufacturing engineers, in contrast, now saw their task in terms of stability, incremental change, and technical simplicity in order to reach higher yields. TD scientists were expected to evaluate and introduce new process equipment and materials (e.g., process gases) that enable technical advance. Manufacturing engineers, however, now realized that these changes required recharacterizing the process, a painful and time-consuming relearning of the process parameters and how and when to adjust them.

Increasing the emphasis on large-scale manufacturing engineering competence was difficult for Intel. The early technical heroes at Intel has been TD scientists who understood a fundamental physical phenomenon and converted it into a working product prototype. The line separating TD and manufacturing at Intel was drawn at the point of creating a functioning prototype. Jelinek and Schoonhoven (1990: 355) pointed out that recharacterizing or "tweaking" the manufacturing processes had been consistent with Intel's strategy of being first to market with premium-priced products. Tweaking had worked in the past, and it had been a source of pride to manufacturing people that Intel could run manufacturing processes that were not stable.

As process technology began to evolve more quickly, each generation of product not only required a new process but an entirely new set of capital equipment. Thus it became very disruptive to current production to carry out process technology development on the line. Also, geographical proximity turned out not necessarily to lead to tight functional integration. TD groups tended to provide only minimum process characterization, and the manufacturing groups tended to develop the "not invented here" (NIH) syndrome. Often process yields would dip after a transfer of technology from TD to manufacturing and would only recover after the manufacturing engineers learned the process. This effect was internally known as the "Intel U." One manager pointed out that, on occasion, the combination of manufacturing's NIH and the minimal process characterization by the TD group resulted in an Intel U spanning more than six months (Graham and Burgelman, 1991: 3). Also, Intel's growth required adding fabs in new locations. By 1985, Intel had eight fabs spread over four states (California, Oregon, Arizona, New Mexico) and Israel. The addition of new fabs further impeded the transfer of technology as pockets of technical competence proliferated across the different fabs. Although management tried to improve the hand-off from TD to manufacturing by formal rules, this made the process more bureaucratic and time consuming and did not fundamentally change the behavior of the TD and manufacturing groups.

Inertial competitive responses. Struggling to maintain a competitive advantage, Intel continued to rely on innovative TD efforts through several successive DRAM generations. For four successive product generations, the DRAM TD group came up with an innovative process solution that was ahead of its time (Figure 2). In 1979, Intel introduced the first 5-volt "single-power-supply" 16K DRAM. Single-power supply greatly simplified the customer's own design and production tasks. Intel was the only supplier of this product and captured a price premium of double the industry average for three-power-supply 16K DRAMs. Intel expected the 64K DRAM generation to be introduced later and to be based on a single-power supply. Fujitsu introduced a standard 64K DRAM in 1979, however, and captured a large market share. The single-power-supply 16K DRAM remained a niche product, and Intel fell behind in manufacturing yields relative to top Japanese producers. In 1982, Intel's 64K DRAM with "redundancy" entered production. Redundancy involved adding an extra column of memory elements in a chip so that in the event of a process-induced defect, the auxiliary column could be activated. This allowed a memory chip that was defective at testing to be reprogrammed before shipment and could increase yields. Intel expected that redundancy would help overcome its disadvantage in manufacturing yields relative to the Japanese and that the 256K DRAM generation would be based on redundancy. This time, however, its plan was thwarted by Fujitsu and Hitachi, which entered with a standard 256K DRAM in 1982 and captured a large market share. In 1983, Intel decided to produce a Complementary MOS (CMOS) 256K DRAM and to cancel the standard n-channel MOS (NMOS) 256K DRAM effort. CMOS had the advantage of very low power consumption. In 1984, Intel introduced first a 64K CMOS DRAM and then a 256K CMOS DRAM and was the only supplier of these chips. Intel hoped to offset its manufacturing cost disadvantage with a technically superior product. Intel expected that CMOS would become the standard for the 256K and later DRAM generations, but it did not become the standard for the 256K generation. During mid-1984, the DRAM TD group was working on the 1 Meg DRAM generation and focused on an advanced capability in "thin dielectrics," which allowed them to reduce minimum feature size to 1 micron instead of changing the entire DRAM cell design. The DRAM TD group estimated its design was two years ahead of the competition.

In each of these instances, Intel's innovative TD effort did not produce competitive advantage for the relevant DRAM generation. Intel technologists saw the new technological advances as the leading edge. Marketing people saw them as niche products with higher margins. They hoped that the entire market would quickly go for the new technology, but even the up to double margins available with the niche products were unattractive, given the low margins in the commodity markets to begin with, and while the market did go for Intel's TD innovations eventually, it always did so for later generations.

Intel's inertial competitive responses resulted in the company's losing its strategic position in DRAMs over time. Table 2 shows the evolution of worldwide unit shipments of different generations of DRAMs (in thousands) and Intel's market shares between 1974 and 1984. Table 2 shows that as of the 16K DRAM generation, Intel was beginning to fall behind the competition. Figure 3 shows the evolution of market shares of the major competitors in DRAMs and the evolution of DRAM market volumes (in dollars) between 1974 and 1985. By 1980, Intel's market share had dwindled to ninth in the industry.

Table 2

Evolution of DRAM Volumes and Intel Market Share, 1974–1984*

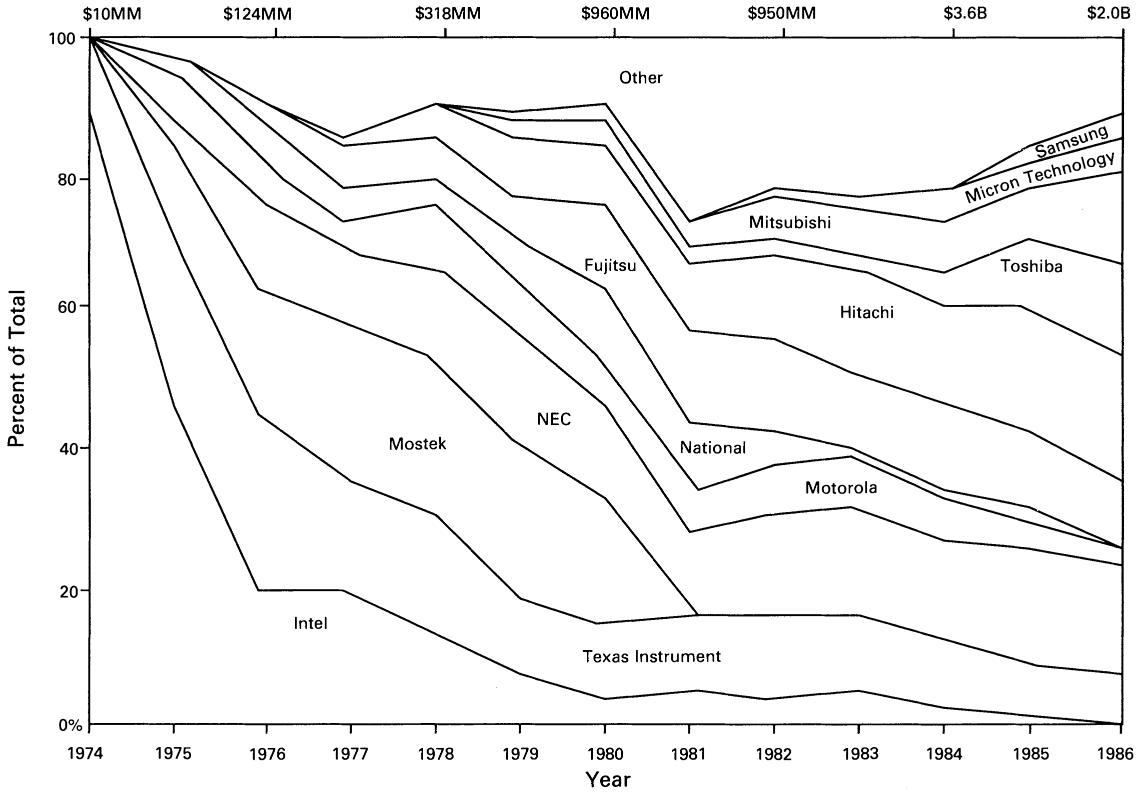
Product	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
Worldwide unit shipments of DRAMS (in thousands)											
4K	615	5,290	28,010	57,415	77,190	70,010	31,165	13,040	4,635	2,400	1,250
16K3PS†			50	2,008	20,785	69,868	182,955	215,760	263,050	239,210	120,690
16K 5V						150	1,115	5,713	23,240	57,400	40,600
64K					1	36	441	12,631	103,965	371,340	851,600
256K									10	1,700	37,980
Intel DRAM market share (%)											
4K	82.9	45.6	18.7	18.1	14.3	8.7	3.2				
16K3PS†			37.0	27.9	11.5	4.4	2.1	2.4	2.3	1.9	1.4
16K 5V						100.0	94.0	66.5	33.1	11.7	12.3
64K							0.7	0.2	1.5	3.5	1.7
256K											0.1
Total Share	82.9	45.6	19.0	20.0	12.7	5.8	2.9	4.1	3.5	3.6	1.3

* Source: Dataquest.
† 16K 3PS refers to the industry-standard, three-power-supply DRAM. The 16K 5V model requires only one power supply.

Distinctive Competence

Intel's initial success was based on its core DRAM business, but early on, its technological competence generated two important innovations. EPROMs and microprocessors were unplanned new technologies with major commercial potential. EPROM was invented by Dov Frohman, who was trying to understand and remedy a strange phenomenon that was causing reliability problems with Intel's MOS process technology. Even though there were no immediate market applications, CEO Gordon Moore decided to support the new technology. Microprocessors came about because Busicom, a Japanese calculator company, contacted Intel for the development of a new chip set. Busicom had envisioned a set of around 15 chips designed to perform advanced calculator functions. Ted Hoff, an Intel technologist, saw the opportunity to build a simpler set of a few general-purpose chips that could be programmed to carry out each of the calculator instructions, and his chip architecture was implemented by a team of Intel designers under the direction of Federico Faggin. The new device became later known as the "microprocessor," and Busicom initially owned the design. Ted Hoff, who believed that Intel could use the new device as a general purpose solution in many applications, lobbied heavily with top management to renegotiate the rights to the chip design, and Busicom eventually sold the right for all noncalculator applications back to Intel. Vice President of Sales Ed Gelbach remembered the management decision: "Originally, I think, we saw it [microprocessors] as a way to sell more memories and we were willing to make the investment on that basis" (Cogan and Burgelman, 1990: 6). Both EPROMs and microprocessors became important sources of sales revenue for Intel.

Figure 3. Evolution of market share of key competitors and market size in the DRAM industry (1974–1986).

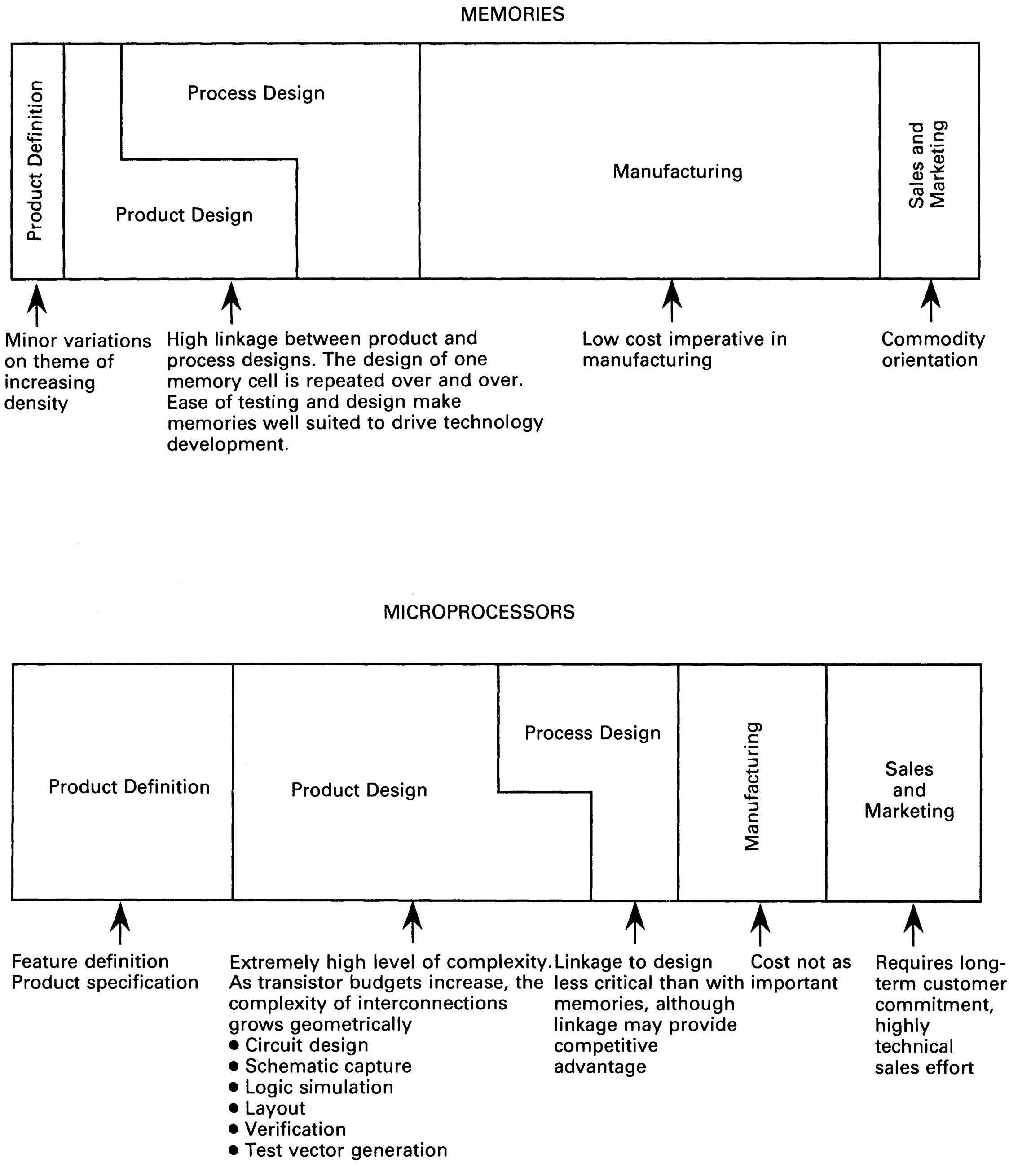


Source: Dataquest

Changing relative importance of distinctive competencies. A key benefit of the development of the microprocessor was that a new competence evolved from Intel's basic competence in circuit integration: Intel developed a single-chip, general logic device that would retrieve its application instructions from semiconductor memory. The growing microprocessor business triggered a change in the relative importance of different distinctive competencies within Intel. By the mid-1980s, as Andy Grove put it, "Intel had moved from a silicon-based distinctive competence (TD) in memory products to a distinctive competence in implementing design architectures in logic products." Figure 4 provides my estimate, informally confirmed by top management, of the relative importance of different distinctive competencies for the memory and microprocessor businesses.

Designing a microprocessor was qualitatively different from designing a memory product. The value added in microprocessor development was in logic design and in being able to interconnect a highly irregular array of building-block cells (product design). Mastering microprocessor design complexity became relatively more important than the ability to increase chip density (process design). The first microprocessor designs had only a few thousand transistors and were designed, developed, and tested manually. Throughout the seventies and early eighties, constant TD advances led to a quadrupling of the

Figure 4. Relative importance of different distinctive competencies for competitive advantage: Memories vs. microprocessors.



Source: Researchers' Estimates

"transistor budgets" available to designers every two to three years. Gordon Moore pointed out a dilemma: The time consumed by the product design process increased geometrically with the number of transistors in the design. Moore predicted that without dramatic advances in computer-aided-design (CAD) technology, the time to design a microprocessor would quickly become an insurmountable bottleneck in the product-development cycle. Under Moore's impulse, Intel embarked on a massive program to build design expertise and CAD tools, investing over $250 million between 1983 and 1987. A written memorandum stated: "... prior to 1981 our [design] tool mix was 70% externally sourced, 20% externally sourced and modified, and 10% internally developed. . . . By 1985, it was 15%, 30%, 55%." The CAD tools and a growing library of successive generations of circuit designs constituted new assets supporting Intel's growing distinctive competencies in implementing microprocessor design architectures.

Figure 4 also indicates that the microprocessor business required Intel to reinforce its product definition and marketing and sales competencies in order to get "design wins." A design win involves convincing customers to design Intel chips into their products (Davidow, 1986: 5). As with DRAMs earlier on, a key to success was the ability to educate customers on how they could use the new products in their own product design. But the design win in microprocessors was very different from the memory design win, since many more factors needed to be coordinated to cultivate a customer relationship. In microprocessors, the customer made a long-term decision about a chip architecture and thereby to a very limited number of suppliers; in memories, there was a greater number of potential suppliers. Aggressive task forces helped Intel get many design wins against Motorola, including IBM's selection of the 8088 as the central processing unit (CPU) for its first personal computer (Davidow, 1986). These efforts were significantly enhanced by the availability of development tools for customers, the sales of which exceeded for a while the microprocessor sales themselves, and by Intel's emphasis on showing customers the upward compatibility path of next-generation products.

TD, however, remained very important. Intel divided its technology development into three groups that represented the three major TD areas: DRAM, EPROM, and microprocessors. The three groups each developed distinctive competencies that related to their product responsibilities (Cogan and Burgelman, 1990). The DRAM group was viewed as distinct from the other two teams because DRAM TD, as noted earlier, required a very tight relationship between product design and TD. The DRAM TD group led the company in line-width reduction, which involved the ability to define patterns of ever-narrower dimensions and to invent creative ways of reducing the required number and size of components per memory cell. Reduced line-width allowed greater circuit density and greater performance and thus created higher value. The DRAM TD group was already developing a 1-micron process while the microprocessor TD group was still developing a 1.5-micron process. Both EPROMs and microprocessors benefited from the DRAM TD group's distinctive competence in line-width reduction.

Corporate Strategy

Intel's corporate strategy was subject to strong inertial forces. By 1980, the company's total market share in DRAMs was less than 3 percent (Table 2). Yet, rational justifications for staying in DRAMs were put forward by CEO Gordon Moore and by VP of Sales Ed Gelbach. Moore continued to support the idea of DRAMs as the company's technology driver and made sure that Intel continued to fund DRAM TD at the same level as other, more successful businesses. For instance, while DRAMs were estimated to account for only about 3 percent of Intel's $1.6 billion sales revenues in 1984, budgeted expenditures for DRAM TD for 1985 were estimated to be roughly $65 million—one third of total R&D and about the same as for EPROMs and microprocessors each (Cogan and Burgelman, 1990). DRAMs were viewed as the technology driver because they were still the largest volume product produced by Intel and thus were perceived to be the basis of the company's learning curve. This was, in retrospect, a weak justification, given that Intel's market share was much smaller than that of its rivals.

Gelbach continued to support DRAMs, based on the idea that Intel needed to offer a one-stop semiconductor shopping list of products to its customers. Given Intel's low market share in DRAMs relative to its market share in microprocessors, this was also a weak argument, but Gelbach was concerned that Intel had a reputation for moving out of products with declining margins and leaving customers to fend for themselves. This was especially important in DRAMs because Intel had been the first and in 1984 was still the only firm offering CMOS DRAMs. Gelbach recalled, "In board meetings, the question of DRAMs would often come up. I would support them from a market perspective, and Gordon [Moore] would support them because they were our technology driver. Andy [Grove] kept quiet on the subject. Even though it wasn't profitable, the board agreed to stay in it on the face of our arguments" (Cogan and Burgelman, 1990: 13).

Emotional attachment by many top managers to the product that had "made Intel" was also part of the inertial force. In the course of the interviews, most managers mentioned emotional factors to explain why it had taken so long for Intel to get out of the DRAM business. One middle manager, for instance, said that Intel had lived on DRAMs and that it was therefore difficult to get out: "It was kind of like Ford deciding to get out of cars." Gordon Moore said that the general manager of Intel's Components Division had the strongest feelings about it, because he came from Texas Instruments and was in favor of commodity businesses. The general manager of the Components Division confirmed that it had been an emotional time and it was difficult to be rational. He said that his dilemma was excruciating, that he couldn't get the company to make a decision that would allow him to take appropriate actions. He said that in the spring of 1985, it was difficult to get the company to discuss the issue but that his business managers were desperately hammering him for decisions while losses were increasing. He said that he tried to get Gordon Moore on one side and Andy Grove on the other. He said that Andy felt very strongly that all resources should be in logic and that he wanted to turn the DRAM TD group into an advanced logic R&D group. Andy's vision for Intel was in microprocessors. He quoted Andy as saying, "Don't worry about the memory business, it is not important to our future." He said that

Grove ultimately prevailed, and he himself stepped down in the summer of 1985. Andy then assumed direct operational control. Another middle manager also said that top managers were torn by their emotions but that Andy Grove had told him to "make data based decisions and not to fear emotional opposition."

Bounded rationality in seeing the implications of events signaling strategic change also played a role in the relative inertia of Intel's corporate strategy. Strategic change is usually clearer in retrospect than during the period when it is happening, especially in high-velocity environments. Important events are often the result of the accumulation of smaller steps that are mixed with the multitude of routine events at any given time. Gordon Moore (1990: 95) pointed out, "While IBM's use of our microprocessor and our dropping out of the DRAM market seem like independent, dramatic, rapid decisions, they really weren't. They were a series of smaller decisions that ultimately led to a final dramatic outcome." The decline of the DRAM business within Intel was signaled by an incremental decrease in commitment of manufacturing capacity to DRAMs, but the implications of these incremental decisions were not immediately clear to top management. Similarly, the enormous importance of the personal computer for Intel's microprocessor business was not immediately obvious. Intel's list of the top fifty anticipated applications for the 80286 microprocessor, the successor to the 8088 microprocessor chosen by IBM for its first personal computer, did not include the personal computer (Cogan and Burgelman, 1990). Andy Grove later pointed out that if Intel had foreseen the dramatic growth of the personal computer business, it might have been easier to exit from the memory business (personal communication, 1992).

A valid top management concern, however, was that DRAMs were viewed as a core technology of the company, not just a product. The tight link between product and process design in DRAMs made it easier to do failure analysis on memory products than on logic products. Engineers could use the test failure pattern to locate the physical locations of failure on a DRAM device much more quickly than on a microprocessor. In 1984, a new technological development led to a divergence between DRAM, 4-transistor static random access memory (SRAM) and 6-transistor SRAM technology, and it was unclear to top management which of these memory technologies would best support failure analysis for logic products. Also, as noted earlier, the DRAM TD group was farthest along in line-width reduction, a critical competence for all products including microprocessors. It was relatively easier to design a leading-edge geometry (1 micron in 1984) in DRAM than to design a leading-edge geometry in microprocessors. Top management was concerned that exiting from DRAMs might result in losing the DRAM TD group. Hence, while the exit looks surprisingly slow from the point of view of corporate strategy, it is less clearly so from a competence point of view.

Recalling how the matter was finally resolved, Andy Grove, Intel's chief operating officer (COO) at the time, emphasized the difficulty top managers experience in dissociating themselves from the strategy that made the company successful in the past (Graham and Burgelman, 1991: 1):

Don't ask managers, What is your strategy? Look at what they do! Because people will pretend. . . . The fact is that we had become a non-factor in DRAMs, with 2–3% market share. The DRAM business just passed us by! Yet, many people were still holding to the "self-evident truth" that Intel was a memory company. One of the toughest challenges is to make people see that these self-evident truths are no longer true. . . . I recall going to see Gordon [Moore] and asking him what a new management would do if we were replaced. The answer was clear: Get out of DRAMs. So, I suggested to Gordon that we go through the revolving door, come back in, and just do it ourselves.

Internal Selection Environment and Strategic Action

An important administrative element of Intel's structural context was the requirement that product divisions share fabs. Sharing was facilitated by the fact that fabs could, initially, be fairly easily converted from DRAM to EPROM or microprocessor production. DRAMs, EPROMs, and microprocessors would be given minimum capacity allocations to maintain long-term market position. In times when demand was strong and capacity constrained sales, however, product division managers would get together monthly to decide on how to load the factories based on the rule to maximize margin-per-wafer-start. Deciding which type of product to put on a wafer at the start of the sequence of production steps was a key decision. The adoption of this rule reflected the fact that Intel's businesses were characterized by high asset intensity (and hence low asset turnover), and return on sales was important for profitability. The rule involved a complex calculation. Each product was assigned a total amount of manufacturing activity based on the number of steps it required. Total manufacturing costs were then allocated to products on the basis of manufacturing activity. For each product, the overall yield (number of good die at final test versus total number of die on starting wafer) was applied as a divisor to the manufacturing cost to arrive at a total cost per good part. The sales price was then used to calculate margin per part and margin per activity. Intel's chief financial officer said that the difference between margins for DRAMs and for the highest margin products (microprocessors) could be an order of magnitude (Cogan and Burgelman, 1990: 12).

Incremental decline in DRAM capacity allocation. The rule to maximize margin-per-wafer-start guiding manufacturing resource allocation seemed to capture a great amount of information about internal and external conditions. It was clear that high margins reflected Intel's competitive advantage in microprocessors. But maximize margin-per-wafer-start was a rule that would systematically lead niche markets to be selected over commodity markets. Choosing niche markets was consistent with Intel's historical strategy of premium pricing for leading-edge products. Also, whereas the maximize-margin-per-wafer-start rule did not necessarily lead to profit maximization, the rapid growth in demand for Intel microprocessors made it difficult for managers associated with the memory business to challenge the internal allocation rule on that basis. Within fabs capable of producing both memory and microprocessor products, the allocation rule led to a gradual change in mix in favor of microprocessors. Intel's capacity allocation to DRAMs gradually declined relative to the fast-growing DRAM market and relative to the capacity allocation to microprocessors. By 1984, DRAM production was restricted to one fab out of a network of eight plants. Microprocessors, in contrast, had become the largest component in Intel's sales revenue by 1982 and continued to grow in relative importance. EPROMs still represented more than 15 percent of sales in 1982, but their share in Intel's sales was declining in the period 1982–1985.

The strategic context of the DRAM business within Intel gradually dissolved as a result of the incremental decline in the allocation of manufacturing resources. These allocation decisions contradicted top managers' beliefs about the importance of DRAMs and gradually undermined the legitimacy of the DRAM business in Intel's corporate strategy. As middle-level managers in the DRAM business experienced difficulties in obtaining capacity allocations—which, in turn, made it more difficult to compete—they proposed that Intel restructure itself. In 1982, a middle-level manager responsible for several fabrication sites proposed to align the Memory Components Division, which was part of Intel's Components Group, with a dedicated DRAM manufacturing capability, but top management rejected the proposal. In spring 1984, the manufacturing manager of the last fab making DRAMs proposed an investment of approximately $80 million for a DRAM-exclusive facility. His proposal was based on simple, standard process technology and manufacturing instead of on Intel's traditional leading-edge TD approach. Top management refused the investment (Graham and Burgelman, 1991).

An important cultural element of Intel's structural context was the tradition of encouraging open debate about the business merit of different strategic initiatives, constructive confrontation (Jelinek and Schoonhoven, 1990), and the rule that knowledge (or information) power should not be overwhelmed by hierarchical position power (Grove, 1983). Andy Grove maintained that at Intel "no one was ever told to shut up." This made it possible for some middle-level managers of the DRAM business to challenge the way Intel was pursuing the business, but, simultaneously, for some others to make decisions that implicitly or inadvertently undermined the idea of Intel as a memory company and pushed the company further toward becoming a microcomputer company. While top management continued to view DRAMs as a strategic business, and the new corporate strategy of Intel the microcomputer company had not yet become articulated, some middle-level managers made decisions that capitalized on the rapid growth of the microprocessor business and further dissolved the strategic context of DRAMs.

Tradeoffs in process technology choice. A crucial decision was made in 1984 by a middle-level manager who was in charge of the 4-transistor and 6-transistor SRAM process technology developments and TD for the 80386 microprocessor. This manager decided to drop work on the 4-transistor process technology that would have offered Intel the opportunity to introduce a cost-effective SRAM for the commodity market and to focus all effort on the 6-transistor process technology that would also benefit the 80386 microprocessor development. From his perspective, the 80386 process technology development was critical because it involved a team of sixty people, five times the number he had managed before. He had a strong incentive to make the SRAM process technology effort feed into the 80386 TD effort and was determined to consolidate both efforts. But this middle manager's decision implied that resource trade-offs between the memory and microprocessor businesses now went beyond allocating manufacturing capacity and needed to involve the process technology foundation of the memory business. This decision contributed to the dissolution of the strategic context for commodity memories, including DRAMs. Andy Grove recalled:

> By mid-1984, some middle-level managers had made the decision to adopt a new process technology which inherently favored logic [microprocessor] rather than memory advances, thereby limiting the decision space within which top management could operate. The faction representing the microprocessor business won the debate even though the 80386 had not yet become the big revenue generator that it would eventually become.

By the end of 1984, top management was finally forced to face up to the dissolving strategic context for DRAMs. It was clear, in November 1984, that to regain leadership in the 1 Meg DRAM implied capital investment of several hundred million dollars. The 1 Meg DRAM investment decision thus forced a test of Intel's real strategic commitment to the DRAM business (Ghemawat, 1991). Top management decided against it. The November 1984 decision not to put the 1 Meg DRAM into production eliminated the possibility of Intel's remaining a player in the DRAM business.

New Strategic Harmony

During the period bracketed by the November 1984 decision not to put the 1 Meg DRAM in production and the October 1985 decision to stop producing DRAMs altogether, Intel top management struggled with implementing the exit decision. Top management attempted to juggle the need to "stop the bleeding" in DRAMs with the need to maintain continuity and take advantage of competencies that would be lost by "cutting off the leg" (Graham and Burgelman, 1991: 1). Some senior managers attempted to take advantage of what Andy Grove called "top management's dancing around the exit decision" by continuing to try to find alternative approaches to stay in DRAMs after all. The existing organizational structure impeded implementation, since those who had to make the changes—especially the general manager of the Components Division—were being asked to make themselves less important to the organization. As noted earlier, in the summer of 1985, COO Grove imposed change by restructuring the organization and reassigning senior managers.

The delay in implementation was also at least in part due to top management needing time to sort out and protect the distinctive competencies associated with the DRAM business that were also important to Intel's other businesses. Between November 1984 and March 1985, the DRAM TD group was allowed to continue working on 1 Meg DRAM prototypes, thereby preventing the almost certain loss of some of the most important TD talent in the company. Top management also decided in December 1984 to assign the group the task of shrinking the 386 microprocessor to 1 micron, which assured the continuation of technology leadership in microprocessors. Realizing that top management had waited a long time to bring Intel's official corporate strategy in line with the realities of internal resource allocation, COO Grove went to visit the DRAM TD group during the third quarter of 1985 and addressed the group with the unequivocal, "Welcome to the mainstream Intel," thereby forcefully articulating Intel's new corporate strategy as the world's leading "microcomputer company."

Routines. The exit from DRAMs also offered the opportunity for top management to cause what Andy Grove called the "internal creative destruction" of routines that, while associated with past success, had outgrown their effectiveness and needed to be changed (Cogan and Burgelman, 1991). A key example was the geographical basis of integrating process technology development and manufacturing. By the end of 1985, the transfer of process technology from TD to manufacturing was no longer viewed as dependent on geographical proximity but, rather, on creating the appropriate incentive system. TD was no longer allowed to start a new process technology until manufacturing was able to get the previous one up and running in the factory with the help of TD.

The leader of Intel's DRAM TD group said that his group was perhaps the first to realize that learning-curve effects could be attained through intelligent statistical analysis of a limited number of wafers as well as through the brute force of large-scale wafer production. Intel's director of TD pointed out that working with suppliers of semiconductor equipment had become an effective way to track the advances of the DRAM producers and to make sure that Intel's own manufacturing capabilities for microprocessors remained state of the art. Intel learned that it could strike effective alliances with world-class, large-scale manufacturers of DRAMs, such as NMB in Japan, and sell the devices as part of its product offerings without having to incur the ever-increasing capital investments in fabrication facilities for memory products (Cogan and Burgelman, 1991). This lesson affected Intel's decision to stop investing in EPROM manufacturing capacity in 1991.

Looking back at the DRAM experience, Intel top management realized that, on balance, the strategic business exit from DRAMs had worked well for Intel. This allowed Andy Grove to go around the company and retroactively rationalize the strategic exit from DRAMs: He confirmed that earlier strategic actions, while not guided by official corporate strategy, had nevertheless been beneficial for the company. One senior manager recalled that sometime in late 1988, Grove made a presentation to Intel employees in which he had a chart that showed businesses in which Intel had succeeded and businesses in which Intel had failed. This manager said he cringed at the thought of having to sit through yet another discussion of the failure of DRAMs. But he was surprised when Grove described DRAMs as a complete success for Intel. Grove reportedly said that the DRAM business had supported the company for over 10 years, had been well managed, had developed key corporate competencies that were redeployed when needed most, and was a business that Intel exited at just the right time.

DISCUSSION: PROCESS THEORY OF STRATEGIC BUSINESS EXIT

The conceptual framework and findings reported in the preceding sections serve as building blocks for the construction of a grounded process theory of strategic business exit (Glaser and Strauss, 1967; Mohr, 1982). They yield several testable theoretical propositions concerning forms of internal inertia and the role of internal selection in strategic business exit that contribute to the development of a dynamic theory of the role of strategy in firm evolution (e.g., Porter, 1991).

Forms of Internal Inertia

Relative inertia in distinctive technological competence. Earlier research has found inertial tendencies in the strategic responses of firms faced with radical (Cooper and Schendel, 1976; Tushman and Anderson, 1986) or architectural (Henderson and Clark, 1990) technological innovation that led to their having to exit certain businesses or, in some cases, to their demise. The present study suggests that inertial tendencies may also drive the strategic responses of firms facing industry-level changes that move patterns of technological innovation from "fluid" to "specific" (Utterback and Abernathy, 1975), leading to forced exit. Intel continued to rely on TD competence to compete even though the basis of competitive advantage in the DRAM industry had shifted. Inertia in Intel's technological competence deployment did not preclude it from trying to adapt, but it influenced the trajectory of adaptive efforts. Inertial forces led to adaptive efforts based on TD advances that were, in four successive DRAM generations, too early in relation to industry dynamics. Dwindling market share eventually forced Intel to exit from the DRAM business. The study of strategic business exit thus suggests the need to consider inertial forces that make it difficult for firms to continue matching distinctive technological competence with the evolving basis of competition in the industry (Andrews, 1980). More formally,

Proposition 1a: The stronger a firm's distinctive technological competence, the stronger the firm's tendency to continue to rely on it in the face of industry-level changes in the basis of competitive advantage.

Proposition 1a is consistent with earlier findings showing that core competence may become a competence trap (Levitt and March, 1988) or core rigidity (Leonard-Barton, 1992), but this study also confirms that the productive potential of a firm's technological competencies may extend beyond the boundaries set by its product-market strategy at any given time (e.g., Pavitt, Robson, and Townsend, 1989). Through the autonomous strategic initiatives of middle-level managers, technological competencies may engender unanticipated innovations that are outside the scope of the official corporate strategy (Burgelman, 1983a, 1991). This study suggests that such innovations may trigger coevolutionary processes that change the mix of the firm's distinctive technological competencies and its product-market strategy. Inertia looked at with dismay from current product-market positioning or portfolio-planning perspectives may thus sometimes be looked at more favorably from a resource or competence-based perspective (e.g., Penrose, 1968; Wernerfelt, 1984; Barney, 1986a). More formally,

Proposition 1b: The stronger the firm's technological competence, the higher the probability that it will generate unanticipated innovations that, if successful, will change the firm's mix of distinctive competence and product-market position.

Proposition 1b does not imply that unanticipated technological innovations are viable, nor that the firm will necessarily pursue them. But it does suggest the need to reexamine the processes driving technological leaders and first movers (e.g., Porter, 1983; Teece, 1986; Burgelman and Rosenbloom, 1989; Lieberman and Montgomery, 1989). It seems quite possible that such competitive stances—often associated with "technology push"—may originate from inertial forces associated with the firm's distinctive technological competence as well as from official corporate strategy.

Inertia of official corporate strategy relative to strategic action. A second form of relative inertia was associated with Intel's official corporate strategy. While Intel is widely regarded as one of the most innovative and adroitly managed high-technology firms, the DRAM exit story suggests that even extraordinarily capable and technically sophisticated top managers, such as Gordon Moore and Andy Grove, do not always have the foresight of the mythical Olympian CEO making strategy. Rational justification, emotional attachment, and bounded rationality, mixed with valid concerns about protecting a core technology of the firm, made it very difficult for Intel's top management to exit from DRAMs. At the same time, actions by some middle-level managers responding to external and internal selection pressures had already begun to dissolve the strategic context of DRAMs and undermine the reality of Intel the memory company. Incremental shifts in the allocation of scarce manufacturing resources from DRAMs to microprocessors and technological trade-offs favoring microprocessors over DRAMs happened before the official corporate strategy was restated. The study of strategic business exit thus confirms that strategic actions often diverge from statements of strategy (e.g., Argyris and Schon, 1978; Mintzberg, 1978), that resource allocation and official strategy are not necessarily tightly linked (Bower, 1970), and that strategic actions of complex firms involve multiple levels of management simultaneously (Burgelman, 1983a). In addition, the findings suggest that these middle-level actions provide potentially important signals about the evolution of external selection pressures, especially in dynamic environments. More formally,

Proposition 2: In dynamic environments, actions of middle-level managers that diverge from official corporate strategy may signal important changes in external selection pressures.

The Role of Internal Selection

Prevents escalation of commitment. To some extent, Intel was lucky that there was some fungibility between products and fabs, which reduced exit barriers (Porter, 1980), and that the maximize-margin-per-wafer-start rule prevented escalation of commitment (Staw, Sandelands, and Dutton, 1981) to the DRAM business during the period that Intel's official corporate strategy was in flux. This type of short-term-oriented rule, in isolation, might equally well have thwarted development of new technologies or strategic thrusts, but this rule was only one element of the internal selection environment created by top management. The maximize-margin-per-wafer-start rule required product divisions to compete for shared manufacturing resources and forced open debates concerning resource allocation. The criteria governing these debates were constructive confrontation based on knowledge rather than hierarchical position and economic performance in the market place rather than success in internal politicking. These criteria ensured that the internal selection processes accurately reflected the competitive pressures faced by different businesses in their external environment. They became the focal point (Schelling, 1960; Camerer and Vepsalainen, 1988; Kreps, 1990) around which the organization came together and prevented the coevolution of its distinctive competence and the basis of competition in the DRAM industry before the official strategic decision to exit from DRAMs had been made.

Once established by top management, the internal selection environment constrained the purposeful behavior of individual participants (Coleman, 1986). It was difficult, even for the top managers themselves, to deviate from the criteria constituting the internal selection environment. As DRAMs began to lose out in the resource allocation process, middle-level managers of the DRAM business attempted to change Intel's structural context and lobbied for their own manufacturing resources to compete better as a commodity business. But they could not escape thorough debate and could not win their case. Even though top management continued to invest heavily in DRAM TD, it did not interfere with the manufacturing capacity allocations that were decided at lower levels in the organization. Eventually, CEO Gordon Moore and other top managers accepted the results of the internal selection processes. More formally,

Proposition 3: Firms whose internal selection criteria accurately reflect external selection pressures are more likely to strategically exit from some businesses than firms whose internal selection criteria do not accurately reflect external selection pressures.

Proposition 3 implies that the firm's internal selection environment may be more important for adaptation than its official corporate strategy (Burgelman, 1991) and may be a source of sustained competitive advantage (Barney, 1986b). It establishes a seemingly simple criterion for adaptation that, as the recent troubles of IBM, Apple, NeXT, and other companies indicate, is surprisingly difficult to satisfy over long periods of time.

Links competence with opportunity. The dissolution of the strategic context of DRAMs was facilitated by the emergence of new distinctive competence-based business opportunities within Intel. Internal entrepreneurial initiatives brought competition for resources within the boundaries of the firm and forced it to make strategic choices. By favoring microprocessors over memories, the internal selection environment reinforced the coevolution of distinctive competence and the basis of competition in the microprocessor industry before the new strategy of Intel the microcomputer company was in place. The strategic choices shifted resources away from the memory business to the microprocessor business, thus causing strategic renewal. Strategic renewal, in turn, made it easier to exit from the memory business. More formally,

Proposition 4: Firms that have new businesses competing with existing businesses for relatively scarce resources are more likely to make a strategic exit from existing businesses than are firms that are not confronted with such strategic choices.

Proposition 4 is consistent with earlier research on the restructuring of the global petrochemical industry (Bower, 1986: 10) and the steel castings industry in the U.K. (Baden-Fuller, 1989) that suggested that financially strong and diversified companies are often the first to exit. Also, diversification through internal entrepreneurship may motivate firms to evaluate the opportunity cost of existing businesses (Burgelman, 1983b). Gilmour (1973) has documented how one firm's acquisition of another created new resource demands that made top management aware of the relatively low profitability of the existing business and thereby activated the divestment process.

Depends on strategic recognition capacity. To some extent, Intel was also lucky in having a distinctive competence base capable of generating new, high-growth business opportunities that provided alternatives to the DRAM business. But Intel's top management needed to be able to recognize their importance and support them in-house. Gordon Moore allowed Dov Frohman to pursue the EPROM development before there was a clear market need for it. Top management responded to Ted Hoff's championing by buying back the rights to the microprocessor before microprocessors were established in the market.

Later on, while top management had not yet redefined Intel's corporate strategy in terms of the microcomputer company, it resisted the efforts of some middle-level managers to redefine the strategic context of DRAMs within Intel and to commit the company to competing on the terms required by a commodity business. Top management recognized that Intel was neither oriented toward nor equipped for competing in a commodity business. Thus, determining the strategic context for microprocessors (a new business) and dissolving the strategic context for memories (an existing business) depended critically on top management's ability to see the broader strategic implications for the firm of strategic actions taken by middle-level managers, in the former case, before the new official strategy of Intel the microcomputer company had been formally stated; in the latter case, before the exit from memories had been formally decided. Such strategic recognition (Burgelman, 1983b; Van de Ven, 1986) implies the possibility of self-reflexive evaluation of means and ends in the light of changing circumstances but without having to resort to foresight or grand strategy. It also does not assume that top management is necessarily the prime mover in strategy. Rather, it is predicated on strategic initiatives of middle-level managers that top management can assess and support or not support. Strategic recognition augments the adaptive value of the internal selection environment. More formally,

Proposition 5: Firms that have top managers with strong strategic recognition capacity are more likely to make strategic exits from businesses than firms that have top managers with weak strategic recognition capacity.

For proposition 5 not to be a tautology, strategic recognition capacity must, of course, be established independent of a given strategic exit decision. A top manager's strategic recognition capacity could be measured, for instance, by his or her record in supporting and rejecting previous middle-level managerial initiatives.

Produces organizational learning. The dissolution of the strategic context for DRAMs concluded with retroactive rationalization efforts by top management. The exit decision had required top management to examine DRAMs strategically, from a distinctive-competence perspective as well as from product-market and financial-results perspectives. Retroactive rationalization affirmed that the outcomes of the strategic exit were beneficial from the firm's point of view and explicated why that was the case. Top management now took the explicit position that strategic exit was a natural part of competing in high-velocity environments. Once top management had brought the official corporate strategy back in line with the realities of viable strategic actions by middle-level managers, the strategic learning process continued. Top management was now ready to examine the other semiconductor memory businesses in light of the new official corporate strategy of Intel as a microcomputer company. It was ready to set the stage for the strategic exit from EPROM manufacturing, thereby further freeing up resources for the microprocessor business. Exiting from memories had required top management to consider why staying in the microprocessor business was more attractive. More formally,

Proposition 6: Firms that have strategically exited from a business are likely to have a better understanding of the links between their distinctive competence and the basis of competition in the industries in which they remain active than are firms that have not strategically exited from a business.

Alternative Conjectures

But what would have happened if Intel's top managers had understood more quickly that DRAMs had become unviable and had actively sought to diversify their business portfolio? Would they have done better? Or suppose Intel had more closely tracked the evolving basis of competitive advantage in the DRAM industry. Would it have done better? These questions cannot be answered definitively in the context of this study because it was not possible to set up an experiment. But they raise important issues concerning alternative concepts of corporate strategy and forms of adaptation. From a portfolio-planning perspective, the delay in exiting the DRAM business could be viewed as a manifestation of crippling inertia, but such a perspective does not consider the implications of exit for the firm's distinctive competencies. While the study confirms that business exit is viewed by top management as an investment decision (Baden-Fuller, 1989: 956), it also suggests that top management is concerned with identifying the elements of distinctive competence associated with the failing business that have the potential to be transferred to new businesses. As noted earlier, this requires time and a capacity for recognizing the substantive aspects of competencies as well as appreciating the financial performance characteristics of different businesses. The conjecture supported by previous research (e.g., Porter, 1987) is that Intel would probably have done worse if it had simply divested the DRAM business and entered new businesses through acquisition. Intel would have dissolved the strategic context for DRAMs too soon and thereby failed to capitalize on the full potential of its distinctive competencies in DRAMs. Some of these competencies could be effectively deployed in the microprocessor business, which represented an opportunity for strategic renewal for Intel. Hence, the time involved in dissolving the strategic context for DRAMs helped prevent strategic change that might have been too rapid (e.g., Levitt and March, 1988; Hambrick and D'Aveni, 1990).

Adaptation through strategic renewal is quite different from adaptation through tracking the basis for competitive advantage in the industry. Intel did not closely track the basis of competitive advantage in the DRAM industry. If Intel's top managers had chosen to follow the logic of competitive advantage in the DRAM business, they would have had to commit hundreds of millions of dollars to a commodity market characterized by relatively low and highly volatile margins. Again, the conjecture is that Intel probably would have done less well.

IMPLICATIONS AND CONCLUSION

This study found that strategic business exit has implications for the firm's distinctive competencies as well as for its product-market position. The findings support the view that top managers must learn to understand the linkage between a firm's businesses in terms of distinctive competencies (Prahalad and Hamel, 1990) and suggest that strategic business exits may help the learning process. The study also found that Intel was able to transform itself from a memory company into a microcomputer company, in part, because it was able to generate product-market alternatives offering top management strategic choices (Eisenhardt, 1989a). This suggests that top managers should nurture the development of the technological competence base of the firm and be ready to transfer key competencies to new product-market activities before these product-market activities have become powerful in the firm. Furthermore, the study found that Intel was able to transform itself because top management had evolved an internal selection environment that was more adaptively robust than the official corporate strategy. The implication of evolving such an internal selection environment is that strategic actions by middle-level managers will sometimes diverge from official corporate strategy and may signal important environmental changes. Top managers must guard against approaches that will mask or eliminate disharmony without addressing the underlying divergences that cause it. They must develop a capacity for strategic recognition to guide the organization while a new strategic direction is taking shape and be able to decide when is the right time to bring official strategy and strategic action back in line with each other. Finally, the findings indicate that strategic business exit is not equivalent to failure and that new leadership does not necessarily imply new leaders. Andy Grove understood that Gordon Moore and he could walk through the revolving door, retake charge, and do the difficult job of exiting from DRAMs themselves.

While conclusions drawn from one case study require healthy caution, the process theory of strategic business exit presented in this paper provides insight into the organizational capability needed for long-term survival. Dynamic competence that generates new variations, internal selection that correctly reflects external selection pressures, and top management's capacity for recognizing and retaining viable strategic initiatives are key components of such organizational capability. Strategy making supported by this organizational capability results in the timely expansion and contraction of internal support for different businesses. This, in turn, leads to the firm's entering into and exiting from businesses on the basis of its distinctive competence as it evolves. This paper thus contributes to theory about the role of strategy in firm evolution. The theoretical framework, grounded in the study of strategic business exit, identifies key forces whose interplays determine, in part, why some firms are more likely to survive than others. This framework may be used as a tool to explore more generally how coevolution and adaptation at the firm level come about, without having to assume that top managers have extraordinary foresight and a grand strategy.

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