CHAPTER **SEVEN**

Discovering New and Emerging Markets

Markets that do not exist cannot be analyzed: Suppliers and customers must discover them together. Not only are the market applications for disruptive technologies *unknown* at the time of their development, they are *unknowable.* The strategies and plans that managers formulate for confronting disruptive technological change, therefore, should be plans for learning and discovery rather than plans for execution. This is an important point to understand, because managers who believe they know a market's future will plan and invest very differently from those who recognize the uncertainties of a developing market.

Most managers learn about innovation in a *sustaining technology context* because most technologies developed by established companies are sustaining in character. Such innovations are, by definition, targeted at known markets in which customer needs are understood. In this environment, a planned, researched approach to evaluating, developing, and marketing innovative products is not only possible, it is critical to success.

What this means, however, is that much of what the best executives in successful companies have learned about managing innovation is not relevant to disruptive technologies. Most marketers, for example, have been schooled extensively, at universities and on the job, in the important art of listening to their customers, but few have any theoretical or practical training in how to discover markets that do not yet exist. The problem with this lopsided experience base is that when the same analytical and decision-making processes learned in the school of sustaining innovation are applied to enabling or disruptive technologies, the effect on the company can be paralyzing. These processes demand crisply quantified information when none exists, accurate estimates of financial returns when neither revenues nor costs can be known, and

management according to detailed plans and budgets that cannot be formulated. Applying inappropriate marketing, investment, and management processes can render good companies incapable of creating the new markets in which enabling or disruptive technologies are first used.

In this chapter we shall see how experts in the disk drive industry were able to forecast the markets for sustaining technologies with stunning accuracy but had great difficulty in spotting the advent and predicting the size of new markets for disruptive innovations. Additional case histories in the motorcycle and microprocessor industries further demonstrate the uncertainty about emerging market applications for disruptive or enabling technologies, even those that, in retrospect, appear obvious.

FORECASTING MARKETS FOR SUSTAINING VERSUS DISRUPTIVE TECHNOLOGIES

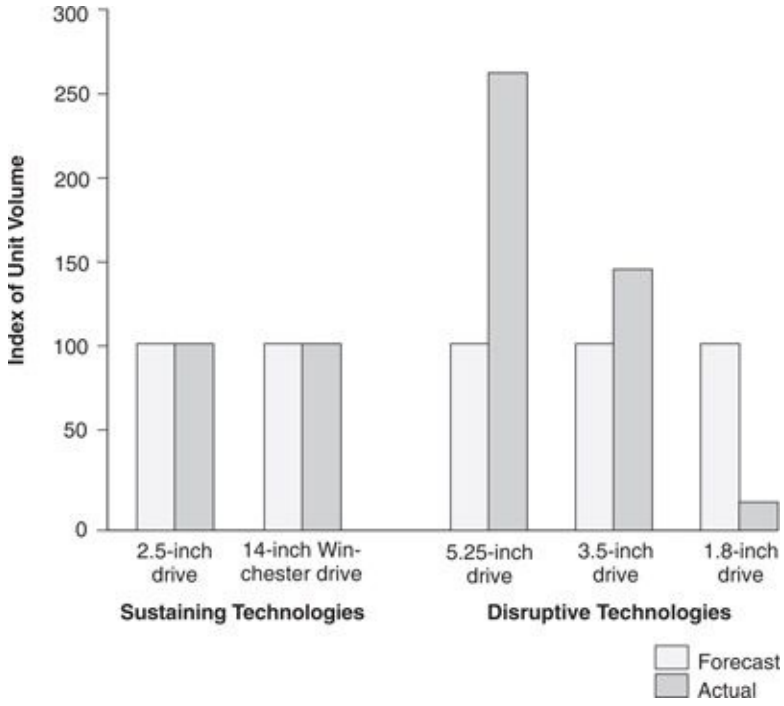
An unusual amount of market information has been available about the disk drive industry from its earliest days—a major reason why studying it has yielded such rich insights. The primary source of data, *Disk/Trend Report*, published annually by Disk/Trend, Inc., of Mountain View, California, lists every model of disk drive that has ever been offered for sale by any company in the world, for each of the years from 1975 to the present. It shows the month and year in which each model was first shipped, lists the performance specifications of the drive, and details the component technologies used. In addition, every manufacturer in the world shares with *Disk/Trend* its sales by product type, with information about what types of customers bought which drive. Editors at *Disk/Trend* then aggregate this data to derive the size of each narrowly defined market segment and publish a listing of the major competitors' shares, carefully guarding all proprietary data. Manufacturers in the industry find the reports so valuable that they all continue to share their proprietary data with *Disk/Trend.*

In each edition, *Disk/Trend* publishes the actual unit volumes and dollar sales in each market segment for the year just past and offers its forecasts for each of the next four years in each category. Given its unparalleled access to industry data spanning two decades, this publication offers an unusual chance to test through unfolding market history the accuracy of past predictions. Over all, *Disk/Trend* has a remarkable track record in forecasting the future of established markets, but it has struggled to estimate accurately the size of new markets enabled by disruptive disk drive technologies.

The evidence is summarized in Figure 7.1, which compares the total unit volumes that *Disk/Trend Report* had forecast would be shipped in the first four years after commercial shipments of each new disk drive architecture began, to the total volumes that were actually shipped over that four-year period. To facilitate comparison, the heights of the bars measuring forecast shipments were normalized to a value of 100, and the volumes actually shipped were scaled as a percentage of the forecast. Of the five new architectures for which *Disk/Trend*'s forecasts were available, the 14-inch Winchester and the 2.5-inch generation were sustaining innovations, which were sold into the same value networks as the preceding generation of drives. The other three, 5.25-, 3.5-, and 1.8-inch

drives, were disruptive innovations that facilitated the emergence of new value networks. (*Disk/Trend* did not publish separate forecasts for 8-inch drives.)

Figure 7.1 The Four Years after the First Commercial Shipments: Sustaining versus Disruptive Technologies



Source: Data are from various issues of *Disk/Trend Report.*

Notice that *Disk/Trend*'s forecasts for the sustaining 2.5-inch and 14-inch Winchester technologies were within 8 percent and 7 percent, respectively, of what the industry actually shipped. But its estimates were off by 265 percent for 5.25-inch drives, 35 percent for 3.5-inch drives (really quite close), and 550 percent for 1.8-inch drives. Notably, the 1.8-inch drive, the forecast of which *Disk/Trend* missed so badly, was the first generation of drives with a primarily non-computer market.

The *Disk/Trend* staff used the same methods to generate the forecasts for

sustaining architectures as they did for disruptive ones: interviewing leading customers and industry experts, trend analysis, economic modeling, and so on. The techniques that worked so extraordinarily well when applied to sustaining technologies, however, clearly failed badly when applied to markets or applications that did not yet exist.

IDENTIFYING THE MARKET FOR THE HP 1.3-INCH KITTYHAWK DRIVE

Differences in the forecastablity of sustaining versus disruptive technologies profoundly affected Hewlett-Packard's efforts to forge a market for its revolutionary, disruptive 1.3-inch Kittyhawk disk drive. [1] In 1991, Hewlett-Packard's Disk Memory Division (DMD), based in Boise, Idaho, generated about $600 million in disk drive revenues for its $20 billion parent company. That year a group of DMD employees conceived of a tiny, 1.3-inch 20 MB drive, which they code-named Kittyhawk. This was indeed a radical program for HP: The smallest drive previously made by DMD had been 3.5-inches, and DMD had been one of the last in the industry to introduce one. The 1.3-inch Kittyhawk represented a significant leapfrog for the company—and, most notably, was HP's first attempt to lead in a disruptive technology.

For the project to make sense in a large organization with ambitious growth plans, HP executives mandated that Kittyhawk's revenues had to ramp to $150 million within three years. Fortunately for Kittyhawk's proponents, however, a significant market for this tiny drive loomed on the horizon: hand-held palm-top computers, or personal digital assistants (PDAs). Kittyhawk's sponsors, after studying projections for this market, decided that they could scale the revenue ramp that had been set for them. They consulted a market research firm, which confirmed HP's belief that the market for Kittyhawk would indeed be substantial.

HP's marketers developed deep relationships with senior executives at major companies in the computer industry, for example, Motorola, ATT, IBM, Apple, Microsoft, Intel, NCR, and Hewlett-Packard itself, as well as at a host of lesser-known startup companies. All had placed substantial product development bets on the PDA market. Many of their products were designed with Kittyhawk's features in mind, and Kittyhawk's design in turn reflected these customers' well-researched needs.

The Kittyhawk team concluded that developing a drive that met these customers' requirements would be a demanding but feasible technological stretch, and they launched an aggressive twelve-month effort to develop the tiny device. The result, shown in Figure 7.2, was impressive. The first version packed 20 MB, and a second model, introduced a year later, stored 40 MB. To meet the

ruggedness demanded in its target market of PDAs and electronic notebooks, Kittyhawk was equipped with an impact sensor similar to those used in automobile airbag crash sensors and could withstand a three-foot drop onto concrete without data loss. It was designed to sell initially at $250 per unit.

Although Kittyhawk's technical development went according to plan, the development of applications for it did not. The PDA market failed to materialize substantially, as sales of Apple's Newton and competing devices fell far short of aspirations. This surprised many of the computer industry experts whose opinions HP's marketers had worked so hard to synthesize. During its first two years on the market, Kittyhawk logged just a fraction of the sales that had been forecast. The sales achieved might have initially satisfied startup companies and venture capitalists, but for HP's management, the volumes were far below expectations and far too small to satisfy DMD's need to grow and gain overall market share. Even more surprising, the applications that contributed most significantly to Kittyhawk's sales were not in computers at all. They were Japanese-language portable word processors, miniature cash registers, electronic cameras, and industrial scanners, none of which had figured in Kittyhawk's original marketing plans.

Figure 7.2 Hewlett-Packard's Kittyhawk Drive

Source: Hewlett Packard Company. Used by permission.

Even more frustrating, as the second anniversary of Kittyhawk's launch approached, were the inquiries received by HP marketers from companies making mass-market video game systems to buy very large volumes of Kittyhawk—if HP could make a version available at a lower price point. These companies had been aware of Kittyhawk for two years, but they reported that it had taken some time for them to see what could be done with a storage device so small.

To a significant extent, HP had designed Kittyhawk to be a sustaining technology for mobile computing. Along many of the metrics of value in that application—small size, low weight and power consumption, and ruggedness—Kittyhawk constituted a discontinuous sustaining improvement relative to 2.5- and 1.8-inch drives. Only in capacity (which HP had pushed as far as possible) was Kittyhawk deficient. The large inquiries and orders that finally began arriving for the Kittyhawk, however, were for a *truly* disruptive product: something priced at $50 per unit and with limited functionality. For these applications, a capacity of 10 MB would have been perfectly adequate.

Unfortunately, because HP had positioned the drive with the expensive features needed for the PDA market rather than designing it as a truly disruptive product, it simply could not meet the price required by home video game manufacturers. Having invested so aggressively to hit its original targets as defined by the PDA application, management had little patience and no money to redesign a simpler, defeatured 1.3-inch drive that fit the market applications that had finally become clear. HP withdrew Kittyhawk from the market in late 1994.

The HP project managers concede in retrospect that their most serious mistake in managing the Kittyhawk initiative was to act as if their forecasts about the market were right, rather than as if they were wrong. They had invested aggressively in manufacturing capacity for producing the volumes forecast for the PDA market and had incorporated design features, such as the shock sensor, that were crucial to acceptance in the PDA market they had so carefully researched. Such planning and investment is crucial to success in a sustaining technology, but, the managers reflected, it was not right for a disruptive product like Kittyhawk. If they had the opportunity to launch Kittyhawk all over again, they would assume that neither they nor anyone else knew for sure what kinds of customers would want it or in what volumes. This would lead them toward a much more exploratory, flexible approach toward

would lead them toward a much more exploratory, flexible approach toward product design and investment in manufacturing capacity; they would, given another chance, feel their way into the market, leaving enough resources to redirect their program if necessary and building upon what they learned on the way.

Hewlett-Packard's disk drive makers are not the only ones, of course, who behaved as if they knew what the market for a disruptive technology would be. They are in stellar company, as the following case histories show.

HONDA'S INVASION OF THE NORTH AMERICAN MOTORCYCLE INDUSTRY

Honda's success in attacking and dominating the North American and European motorcycle markets has been cited as a superb example of clear strategic thinking coupled with aggressive and coherent execution. According to these accounts, Honda employed a deliberate manufacturing strategy based on an experience curve in which it cut prices, built volume, aggressively reduced costs, cut prices some more, reduced costs further, and built an unassailable volume-based low-cost manufacturing position in the motorcycle market. Honda then used that base to move upmarket and ultimately blew all established motorcycle manufacturers out of the market except for Harley-Davidson and BMW, which barely survived. [2] Honda combined this manufacturing triumph with a clever product design, catchy advertising, and a convenient, broad-based distributor/retailer network tailored to the informal cyclists who constituted Honda's core customer base. Told in this manner, Honda's history is a tale of strategic brilliance and operational excellence that all managers dream will be told about them someday. The reality of Honda's achievement, as recounted by the Honda employees who were managing the business at the time, however, is quite different. [3]

During Japan's years of post-war reconstruction and poverty, Honda had emerged as a supplier of small, rugged motorized bicycles that were used by distributors and retailers in congested urban areas to make small deliveries to local customers. Honda developed considerable expertise in designing small, efficient engines for these bikes. Its Japanese market sales grew from an initial annual volume of 1,200 units in 1949 to 285,000 units in 1959.

Honda's executives were eager to exploit the company's low labor costs to export motorbikes to North America, but there was no equivalent market there for its popular Japanese "Supercub" delivery bike. Honda's research showed that Americans used motorcyles primarily for over-the-road distance driving in which size, power, and speed were the most highly valued product attributes. Accordingly, Honda engineers designed a fast, powerful motorcycle specifically for the American market, and in 1959 Honda dispatched three employees to Los Angeles to begin marketing efforts. To save living expenses, the three shared an apartment, and each brought with him a Supercub bike to provide cheap

transportation around the city.

The venture was a frustrating experience from the beginning. Honda's products offered no advantage to prospective customers other than cost, and most motorcycle dealers refused to accept the unproven product line. When the team finally succeeded in finding some dealers and selling a few hundred units, the results were disastrous. Honda's understanding of engine design turned out not to be transferable to highway applications, in which bikes were driven at high speeds for extended periods: The engines sprung oil leaks and the clutches wore out. Honda's expenses in air-freighting the warrantied replacement motorcycles between Japan and Los Angeles nearly sunk the company.

Meanwhile, one Saturday, Kihachiro Kawashima, the Honda executive in charge of the North American venture, decided to vent his frustrations by taking his Supercub into the hills east of Los Angeles. It helped: He felt better after zipping around in the dirt. A few weeks later he sought relief dirt-biking again. Eventually he invited his two colleagues to join him on their Supercubs. Their neighbors and others who saw them zipping around the hills began inquiring where they could buy those cute little bikes, and the trio obliged by special-ordering Supercub models for them from Japan. This private use of what became known as off-road dirt bikes continued for a couple of years. At one point a Sears buyer tried to order Supercubs for the company's outdoor power equipment departments, but Honda ignored the opportunity, preferring to focus on selling large, powerful, over-the-road cycles, a strategy that continued to be unsuccessful.

Finally, as more and more people clamored for their own little Honda Supercubs to join their dirt-biking friends, the potential for a very different market dawned on Honda's U.S. team: Maybe there was an undeveloped off-the-road recreational motorbike market in North America for which— quite by accident—the company's little 50cc Supercub was nicely suited. Although it took much arguing and arm-twisting, the Los Angeles team ultimately convinced corporate management in Japan that while the company's large bike strategy was doomed to failure, another quite different opportunity to create a totally new market segment merited pursuit.

Once the small-bike strategy was formally adopted, the team found that securing dealers for the Supercub was an even more vexing challenge than it had been for its big bikes. There just weren't any retailers selling that class of product. Ultimately, Honda persuaded a few sporting goods dealers to take on its line of motorbikes, and as they began to promote the bikes successfully, Honda's innovative distribution strategy was born.

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Honda had no money for a sophisticated advertising campaign. But a UCLA student who had gone dirt-biking with his friends came up with the advertising slogan, “You meet the nicest people on a Honda,” for a paper he wrote in an advertising course. Encouraged by his teacher, he sold the idea to an advertising agency, which then convinced Honda to use it in what became an award-winning advertising campaign. These serendipitous events were, of course, followed by truly world-class design engineering and manufacturing execution, which enabled Honda to repeatedly lower its prices as it improved its product quality and increased its production volumes.

Honda’s 50cc motorbike was a disruptive technology in the North American market. The rank-ordering of product attributes that Honda’s customers employed in their product decision making defined for Honda a very different value network than the established network in which Harley-Davidson, BMW, and other traditional motorcycle makers had competed.

From its low-cost manufacturing base for reliable motorbikes, using a strategy reminiscent of the upmarket invasions described earlier in disk drives, steel, excavators, and retailing, Honda turned its sights upmarket, introducing between 1970 and 1988 a series of bikes with progressively more powerful engines.

For a time in the late 1960s and early 1970s, Harley attempted to compete head-on with Honda and to capitalize on the expanding lowend market by producing a line of small-engine (150 to 300 cc) bikes acquired from the Italian motorcycle maker Aeromecchania. Harley attempted to sell the bikes through its North American dealer network. Although Honda’s manufacturing prowess clearly disadvantaged Harley in this effort, a primary cause of Harley’s failure to establish a strong presence in the small-bike value network was the opposition of its dealer network. Their profit margins were far greater on high-end bikes, and many of them felt the small machines compromised Harley-Davidson’s image with their core customers.

Recall from chapter 2 the finding that within a given value network, the disk drive companies and their computer-manufacturing customers had developed very similar economic models or cost structures, which determined the sorts of business that appeared profitable to them. We see the same phenomenon here. Within their value network, the economics of Harley’s dealers drove them to favor the same type of business that Harley had come to favor. Their coexistence within the value network made it difficult for either Harley or its dealers to exit the network through its bottom. In the late 1970s Harley gave in and

repositioned itself at the very high end of the motorcycle market—a strategy reminiscent of Seagate's repositioning in disk drives, and of the upmarket retreats of the cable excavator companies and the integrated steel mills.

Interestingly, Honda proved just as inaccurate in estimating *how large* the potential North American motorcycle market was as it had been in understanding *what* it was. Its initial aspirations upon entry in 1959 had been to capture 10 percent of a market estimated at 550,000 units per year with annual growth of 5 percent. By 1975 the market had grown 16 percent per year to 5,000,000 annual units—units that came largely from an application that Honda could not have foreseen. [4]

INTEL’S DISCOVERY OF THE MICROPROCESSOR MARKET

Intel Corporation, whose founders launched the company in 1969 based on their pioneering development of metal-on-silicon (MOS) technology to produce the world’s first dynamic random access memory (DRAM) integrated circuits, had become by 1995 one of the world’s most profitable major companies. Its storied success is even more remarkable because, when its initial leadership position in the DRAM market began crumbling between 1978 and 1986 under the onslaught of Japanese semiconductor manufacturers, Intel transformed itself from a second-tier DRAM company into the world’s dominant microprocessor manufacturer. How did Intel do it?

Intel developed the original microprocessor under a contract development arrangement with a Japanese calculator manufacturer. When the project was over, Intel’s engineering team persuaded company executives to purchase the microprocessor patent from the calculator maker, which owned it under the terms of its contract with Intel. Intel had no explicit strategy for building a market for this new microprocessor; the company simply sold the chip to whoever seemed to be able to use it.

Mainstream as they seem today, microprocessors were disruptive technologies when they first emerged. They were capable only of limited functionality, compared to the complex logic circuits that constituted the central processing units of large computers in the 1960s. But they were small and simple, and they enabled affordable logic and computation in applications where this previously had not been feasible.

Through the 1970s, as competition in the DRAM market intensified, margins began to decline on Intel’s DRAM revenues while margins on its microprocessor product line, where there was less competition, stayed robust. Intel’s system for allocating production capacity operated according to a formula whereby capacity was committed in proportion to the gross margins earned by each product line. The system therefore imperceptibly began diverting investment capital and manufacturing capacity away from the DRAM business and into microprocessors—without an explicit management decision to do so. [5] In fact, Intel senior management continued to focus most of its own attention and energy on DRAM, even while the company’s resource allocation processes were gradually implementing an exit from that business.

This de facto strategy shift, driven by Intel's autonomously operating resource allocation process, was fortuitous. Because so little was known of the microprocessor market at that time, explicit analysis would have provided little justification for a bold move into microprocessors. Gordon Moore, Intel co-founder and chairman, for example, recalled that IBM's choice of the Intel 8088 microprocessor as the "brain" of its new personal computer was viewed within Intel as a "small design win." [6] Even after IBM's stunning success with its personal computers, Intel's internal forecast of the potential applications for the company's next-generation 286 chip did not include personal computers in its list of the fifty highest-volume applications. [7]

In retrospect, the application of microprocessors to personal computers is an obvious match. But in the heat of the battle, of the many applications in which microprocessors might have been used, even a management team as astute as Intel's could not know which would emerge as the most important and what volumes and profits it would yield.

UNPREDICTABILITY AND DOWNWARD IMMOBILITY IN ESTABLISHED FIRMS

The reaction of some managers to the difficulty of correctly planning the markets for disruptive technologies is to work harder and plan smarter. While this approach works for sustaining innovations, it denies the evidence about the nature of disruptive ones. Amid all the uncertainty surrounding disruptive technologies, managers can always count on one anchor: *Experts' forecasts will always be wrong.* It is simply impossible to predict with any useful degree of precision how disruptive products will be used or how large their markets will be. An important corollary is that, because markets for disruptive technologies are unpredictable, companies'

initial strategies for entering these markets will generally be wrong.

How does this statement square with the findings presented in Table 6.1, which showed a stunning difference in the posterior probabilities of success between firms that entered new, emerging value networks (37 percent) and those that entered existing value networks (6 percent)? If markets cannot be predicted in advance, how can firms that target them be more successful?

Indeed, when I have shown the matrix in Table 6.1 to managerial audiences, they are quite astonished by the differences in the magnitudes and probabilities of success. But it is clear that the managers don't believe that the results can be generalized to their own situations.

The findings violate their intuitive sense that creating new markets is a genuinely risky business.

8

Failed Ideas versus Failed Businesses

The case studies reviewed in this chapter suggest a resolution to this puzzle. There is a big difference between the failure of an *idea* and the failure of a *firm.* Many of the ideas prevailing at Intel about where the disruptive microprocessor could be used were wrong; fortunately, Intel had not expended all of its resources implementing wrong-headed marketing plans while the right market direction was still unknowable. As a company, Intel survived many false starts in its search for the major market for microprocessors. Similarly, Honda's idea about how to enter the North American motorcycle market was wrong, but the company didn't deplete its resources pursuing its big-bike strategy and was able to invest aggressively in the winning strategy after it had emerged. Hewlett-Packard's Kittyhawk team was not as fortunate. Believing they had identified the winning strategy, its managers spent their budget on a product design and the manufacturing capacity for a market application that never emerged. When the ultimate applications for the tiny drive ultimately began to coalesce, the Kittyhawk team had no resources left to pursue them.

Research has shown, in fact, that the vast majority of successful new business ventures abandoned their original business strategies when they began implementing their initial plans and learned what would and would not work in the market.

[9] The dominant difference between successful ventures and failed ones, generally, is not the astuteness of their original strategy.

Guessing the right strategy at the outset isn't nearly as important to success as conserving enough resources (or having the relationships with trusting backers or investors) so that new business initiatives get a second or third stab at getting it right. Those that run out of resources or credibility before they can iterate toward a

viable strategy are the ones that fail.

Failed Ideas and Failed Managers

In most companies, however, individual managers don't have the luxury of surviving a string of trials and errors in pursuit of the strategy that works. Rightly or wrongly, individual managers in most organizations believe that they *cannot* fail: If they champion a project that fails because the initial marketing plan was wrong, it will constitute a blotch on their

track record, blocking their rise through the organization. Because failure is intrinsic to the process of finding new markets for disruptive technologies, the inability or unwillingness of individual managers to put their careers at risk acts as a powerful deterrent to the movement of established firms into the value networks created by those technologies. As Joseph Bower observed in his classic study of the resource allocation process at a major chemical company, "Pressure from the market reduces both the probability and the cost of being wrong.

[10]

Bower's observation is consistent with the findings in this book about the disk drive industry. When demand for an innovation was assured, as was the case with sustaining technologies, the industry's established leaders were capable of placing huge, long, and risky bets to develop whatever technology was required. When demand was not assured, as was the case in disruptive technologies, the established firms could not even make the technologically straightforward bets required to commercialize such innovations. That is why 65 percent of the companies entering the disk drive industry attempted to do so in an established, rather than emerging market. Discovering markets for emerging technologies inherently involves failure, and most individual decision makers find it very difficult to risk backing a project that might fail because the market

find it very difficult to risk backing a project that might fail because the market is not there.

Plans to Learn versus Plans to Execute

Because failure is intrinsic to the search for initial market applications for disruptive technologies, managers need an approach very different from what they would take toward a sustaining technology. In general, for sustaining technologies, plans must be made before action is taken, forecasts can be accurate, and customer inputs can be reasonably reliable. Careful planning, followed by aggressive execution, is the right formula for success in sustaining technology.

But in disruptive situations, action must be taken before careful plans are made. Because much less can be known about what markets need or how large they can become, plans must serve a very different purpose: They must be plans for *learning* rather than plans for implementation. By approaching a disruptive business with the mindset that they can't know where the market is, managers would identify what critical information about new markets is most necessary and in what sequence that information is needed. Project and business plans would mirror those priorities, so that key pieces of information would be created, or important uncertainties resolved, before expensive commitments of capital, time, and money were required.

Discovery-driven planning, which requires managers to identify the assumptions upon which their business plans or aspirations are based, [11] works well in addressing disruptive technologies. In the case of Hewlett-Packard's Kittyhawk disk drive, for example, HP invested significant sums with its manufacturing partner, the Citizen Watch Company, in building and tooling a highly automated production line. This commitment was based on an assumption that the volumes forecast for the drive, built around forecasts by HP customers of PDA sales, were accurate. Had HP's managers instead assumed that nobody knew in what volume PDAs would sell, they might have built small modules of production capacity rather than a single, high-volume line. They could then have held to capacity or added or reduced capacity as key events confirmed or disproved their assumptions.

Similarly, the Kittyhawk product development plan was based on an assumption that the dominant application for the little drive was in PDAs, which demanded high ruggedness. Based on this assumption, the Kittyhawk team committed to components and a product architecture that made the product too

expensive to be sold to the price-sensitive video game makers at the emerging low end of the market. Discovery-driven planning would have forced the team to test its market assumptions *before* making commitments that were expensive to reverse—in this case, possibly by creating a modularized design that easily could be reconfigured or defeatured to address different markets and price points, as events in the marketplace clarified the validity of their assumptions.

Philosophies such as *management by objective* and *management by exception* often impede the discovery of new markets because of where they focus management attention. Typically, when performance falls short of plan, these systems encourage management to close the gap between what was planned and what happened. That is, they focus on unanticipated failures. But as Honda's experience in the North American motorcycle market illustrates, markets for disruptive technologies often emerge from unanticipated successes, on which many planning systems do not focus the attention of senior management. [12] Such discoveries often come by watching how people use products, rather than by listening to what they say.

I have come to call this approach to discovering the emerging markets for disruptive technologies *agnostic marketing*, by which I mean marketing under an explicit assumption that *no one*—not us, not our customers—can know whether, how, or in what quantities a disruptive product can or will be used before they have experience using it. Some managers, faced with such uncertainty, prefer to wait until others have defined the market. Given the powerful first-mover advantages at stake, however, managers confronting disruptive technologies need to get out of their laboratories and focus groups and directly create knowledge about new customers and new applications through discovery-driven expeditions into the marketplace.

NOTES

1. What follows is a summary of the fuller history recounted in “Hewlett-Packard: The Flight of the Kittyhawk,” Harvard Business School, Case No. 9-697-060, 1996.
2. Examples of such histories of Honda’s success include the Harvard Business School case study, “A Note on the Motorcycle Industry—1975,” No. 9-578-210, and a report published by The Boston Consulting Group, “Strategy Alternatives for the British Motorcycle Industry,” 1975.
3. Richard Pascale and E. Tatum Christiansen, “Honda (A),” Harvard Business School Teaching, Case No. 9-384-049, 1984, and “Honda (B),” Harvard Business School, Teaching Case No. 9-384-050, 1984.
4. *Statistical Abstract of the United States* (Washington, D.C.: United States Bureau of the Census, 1980), 648.
5. Intel’s exit from the DRAM business and entry into microprocessors has been chronicled by Robert A. Burgelman in “Fading Memories: A Process Theory of Strategic Business Exit in Dynamic Environments,” *Administrative Science Quarterly* (39), 1994, 24–56. This thoroughly researched and compellingly written study of the process of strategy evolution is well worth reading.
6. George W. Cogan and Robert A. Burgelman, “Intel Corporation (A): The DRAM Decision,” Stanford Business School, Case PS-BP-256.
7. Robert A. Burgelman, “Fading Memories: A Process Theory of Strategic Business Exit in Dynamic Environments,” *Administrative Science Quarterly* (39) 1994.
8. Studies of how managers define and perceive risk can shed significant light on this puzzle. Amos Tversky and Daniel Kahneman, for example, have shown that people tend to regard propositions that they do not understand as more risky, regardless of their intrinsic risk, and to regard things they *do* understand as *less* risky, again without regard to intrinsic risk. (Amos Tversky and Daniel Kahneman, “Judgment Under Uncertainty: Heuristics and Biases,” *Science* [185], 1974, 1124–1131.) Managers, therefore, may view creation of new markets as risky propositions, in the face of contrary evidence, because they do not understand non-existent markets; similarly, they may regard investment in sustaining technologies, even those with high intrinsic risk, as safe because they understand the market need.

9. Among the excellent studies in this tradition are Myra M. Hart, *Founding Resource Choices: Influences and Effects*, DBA thesis, Harvard University Graduate School of Business Administration, 1995; Amar Bhide, "How Entrepreneurs Craft Strategies that Work," *Harvard Business Review*, March–April, 1994, 150–163; Amar Bhide, "Bootstrap Finance: The Art of Start-Ups," *Harvard Business Review*, November–December 1992, 109–118; "Hewlett-Packard's Kittyhawk," Harvard Business School, Case No. 9-697-060; and "Vallourec's Venture into Metal Injection Molding," Harvard Business School, Case No. 9-697-001.

10. Joseph Bower, *Managing the Resource Allocation Process* (Homewood, IL: Richard D. Irwin, 1970), 254.

11. Rita G. McGrath and Ian C. MacMillan, "Discovery-Driven Planning," *Harvard Business Review*, July–August, 1995, 4–12.

12. This point is persuasively argued in Peter F. Drucker, *Innovation and Entrepreneurship* (New York: Harper & Row, 1985). Below, in chapter 9, I recount how software maker Intuit discovered that many of the people buying its *Quicken* personal financial management software were, in fact, using it to keep the books of their small businesses. Intuit had not anticipated this application, but it consequently adapted the product more closely to small business needs and launched *Quickbooks*, which captured more than 70 percent of the small business accounting software market within two years.

CHAPTER **EIGHT**

How to Appraise Your Organization's Capabilities and Disabilities

 When managers assign employees to tackle a critical innovation, they instinctively work to match the requirements of the job with the capabilities of the individuals whom they charge to do it. In evaluating whether an employee is capable of successfully executing a job, managers will assess whether he or she has the requisite knowledge, judgment, skill, perspective, and energy.

Managers will also assess the employee's values—the criteria by which he or she tends to decide what should and shouldn't be done. Indeed, the hallmark of a great manager is the ability to identify the right person for the right job, and to train his or her employees so that they have the capabilities to succeed at the jobs they are given.

Unfortunately, some managers don't think as rigorously about whether their *organizations* have the capability to successfully execute jobs that may be given to them. Frequently, they assume that if the people working on a project individually have the requisite capabilities to get the job done well, then the organization in which they work will also have the same capability to succeed. This often is not the case. One could take two sets of identically capable people and put them to work in two different organizations, and what they accomplish would likely be significantly different.

This is because organizations themselves, independent of the people and other resources in them, have capabilities. To succeed consistently,

good managers need to be skilled not just in choosing, training, and motivating the right people for the right job, but in choosing, building, and preparing the right *organization* for the job as well.

The purpose of this chapter is to describe the theory that lies behind the empirical observations made in chapters 5, 6, and 7—in particular, the observation that the only companies that succeeded in addressing disruptive technology were those that created independent organizations whose size matched the size of the opportunity. The notion that organizations have "core competencies" has been a popular one for much of the last decade.

[1] In practice, however, most managers have found that the concept is sufficiently vague that some supposed "competence" can be cited in support of a bewildering variety of innovation proposals. This chapter brings greater precision to the core competence concept, by presenting a framework to help managers understand, when they are confronted with a necessary change, whether the organizations over which they preside are competent or incompetent of tackling the challenges that lie ahead.

AN ORGANIZATIONAL CAPABILITIES FRAMEWORK

Three classes of factors affect what an organization can and cannot do: its resources, its processes, and its values. When asking what sorts of innovations their organizations are and are not likely to be able to implement successfully, managers can learn a lot about capabilities by disaggre-gating their answers into these three categories.

2

Resources

Resources are the most visible of the factors that contribute to what an organization can and cannot do. Resources include people, equipment, technology, product designs, brands, information, cash, and relationships with suppliers, distributors, and customers. Resources are usually *things*, or *assets*—they can be hired and fired, bought and sold, depreciated or enhanced. They often can be transferred across the boundaries of organizations much more readily than can processes and values. Without doubt, access to abundant and high-quality resources enhances an organization's chances of coping with change.

Resources are the things that managers most instinctively identify when assessing whether their organizations can successfully implement changes that confront them. Yet resource analysis clearly does not tell a sufficient story about capabilities. Indeed, we could deal identical sets of resources to two different organizations, and what they created from those resources would likely be very different—because the capabilities to transform inputs into goods and services of greater value reside in the organization's processes and values.

Processes

Organizations create value as employees transform inputs of resources— people, equipment, technology, product designs, brands, information, energy, and cash —into products and services of greater worth. The patterns of interaction, coordination, communication, and decision-making through which they accomplish these transformations are *processes*. [3] Processes include not just manufacturing processes, but those by which product development, procurement, market research, budgeting, planning, employee development and compensation, and resource allocation are accomplished.

Processes differ not only in their purpose, but also in their visibility. Some processes are "formal," in the sense that they are explicitly defined, visibly documented, and consciously followed. Other processes are "informal," in that they are habitual routines or ways of working that have evolved over time, which people follow simply because they work—or because "That's the way we do things around here." Still other methods of working and interacting have proven so effective for so long that people unconsciously follow them—they constitute the culture of the organization. Whether they are formal, informal, or cultural, however, processes define how an organization transforms the sorts of inputs listed above into things of greater value.

Processes are defined or evolve *de facto* to address specific tasks. This means that when managers use a process to execute the tasks for which it was designed, it is likely to perform efficiently. But when the same, seemingly efficient process is employed to tackle a very different task, it is likely to seem slow, bureaucratic, and inefficient. In other words, a process that defines a *capability* in executing a certain task concurrently defines *disabilities* in executing other tasks. [4] The reason good managers strive for focus in their organizations is that processes and tasks can be readily aligned. [5]

One of the dilemmas of management is that, by their very nature, processes are established so that employees perform recurrent tasks in a consistent way, time after time. To ensure consistency, they are meant *not* to change—or if they must change, to change through tightly controlled procedures. *This means that the very mechanisms through which organizations create value are intrinsically inimical to change*.

Some of the most crucial processes to examine as capabilities or disabilities

aren’t the obvious value-adding processes involved in logistics, development, manufacturing, and customer service. Rather, they are the enabling or background processes that support investment decision-making. As we saw in chapter 7, the processes that render good companies incapable of responding to change are often those that define how market research is habitually done; how such analysis is translated into financial projections; how plans and budgets are negotiated and how those numbers are delivered; and so on. These typically inflexible processes are where many organizations’ most serious disabilities in coping with change reside.

Values

The third class of factors that affect what an organization can or cannot accomplish is its values. The values of an organization are the criteria by which decisions about priorities are made. Some corporate values are ethical in tone, such as those that guide decisions to ensure patient well-being at Johnson & Johnson or that guide decisions about plant safety at Alcoa. But within the Resources-Processes-Values (RPV) framework, values have a broader meaning. An organization's values are the standards by which employees make prioritization decisions—by which they judge whether an order is attractive or unattractive; whether a customer is more important or less important; whether an idea for a new product is attractive or marginal; and so on. Prioritization decisions are made by employees at every level. At the executive tiers, they often take the form of decisions to invest or not invest in new products, services, and processes. Among salespeople, they consist of on-the-spot, day-to-day decisions about which products to push with customers and which not to emphasize.

The larger and more complex a company becomes, the more important it is for senior managers to train employees at every level to make independent decisions about priorities that are consistent with the strategic direction and the business model of the company. A key metric of good management, in fact, is whether such clear and consistent values have permeated the organization. [6]

Clear, consistent, and broadly understood values, however, also define what an organization cannot do. A company's values, by necessity, must reflect its cost structure or its business model, because these define the rules its employees must follow in order for the company to make money. If, for example, the structure of a company's overhead costs requires it to achieve gross profit margins of 40 percent, a powerful value or decision rule will have evolved that encourages middle managers to kill ideas that promise gross margins below 40 percent. This means that such an organization would be *incapable* of successfully commercializing projects targeting low-margin markets. At the same time, another organization's values, driven by a very different cost structure, might enable or facilitate the success of the very same project.

The values of successful firms tend to evolve in a predictable fashion in at least two dimensions. The first relates to acceptable gross margins. As companies add features and functionality to their products and services in order

to capture more attractive customers in premium tiers of their markets, they often add overhead cost. As a result, gross margins that at one point were quite attractive, at a later point seem unattractive. Their values change. For example, Toyota entered the North American market with its Corona model—a product targeting the lowest-priced tiers of the market. As the entry tier of the market became crowded with look-alike models from Nissan, Honda, and Mazda, competition among equally low-cost competitors drove down profit margins. Toyota developed more sophisticated cars targeted at higher tiers of the market in order to improve its margins. Its Corolla, Camry, Previa, Avalon, and Lexus families of cars have been introduced in response to the same competitive pressures—it kept its margins healthy by migrating up-market. In the process, Toyota has had to add costs to its operation to design, build, and support cars of this caliber. It progressively deemphasized the entry-level tiers of the market, having found the margins it could earn there to be unattractive, given its changed cost structure.

Nucor Steel, the leading minimill that led the up-market charge against the integrated mills that was recounted in chapter 4, likewise has experienced a change in values. As it has managed the center of gravity in its product line up-market from re-bar to angle iron to structural beams and finally to sheet steel, it has begun to decidedly deemphasize re-bar—the product that had been its bread and butter in its earlier years.

The second dimension along which values predictably change relates to how big a business has to be in order to be interesting. Because a company's stock price represents the discounted present value of its projected earnings stream, most managers typically feel compelled not just to maintain growth, but to maintain a constant *rate* of growth. In order for a $40 million company to grow 25 percent, it needs to find $10 million in new business the next year. For a $40 *billion* company to grow 25 percent, it needs to find $10 billion in new business the next year. The size of market opportunity that will solve each of these companies' needs for growth is very different. As noted in chapter 6, an opportunity that excites a small organization isn't big enough to be interesting to a very large one. One of the bittersweet rewards of success is, in fact, that as companies become large, they literally lose the capability to enter small emerging markets. This disability is not because of a change in the resources within the companies—their resources typically are vast. Rather, it is because their values change.

Executives and Wall Street financiers who engineer megamergers among

already huge companies in order to achieve cost savings need to account for the impact of these actions on the resultant companies' values. Although their merged organizations might have more resources to throw at innovation problems, their commercial organizations tend to lose their appetites for all but the biggest blockbuster opportunities. Huge size constitutes a very real *disability* in managing innovation. In many ways, Hewlett-Packard's recent decision to split itself into two companies is rooted in its recognition of this problem.

THE RELATIONSHIP BETWEEN PROCESSES AND VALUES, AND SUCCESS IN ADDRESSING SUSTAINING VS. DISRUPTIVE TECHNOLOGIES

The resources-processes-values (RPV) framework has been a useful tool for me to understand the findings from my research relating to the differences in companies' track records in sustaining and disruptive technologies. Recall that we identified 116 new technologies that were introduced in the industry's history. Of these, 111 were sustaining technologies, in that their impact was to improve the performance of disk drives. Some of these were incremental improvements while others, such as magneto-resistive heads, represented discontinuous leaps forward in performance. In all 111 cases of sustaining technology, the companies that led in developing and introducing the new technology were the companies that had led in the old technology. The success rate of the established firms in developing and adopting sustaining technologies was 100 percent.

The other five of these 116 technologies were disruptive innovations—in each case, smaller disk drives that were slower and had lower capacity than those used in the mainstream market. There was no new technology involved in these disruptive products. Yet *none* of the industry's leading companies remained atop the industry after these disruptive innovations entered the market—their batting average was *zero*.

Why such markedly different batting averages when playing the sustaining versus disruptive games? The answer lies in the RPV framework of organizational capabilities. The industry leaders developed and introduced sustaining technologies over and over again. Month after month, year after year, as they introduced new and improved products in order to gain an edge over the competition, the leading companies developed processes for evaluating the technological potential and assessing their customers' needs for alternative sustaining technologies. In the parlance of this chapter, the organizations developed a *capability* for doing these things, which resided in their processes. Sustaining technology investments also fit the values of the leading companies, in that they promised higher margins from better products sold to their leading-edge customers.

On the other hand, the disruptive innovations occurred so intermittently that

no company had a routinized process for handling them. Furthermore, because the disruptive products promised lower profit margins per unit sold and could not be used by their best customers, these innovations were inconsistent with the leading companies' values. The leading disk drive companies had the *resources*—the people, money, and technology—required to succeed at both sustaining and disruptive technologies. But their processes and values constituted disabilities in their efforts to succeed at disruptive technologies.

Large companies often surrender emerging growth markets because smaller, disruptive companies are actually more *capable* of pursuing them. Though start-ups lack resources, it doesn't matter. Their values can embrace small markets, and their cost structures can accommodate lower margins. Their market research and resource allocation processes allow managers to proceed intuitively rather than having to be backed up by careful research and analysis, presented in PowerPoint. All of these advantages add up to enormous opportunity or looming disaster—depending upon your perspective.

Managers who face the need to change or innovate, therefore, need to do more than assign the right resources to the problem. They need to be sure that the organization in which those resources will be working is itself capable of succeeding—and in making that assessment, managers must scrutinize whether the organization's processes and values fit the problem.

THE MIGRATION OF CAPABILITIES

In the start-up stages of an organization, much of what gets done is attributable to its *resources*—its people. The addition or departure of a few key people can have a profound influence on its success. Over time, however, the locus of the organization's capabilities shifts toward its processes and values. As people work together successfully to address recurrent tasks, processes become defined. And as the business model takes shape and it becomes clear which types of business need to be accorded highest priority, values coalesce. In fact, one reason that many soaring young companies flame out after they go public based upon a hot initial product is that whereas their initial success was grounded in resources— the founding group of engineers—they fail to create *processes* that can create a *sequence* of hot products.

An example of such flame out is the story of Avid Technology, a producer of digital editing systems for television. Avid's technology removed tedium from the video editing process. Customers loved it, and on the back of its star product, Avid stock rose from $16 at its 1993 IPO to $49 in mid-1995. However, the strains of being a one-trick pony soon surfaced as Avid was faced with a saturated market, rising inventories and receivables, and increased competition. Customers loved the product, but Avid's lack of effective processes to consistently develop new products and to control quality, delivery, and service ultimately tripped the company and sent its stock back down.

In contrast, at highly successful firms such as McKinsey and Company, the processes and values have become so powerful that it almost doesn't matter which people get assigned to which project teams. Hundreds of new MBAs join the firm every year, and almost as many leave. But the company is able to crank out high-quality work year after year because its core capabilities are rooted in its processes and values rather than in its resources. I sense, however, that these capabilities of McKinsey also constitute its disabilities. The rigorously analytical, data-driven processes that help it create value for its clients in existing, relatively stable markets render it much less capable of building a strong client base among the rapidly growing companies in dynamic technology markets.

In the formative stages of a company's processes and values, the actions and attitudes of the company's founder have a profound impact. The founder often has strong opinions about the way employees ought to work together to reach

has strong opinions about the way employees ought to work together to reach decisions and get things done. Founders similarly impose their views of what the organization's priorities need to be. If the founder's methods are flawed, of course, the company will likely fail. But if those methods are useful, employees will collectively experience for themselves the validity of the founder's problem-solving methodologies and criteria for decision-making. As they successfully use those methods of working together to address recurrent tasks, processes become defined. Likewise, if the company becomes financially successful by prioritizing various uses of its resources according to criteria that reflect the founder's priorities, the company's values begin to coalesce.

As successful companies mature, employees gradually come to assume that the priorities they have learned to accept, and the ways of doing things and methods of making decisions that they have employed so successfully, are the right way to work. Once members of the organization begin to adopt ways of working and criteria for making decisions by assumption, rather than by conscious decision, then those processes and values come to constitute the organization's *culture*. [7] As companies grow from a few employees to hundreds and thousands, the challenge of getting all employees to agree on what needs to be done and how it should be done so that the right jobs are done repeatedly and consistently can be daunting for even the best managers. Culture is a powerful management tool in these situations. Culture enables employees to act autonomously and causes them to act consistently.

Hence, the location of the most powerful factors that define the capabilities and disabilities of organizations migrates over time —from resources toward visible, conscious processes and values, and then toward culture. As long as the organization continues to face the same sorts of problems that its processes and values were designed to address, managing the organization is relatively straightforward. But because these factors also define what an organization *cannot* do, they constitute disabilities when the problems facing the company change. When the organization's capabilities reside primarily in its people, changing to address new problems is relatively simple. But when the capabilities have come to reside in processes and values and *especially* when they have become embedded in culture, change can become extraordinarily difficult.

A case in point: Did Digital Equipment have the capability to succeed in personal computers?

Digital Equipment Corporation (DEC) was a spectacularly successful maker of minicomputers from the 1960s through the 1980s. One might have been tempted to assert, when the personal computer market began to coalesce in the early 1980s, that DEC's "core competence" was in building computers. But if computers were DEC's competence, why did the company stumble?

Clearly, DEC had the *resources* to succeed in personal computers. Its engineers were routinely designing far more sophisticated computers than PCs. DEC had plenty of cash, a great brand, and strong technology. But did DEC have the *processes* to succeed in the personal computer business? No. The processes for designing and manufacturing minicomputers involved designing many of the key components of the computer internally and then integrating the components into proprietary configurations. The design process itself consumed two to three years for a new product model. DEC's manufacturing processes entailed making most components and assembling them in a batch mode. It sold direct to corporate engineering organizations. These processes worked extremely well in the minicomputer business.

The personal computer business, in contrast, required processes through which the most cost-effective components were outsourced from the best suppliers around the globe. New computer designs, comprised of modular components, had to be completed in six-to twelve-month cycles. The computers were manufactured in high-volume assembly lines, and sold through retailers to consumers and businesses. None of these processes required to compete successfully in the personal computer business existed within DEC. In other words, although the *people* working at DEC, as individuals, had the abilities to design, build, and sell personal computers profitably, they were working in an organization that was incapable of doing this because its processes had been designed and had evolved to do *other* tasks well. The very processes that made the company capable of succeeding in one business rendered it incapable of succeeding in another.

And what about DEC's *values*? Because of the overhead costs that were required to succeed in the minicomputer business, DEC had to adopt a set of values that essentially dictated, "If it generates 50 percent gross margins or

more, it's good business. If it generates less than 40 percent margins, it's not worth doing." Management had to ensure that all employees prioritized projects according to this criterion, or the company couldn't make money. Because personal computers generated lower margins, they did not "fit" with DEC's values. The company's criteria for prioritization placed higher-performance minicomputers ahead of personal computers in the resource allocation process. And any attempts that the company made to enter the personal computer business had to target the highest-margin tiers of that market—because the financial results that might be earned in those tiers were the only ones that the company's values would tolerate. But because of the patterns noted in chapter 4—the strong tendency for competitors with low-overhead business models to migrate upmarket—Digital's values rendered it incapable of pursuing a winning strategy.

As we saw in chapter 5, Digital Equipment could have owned *another* organization whose processes and values were tailored to those required to play in the personal computer game. But the particular organization in Maynard, Massachusetts, whose extraordinary capabilities had carried the company to such success in the minicomputer business, was simply incapable of succeeding in the personal computer world.

CREATING CAPABILITIES TO COPE WITH CHANGE

If a manager determined that an employee was incapable of succeeding at a task, he or she would either find someone else to do the job or carefully train the employee to be able to succeed. Training often works, because individuals can become skilled at multiple tasks.

Despite beliefs spawned by popular change-management and reengineering programs, processes are not nearly as flexible or "trainable" as are resources—and values are even less so. The processes that make an organization good at outsourcing components cannot simultaneously make it good at developing and manufacturing components in-house. Values that focus an organization's priorities on high-margin products cannot simultaneously focus priorities on low-margin products. This is why focused organizations perform so much better than unfocused ones: their processes and values are matched carefully with the set of tasks that need to be done.

For these reasons, managers who determine that an organization's capabilities aren't suited for a new task, are faced with three options through which to create new capabilities. They can:

- Acquire a different organization whose processes and values are a close match with the new task
- Try to change the processes and values of the current organization
- Separate out an independent organization and develop within it the new processes and values that are required to solve the new problem

Creating Capabilities Through Acquisitions

Managers often sense that acquiring rather than developing a set of capabilities makes competitive and financial sense. The RPV model can be a useful way to frame the challenge of integrating acquired organizations. Acquiring managers need to begin by asking, "What is it that really created the value that I just paid so dearly for? Did I justify the price because of its resources—its people, products, technology, market position, and so on? Or, was a substantial portion of its worth created by processes and values—unique ways of working and decision-making that have enabled the company to understand and satisfy customers, and develop, make, and deliver new products and services in a timely way?

If the acquired company's processes and values are the real driver of its success, then the last thing the acquiring manager wants to do is to integrate the company into the new parent organization. Integration will vaporize many of the processes and values of the acquired firm as its managers are required to adopt the buyer's way of doing business and have their proposals to innovate evaluated according to the decision criteria of the acquiring company. If the acquiree's processes and values were the reason for its historical success, a better strategy is to let the business stand alone, and for the parent to infuse its resources into the acquired firm's processes and values. This strategy, in essence, truly constitutes the acquisition of new capabilities.

If, on the other hand, the company's *resources* were the primary rationale for the acquisition, then integrating the firm into the parent can make a lot of sense —essentially plugging the acquired people, products, technology, and customers into the parent's processes, as a way of leveraging the parent's existing capabilities.

The perils of the DaimlerChrysler merger that began in the late 1990s, for example, can be better understood through the RPV model. Chrysler had few resources that could be considered unique in comparison to its competitors. Its success in the market of the 1990s was rooted in its processes—particularly in its rapid, creative product design processes, and in its processes of integrating the efforts of its subsystem suppliers. What would be the best way for Daimler to leverage the capabilities that Chrysler brought to the table? Wall Street exerted nearly inexorable pressure on management to consolidate the two organizations in order to cut costs. However, integrating the two companies would likely

vaporize the key processes that made Chrysler such an attractive acquisition in the first place.

This situation is reminiscent of IBM's 1984 acquisition of Rolm. There wasn't anything in Rolm's pool of resources that IBM didn't already have. It was Rolm's processes for developing PBX products and for finding new markets for them that was really responsible for its success. In 1987 IBM decided to fully integrate the company into its corporate structure. Trying to push Rolm's resources—its products and its customers—through the same processes that were honed in its large computer business, caused the Rolm business to stumble badly. And inviting executives of a computer company whose values had been whetted on operating profit margins of 18 percent to get excited about prioritizing products with operating margins below 10 percent was impossible. IBM's decision to integrate Rolm actually destroyed the very source of the original worth of the deal. As this chapter is being written in February 2000, DaimlerChrysler, bowing to the investment community's drumbeat for efficiency savings, now stands on the edge of the same precipice.

Often, it seems, financial analysts have a better intuition for the value of resources than for processes.

In contrast, Cisco Systems' acquisitions process has worked well— because its managers seem to have kept resources, processes, and values in the right perspective. Between 1993 and 1997 it acquired primarily small companies that were less than two years old: early-stage organizations whose market value was built primarily upon their resources— particularly engineers and products. Cisco has a well-defined, deliberate process by which it essentially plugs these resources into the parent's processes and systems, and it has a carefully cultivated method of keeping the engineers of the acquired company happily on the Cisco payroll. In the process of integration, Cisco throws away whatever nascent processes and values came with the acquisition—because those weren't what Cisco paid for. On a couple of occasions when the company acquired a larger, more mature organization—notably its 1996 acquisition of StrataCom—Cisco did *not* integrate. Rather, it let StrataCom stand alone, and infused its substantial resources into the organization to help it grow at a more rapid rate. [8]

On at least three occasions, Johnson & Johnson has used acquisitions to establish a position in an important wave of disruptive technology. Its businesses in disposable contact lenses, endoscopic surgery, and diabetes blood glucose meters were all acquired when they were small, were allowed to stand alone, and were infused with resources. Each has become a billion-dollar business. Lucent Technologies and Nortel followed a similar strategy for catching the wave of

Technologies and Nortel followed a similar strategy for catching the wave of routers, based upon packet-switching technology, that were disrupting their traditional circuit-switching equipment. But they made these acquisitions late and the firms they acquired, Ascend Communications and Bay Networks, respectively, were extraordinarily expensive because they had already created the new market application, data networks, along with the much larger Cisco Systems—and they were right on the verge of attacking the voice network.

Creating New Capabilities Internally

Companies that have tried to develop new capabilities within established organizational units also have a spotty track record, unfortunately. Assembling a beefed-up set of resources as a means of changing what an existing organization can do is relatively straightforward. People with new skills can be hired, technology can be licensed, capital can be raised, and product lines, brands, and information can be acquired. Too often, however, resources such as these are then plugged into fundamentally unchanged processes—and little change results. For example, through the 1970s and 1980s Toyota upended the world automobile industry through its innovation in development, manufacturing, and supply-chain *processes*— without investing aggressively in resources such as advanced manufacturing or information-processing technology. General Motors responded by investing nearly $60 billion in manufacturing *resources*—computer-automated equipment that was designed to reduce cost and improve quality. Using state-of-the-art resources in antiquated processes, however, made little difference in General Motors' performance, because it is in its processes and values that the organization's most fundamental capabilities lie. Processes and values define how resources—many of which can be bought and sold, hired and fired—are combined to create value.

Unfortunately, processes are very hard to change—for two reasons. The first is that organizational boundaries are often drawn to facilitate the operation of present processes. Those boundaries can impede the creation of new processes that cut across those boundaries. When new challenges require different people or groups to interact differently than they habitually have done—addressing different challenges with different timing than historically had been required—managers need to pull the relevant people out of the existing organization and draw a new boundary around a new group. New team boundaries enable or facilitate new patterns of working together that ultimately can coalesce as new processes—new capabilities for transforming inputs into outputs. Professors Steven C. Wheelwright and Kim B. Clark have called these structures heavyweight teams. [9]

The second reason new process capabilities are hard to develop is that, in some cases, managers don't *want* to throw the existing processes out—the methods work perfectly well in doing what they were designed to do. As noted

above, while resources tend to be flexible and can be used in a variety of situations, processes and values are by their very nature *inflexible*. Their very *raison d'e^tre* is to cause the same thing to be done consistently, over and over again. Processes are meant *not* to change.

When disruptive change appears on the horizon, managers need to assemble the capabilities to confront the change *before* it has affected the mainstream business. In other words, they need an organization that is geared toward the new challenge before the old one, whose processes are tuned to the existing business model, has reached a crisis that demands fundamental change.

Because of its task-specific nature, it is impossible to ask one process to do two fundamentally different things. Consider the examples presented in chapter 7, for instance. The market research and planning processes that are appropriate for the launch of new products into existing markets simply aren't capable of guiding a company into emerging, poorly defined markets. And the processes by which a company would experimentally and intuitively feel its way into emerging markets would constitute suicide if employed in a well-defined existing business. If a company needs to do both types of tasks simultaneously, then it needs two very different processes. And it is very difficult for a single organizational unit to employ fundamentally different, opposing processes. As shown below, this is why managers need to create different teams, within which different processes to address new problems can be defined and refined.

Creating Capabilities Through a Spin-out Organization

The third mechanism for new capability creation—spawning them within spin-out ventures—is currently *en vogue* among many managers as they wrestle with how to address the Internet. When are spin-outs a crucial step in building new capabilities to exploit change, and what are the guidelines by which they should be managed? A separate organization is required when the mainstream organization's *values* would render it incapable of focusing resources on the innovation project. Large organizations cannot be expected to allocate freely the critical financial and human resources needed to build a strong position in small, emerging markets. And it is very difficult for a company whose cost structure is tailored to compete in high-end markets to be profitable in low-end markets as well. When a threatening disruptive technology requires a different cost structure in order to be profitable and competitive, or when the current size of the opportunity is insignificant relative to the growth needs of the mainstream organization, then—and only then—is a spin-out organization a required part of the solution.

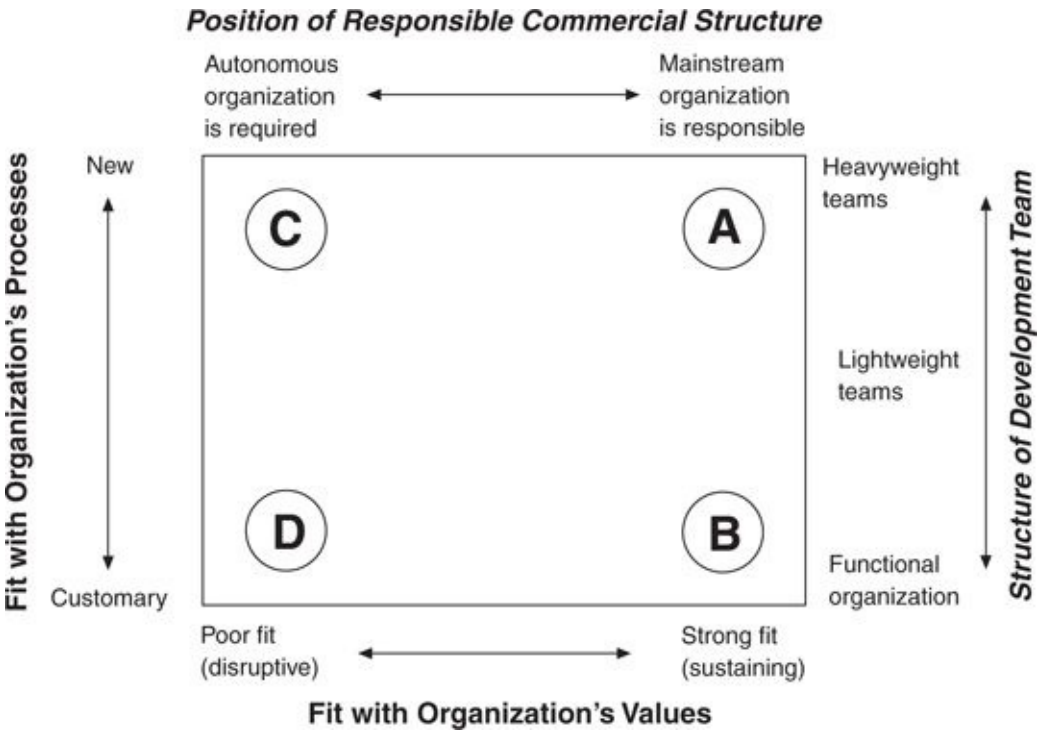
How separate does the effort need to be? The primary requirement is that the project cannot be forced to compete with projects in the mainstream organization for resources. Because values are the criteria by which prioritization decisions are made, projects that are inconsistent with a company's mainstream values will naturally be accorded lowest priority. Whether the independent organization is physically separate is less important than is its independence from the normal resource allocation process.

In our studies of this challenge, we have never seen a company succeed in addressing a change that disrupts its mainstream values absent the personal, attentive oversight of the CEO—precisely because of the power of processes and values and particularly the logic of the normal resource allocation process. Only the CEO can ensure that the new organization gets the required resources and is free to create processes and values that are appropriate to the new challenge. CEOs who view spin-outs as a tool to get disruptive threats off of their personal agendas are almost certain to meet with failure. We have seen no exceptions to this rule.

The framework summarized in Figure 8.1 can help managers exploit the capabilities that reside in their current processes and values when that is possible, and to create new ones, when the present organization is incapable. The

left axis in Figure 8.1 measures the extent to which the existing processes—the patterns of interaction, communication, coordination, and decision-making currently used in the organization—are the ones that will get the new job done effectively. If the answer is yes (toward the lower end of the scale), the project manager can exploit the organization's existing processes and organizational structure to succeed. As depicted in the corresponding position on the right axis, functional or lightweight teams, as described by Clark and Wheelwright, [10] are useful structures for exploiting existing capabilities. In such teams, the role of the project manager is to facilitate and coordinate work that is largely done within functional organizations.

Figure 8.1 Fitting an Innovation's Requirements with the Organization's Capabilities



Note: The left and bottom axes reflect the questions the manager needs to ask about the existing situation. The notes at the right side represent the appropriate

response to the situation on the left axis. The notes at the top represent the appropriate response to the manager's answer to the bottom axis.

On the other hand, if the ways of getting work done and of decision-making in the mainstream business would impede rather than facilitate the work of the new team—because different people need to interact with different people about different subjects and with different timing than has habitually been necessary—then a heavyweight team structure is necessary. Heavyweight teams are tools to create new processes—new ways of working together that constitute new capabilities. In these teams, members do not simply represent the interests and skills of their function. They are charged to act like general managers, and reach decisions and make trade-offs for the good of the *project*. They typically are dedicated and colocated.

The horizontal axis of Figure 8.1 asks managers to assess whether the organization's values will allocate to the new initiative the resources it will need in order to become successful. If there is a poor, disruptive fit, then the mainstream organization's values will accord low priority to the project. Therefore, setting up an autonomous organization within which development and commercialization can occur will be absolutely essential to success. At the other extreme, however, if there is a strong, sustaining fit, then the manager can expect that the energy and resources of the mainstream organization will coalesce behind it. There is no reason for a skunk works or a spin-out in such cases.

Region A in Figure 8.1 depicts a situation in which a manager is faced with a breakthrough but sustaining technological change—it fits the organization's values. But it presents the organization with different types of problems to solve and therefore requires new types of interaction and coordination among groups and individuals. The manager needs a heavyweight development team to tackle the new task, but the project can be executed within the mainstream company. This is how Chrysler, Eli Lilly, and Medtronic accelerated their product development cycles so dramatically. [11] Heavyweight teams are the organizational mechanism that the managers of IBM's disk drive division used to learn how to integrate components more effectively in their product designs, in order to wring 50 percent higher performance out of the components they used. Microsoft's project to develop and launch its Internet browser was located in the Region A corner of this framework. It represented an extraordinary, difficult managerial achievement that required different people to work together

in patterns different than any ever used before within Microsoft. But it was a *sustaining* technology to the company. Its customers wanted the product, and it strengthened the company's integral business model. There was, therefore, no need to spin the project out into a completely different organization.

When in Region B, where the project fits the company's processes and values, a lightweight development team can be successful. In such teams coordination across functional boundaries occurs within the mainstream organization.

Region C denotes an area in which a manager is faced with a disruptive technological change that doesn't fit the organization's existing processes and values. To ensure success in such instances, managers should create an autonomous organization and commission a heavyweight development team to tackle the challenge. In addition to the examples cited in chapters 5, 6, and 7, many companies' efforts to address the distribution channel conflicts created by the Internet should be managed in this manner. In 1999 Compaq Computer, for example, launched a business to market its computers direct to customers over the Internet, so that it could compete more effectively with Dell Computer. Within a few weeks its retailers had protested so loudly that Compaq had to back away from the strategy. This was *very* disruptive to the values, or profit model, of the company and its retailers. The only way it could manage this conflict would be to launch the direct business through an independent company. It might even need a different brand in order to manage the tension.

Some have suggested that Wal-Mart's strategy of managing its on-line retailing operation through an independent organization in Silicon Valley is foolhardy, because the spin-out organization can't leverage Wal-Mart's extraordinary logistics management processes and infrastructure. I believe the spin-out was wise, however, based upon Figure 8.1. The on-line venture actually needs very different logistics processes than those of its bricks-and-mortar operations. Those operations transport goods by the truck-load. On-line retailers need to pick individual items from inventory and ship small packages to diverse locations. The venture is not only disruptive to Wal-Mart's values, but it needs to create its own logistics processes as well. It needed to be spun out separately.

Region D typifies projects in which products or services similar to those in the mainstream need to be sold within a fundamentally lower overhead cost business model. Wal-Mart's Sam's Clubs would fit in this region. These, in fact, can leverage similar logistics management processes as the main company; but budgeting, management, and P&L responsibility needs to be different.

Functional and lightweight teams are appropriate vehicles for exploiting

Functional and lightweight teams are appropriate vehicles for exploiting established capabilities, whereas heavyweight teams are tools for creating new ones. Spin-out organizations, similarly, are tools for forging new values. Unfortunately, most companies employ a one-size-fits-all organizing strategy, using lightweight teams for programs of every size and character. Among those few firms that have accepted the "heavyweight gospel," many have attempted to organize all of their development teams in a heavyweight fashion. Ideally, each company should tailor the team structure and organizational location to the process and values required by each project.

In many ways, the disruptive technologies model is a theory of relativity, because what is disruptive to one company might have a sustaining impact on another. For example, Dell Computer began by selling computers over the telephone. For Dell, the initiative to begin selling and accepting orders over the Internet was a *sustaining* innovation. It helped it make more money in the way it was already structured. For Compaq, Hewlett-Packard, and IBM, however, marketing direct to customers over the Internet would have a powerfully disruptive impact. The same is true in stock brokerage. For discount brokers such as Ameritrade and Charles Schwab, which accepted most of their orders by telephone, trading securities on-line simply helped them discount more cost-effectively—and even offer enhanced service relative to their former capabilities. For full-service firms with commissioned brokers such as Merrill Lynch, however, on-line trading represents a powerful disruptive threat.

SUMMARY

Managers whose organizations are confronting change must first determine that they have the resources required to succeed.

They then need to ask a separate question: does the organization have the processes and values to succeed? Asking this second question is not as instinctive for most managers because the processes by which work is done and the values by which employees make their decisions have served them well. What I hope this framework adds to managers' thinking, however, is that the very capabilities of their organizations also define their disabilities. A little time spent soul-searching for honest answers to this issue will pay off handsomely. Are the processes by which work habitually gets done in

the organization appropriate for this new problem? And will the values of the organization cause this initiative to get high priority, or to languish?

If the answer to these questions is no, it's okay. Understanding problems is the most crucial step in solving them. Wishful thinking about this issue can set teams charged with developing and implementing an innovation on a course fraught with roadblocks, second-guessing, and frustration. The reasons why innovation often seems to be so difficult for established firms is that they employ highly capable people, and then set them to work within processes and values that weren't designed to facilitate success with the task at hand. Ensuring that capable people are ensconced in capable organizations is a major management responsibility in an age such as ours, when the ability to cope with accelerating

change has become so critical.

NOTES

1. See C. K. Prahalad, and Gary Hamel, “The Core Competence of the Corporation,” *Harvard Business Review*, 1990.
2. Many of these ideas emerged from wonderful, stimulating discussions with doctoral students in the Business Policy seminar at the Harvard Business School between 1993 and 1999. I wish to thank all of those students, but in particular Don Sull, Tom Eisenmann, Tomoyoshi Noda, Michael Raynor, Michael Roberto, Deborah Sole, Clark Gilbert, and Michael Overdorf for their contributions to these ideas.
3. The most logical, comprehensive characterization of processes that we have seen is in David Garvin, “The Processes of Organization and Management,” *Sloan Management Review*, Summer, 1998. When we use the term “processes,” we mean for it to include all of the types of processes that Garvin has defined.
4. See Dorothy Leonard-Barton, “Core Capabilities and Core Rigidities: A Paradox in Managing New Product Development,” *Strategic Management Journal* (13), 1992, 111–12
5. Professor Leonardi’s work on this topic, in my opinion, constitutes the fundamental paradigm upon which much subsequent research is being built. 5. See Wickham Skinner, “The Focused Factory,” *Harvard Business Review*, 1974.
6. See, for example, Thomas Peters and Robert Waterman, *In Search of Excellence* (New York: Harper & Row Publishers, 1982).
7. See Edgar Schein, *Organizational Culture and Leadership* (San Francisco: Jossey-Bass Publishers, 1988). This description of the development of an organization’s culture draws heavily from Schein’s research.
8. See Nicole Tempest, “Cisco Systems, Inc. Post-Acquisition Manufacturing Integration,” a teaching case published jointly by the Stanford University Graduate School of Business and the Harvard Business School, 1998.
9. Steven C. Wheelwright and Kim B. Clark, *Revolutionizing Product Development* (New York: The Free Press, 1992).
10. See Kim B. Clark and Steven C. Wheelwright, “Organizing and Leading Heavyweight Development Teams,” *California Management Review* (34), Spring, 1992, 9–28. The concepts described in this article are extremely

important. We highly recommend that managers interested in these problems study it thoughtfully. They define a heavyweight team as one in which team members typically are dedicated and colocated. The charge of each team member is not to represent their functional group on the team, but to act as a *general manager*—to assume responsibility for the success of the entire project, and to be actively involved in the decisions and work of members who come from each functional area. As they work together to complete their project, they will work out new ways of interacting, coordinating, and decision-making that will come to comprise the new processes, or new capabilities, that will be needed to succeed in the new enterprise on an ongoing basis. These ways of getting work done then get institutionalized as the new business or product line grows.

1. See Jeff Dyer, "How Chrysler Created an American Keiretsu," *Harvard Business Review*, July-August, 1996, 42–56; Clayton M. Christensen, "We've Got Rhythm! Medtronic Corporation's Cardiac Pacemaker Business," Harvard Business School, Case No. 698-004; and Steven C. Wheelwright, "Eli Lilly: The Evista Project," Harvard Business School, Case No. 699-016.

CHAPTER **NINE**

Performance Provided, Market Demand, and the Product Life Cycle

The graphs in this book showing the intersecting technology and market trajectories have proven useful in explaining how leading firms can stumble from positions of industry leadership. In each of the several industries explored, technologists were able to provide rates of performance improvement that have exceeded the rates of performance improvement that the market has needed or was able to absorb. Historically, when this *performance oversupply* occurs, it creates an opportunity for a disruptive technology to emerge and subsequently to invade established markets from below.

As it creates this threat or opportunity for a disruptive technology, performance oversupply also triggers a fundamental change in the basis of competition in the product's market: The rank-ordering of the criteria by which customers choose one product or service over another will change, signaling a transition from one phase (variously defined by management theorists) to the next of the product life cycle. In other words, the intersecting trajectories of performance supplied and performance demanded are fundamental triggers behind the phases in the product life cycle. Because of this, trajectory maps such as those used in this book usefully characterize how an industry's competitive dynamics and its basis of competition are likely to change over time.

As with past chapters, this discussion begins with an analysis from the disk drive industry of what can happen when the performance supplied exceeds the market's demands. After seeing the same phenomenon played out in the markets for accounting software and for diabetes care products, the link between this pattern and the phases of the product life cycle will be clear.

PERFORMANCE OVERSUPPLY AND CHANGING BASES OF COMPETITION

The phenomenon of performance oversupply is charted in Figure 9.1, an extract from Figure 1.7. It shows that by 1988, the capacity of the average 3.5-inch drive had finally increased to equal the capacity demanded in the mainstream desktop personal computer market, and that the capacity of the average 5.25-inch drive had by that time surpassed what the mainstream desktop market demanded by nearly 300 percent. At this point, for the first time since the desktop market emerged, computer makers had a choice of drives to buy: The 5.25-and 3.5-inch drives *both* provided perfectly adequate capacity.

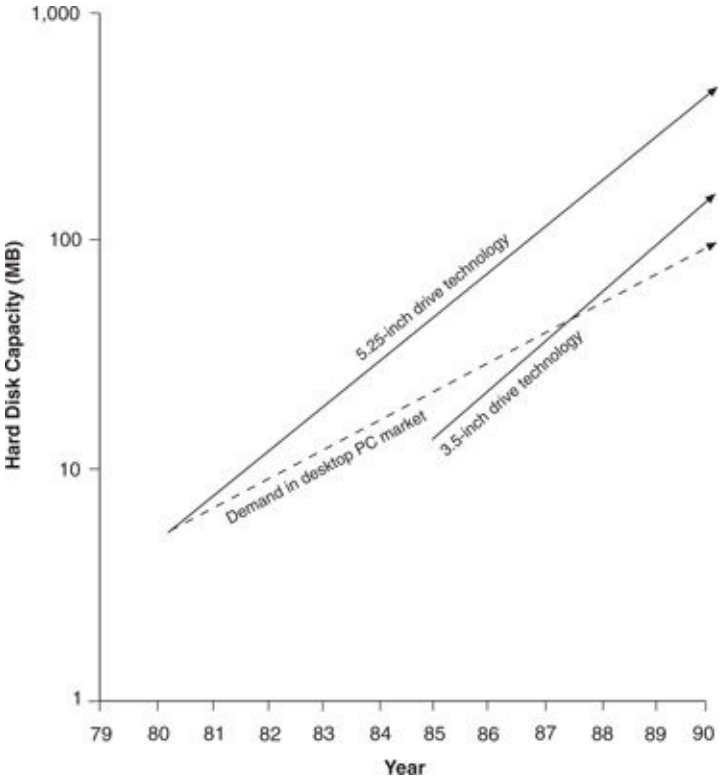
What was the result? The desktop personal computer makers began switching to 3.5-inch drives in droves. Figure 9.2 illustrates this, using a substitution curve format in which the vertical axis measures the ratio of new-to old-technology units sold. In 1985 this measure was .007, meaning that less than 1 percent (.0069) of the desktop market had switched to the 3.5-inch format. By 1987, the ratio had advanced 0.20, meaning that 16.7 percent of the units sold into this market that year were 3.5-inch drives. By 1989, the measure was 1.5, that is, only four years after the 3.5-inch product had appeared as a faint blip on the radar screen of the market, it accounted for 60 percent of drive sales.

Why did the 3.5-inch drive so decisively conquer the desktop PC market? A standard economic guess might be that the 3.5-inch format represented a more cost-effective architecture: If there were no longer any meaningful differentiation between two types of products (both had adequate capacity), price competition would intensify. This was not the case here, however. Indeed, computer makers had to pay, on average, 20 percent more per megabyte to use 3.5-inch drives, and yet they *still* flocked to the product. Moreover, computer manufacturers opted for the costlier drive while facing fierce price competition in their own product markets. Why?

Performance oversupply triggered a change in the basis of competition. Once the demand for capacity was satiated, other attributes, whose performance had not yet satisfied market demands, came to be more highly valued and to constitute the dimensions along which drive makers sought to differentiate their products. In concept, this meant that the most important attribute measured on the vertical axis of figures such as 8.1 changed, and that new trajectories of product performance, compared to market demands, took shape.

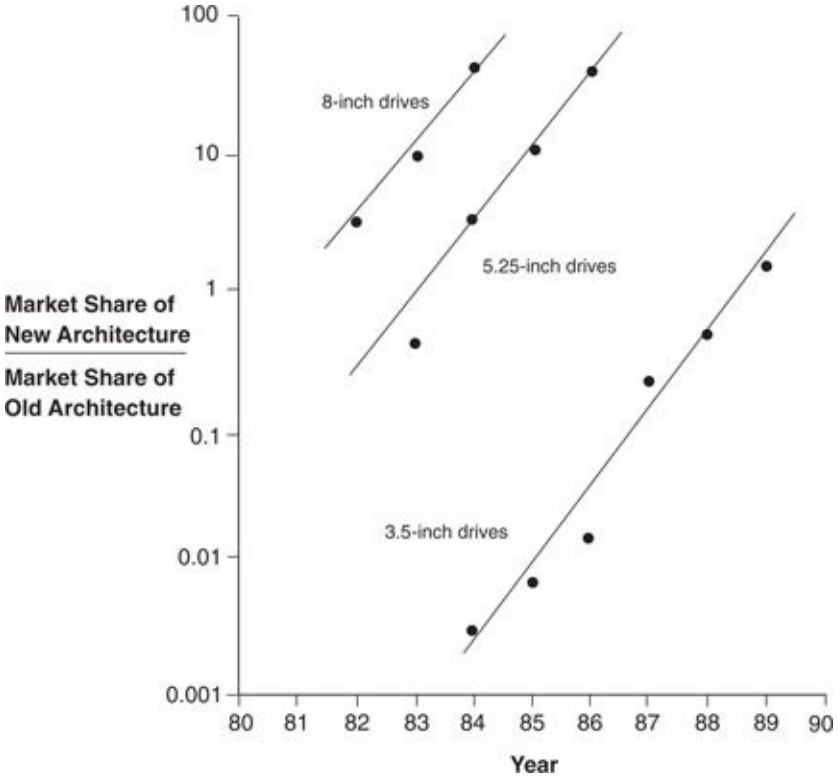
product performance, compared to market demands, took shape.

Figure 9.1 Intersecting Trajectories of Capacity Demanded versus Capacity Supplied in Rigid Disk Drives



Source: Data are from various issues of *Disk/Trend Report.*

Figure 9.2 Substitution of 8-, 5.25-, and 3.5-Inch Drives of 30 to 100 MB



Source: Data are from various issues of *Disk/Trend Report.*

Specifically, in the desktop personal computer marketplace between 1986 and 1988, the smallness of the drive began to matter more than other features. The smaller 3.5-inch drive allowed computer manufacturers to reduce the size, or desktop footprint, of their machines. At IBM, for example, the large XT/AT box gave way to the much smaller PS1/PS2 generation machines.

For a time, when the availability of small drives did not satisfy market demands, desktop computer makers continued to pay a hefty premium for 3.5-inch drives. In fact, using the hedonic regression analysis described in chapter 4, the 1986 shadow price for a one-cubic-inch reduction in the volume of a disk drive was $4.72. But once the computer makers had configured their new generations of desktop machines to use the smaller drive, their demand for even more smallness was satiated. As a result, the 1989 shadow price, or the price premium accorded to smaller drives, diminished to $0.06 for a one-cubic-inch reduction.

Generally, once the performance level demanded of a particular attribute has

been achieved, customers indicate their satiation by being less willing to pay a premium price for continued improvement in that attribute. Hence, performance oversupply triggers a shift in the basis of competition, and the criteria used by customers to choose one product over another changes to attributes for which market demands are not yet satisfied.

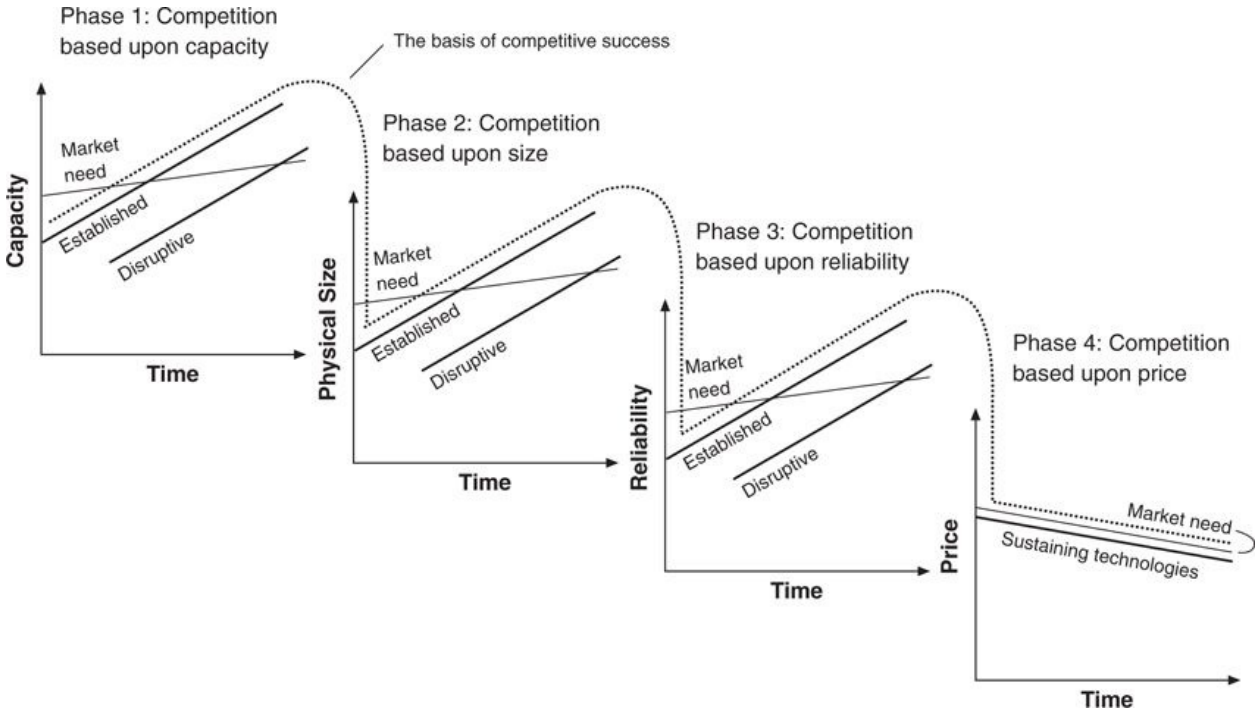
Figure 9.3 summarizes what seems to have happened in the desktop PC market: The attribute measured on the vertical axis repeatedly changed. Performance oversupply in capacity triggered the first redefinition of the vertical axis, from capacity to physical size. When performance on this new dimension satisfied market needs, the definition of performance on the vertical axis changed once more, to reflect demand for reliability. For a time, products offering competitively superior shock resistance and mean time between failure (MTBF) were accorded a significant price premium, compared to competitive offerings. But as MTBF values approached one million hours, [1] the shadow price accorded to an increment of one hundred hours MTBF approached zero, suggesting performance oversupply on that dimension of product performance. The subsequent and current phase is an intense price-based competition, with gross margins tumbling below 12 percent in some instances.

WHEN DOES A PRODUCT BECOME A COMMODITY?

The process of commoditization of disk drives was defined by the interplay between the trajectories of what the market demanded and what the technology supplied. The 5.25-inch drive had become a price-driven commodity in the desktop market by about 1988, when the 3.5-inch drive was still at a premium price. The 5.25-inch drive, in addition, even though priced as a commodity in desktop applications, was at the same time, relative to 8-inch drives, achieving substantial price premiums in higher-tier markets. As described in chapter 4, this explains the aggressive moves upmarket made by established companies.

A product becomes a commodity within a specific market segment when the repeated changes in the basis of competition, as described above, completely play themselves out, that is, when market needs on each attribute or dimension of performance have been fully satisfied by more than one available product. The performance oversupply framework may help consultants, managers, and researchers to understand the frustrated comments they regularly hear from salespeople beaten down in price negotiations with customers: “Those stupid guys are just treating our product like it was a commodity. Can’t they see how much better our product is than the competition’s?” It may, in fact, be the case that the product offerings of competitors in a market continue to be differentiated from each other. But differentiation loses its meaning when the features and functionality have exceeded what the market demands.

Figure 9.3 Changes in the Basis of Competition in the Disk Drive Industry


Phase 1: Competition based upon capacity
The basis of competitive success
Capacity
Market need
Established
Disruptive
Time
Phase 2: Competition based upon size
Physical Size
Market need
Established
Disruptive
Time
Phase 3: Competition based upon reliability
Reliability
Market need
Established
Disruptive
Time
Phase 4: Competition based upon price
Price
Market need
Sustaining technologies
Time

PERFORMANCE OVERSUPPLY AND THE EVOLUTION OF PRODUCT COMPETITION

The marketing literature provides numerous descriptions of the product life cycle and of the ways in which the characteristics of products within given categories evolve over time. [2] The findings in this book suggest that, for many of these models, performance oversupply is an important factor driving the transition from one phase of the cycle to the next.

Consider, for example, the product evolution model, called the *buying hierarchy* by its creators, Windermere Associates of San Francisco, California, which describes as typical the following four phases: functionality, reliability, convenience, and price. Initially, when no available product satisfies the functionality requirements the market, the basis of competition, or the criteria by which product choice is made, tends to be product *functionality*. (Sometimes, as in disk drives, a market may cycle through several different functionality dimensions.) Once two or more products credibly satisfy the market's demand for functionality, however, customers can no longer base their choice of products on functionality, but tend to choose a product and vendor based on *reliability.* As long as market demand for reliability exceeds what vendors are able to provide, customers choose products on this basis—and the most reliable vendors of the most reliable products earn a premium for it.

But when two or more vendors improve to the point that they more than satisfy the reliability demanded by the market, the basis of competition shifts to *convenience*. Customers will prefer those products that are the most convenient to use and those vendors that are most convenient to deal with. Again, as long as the market demand for convenience exceeds what vendors are able to provide, customers choose products on this basis and reward vendors with premium prices for the convenience they offer. Finally, when multiple vendors offer a package of convenient products and services that fully satisfies market demand, the basis of competition shifts to *price.* The factor driving the transition from one phase of the buying hierarchy to the next is performance oversupply.

Another useful conception of industry evolution, formulated by Geoffrey Moore in his book *Crossing the Chasm*, [3] has a similar underlying logic, but articulates the stages in terms of the user rather than the product. Moore suggests that products are initially used by innovators and *early adopters* in an industry—

customers who base their choice solely on the product's functionality. During this phase the top-performing products command significant price premiums. Moore observes that markets then expand dramatically after the demand for functionality in the mainstream market has been met, and vendors begin to address the need for reliability among what he terms *early majority* customers. A third wave of growth occurs when product and vendor reliability issues have been resolved, and the basis of innovation and competition shifts to convenience, thus pulling in the *late majority* customers. Underlying Moore's model is the notion that technology can improve to the point that market demand for a given dimension of performance can be satiated.

This evolving pattern in the basis of competition—from functionality, to reliability and convenience, and finally to price—has been seen in many of the markets so far discussed. In fact, a key characteristic of a disruptive technology is that it heralds a change in the basis of competition.

OTHER CONSISTENT CHARACTERISTICS OF DISRUPTIVE TECHNOLOGIES

Two additional important characteristics of disruptive technologies consistently affect product life cycles and competitive dynamics: First, the attributes that make disruptive products worthless in mainstream markets typically become their strongest selling points in emerging markets; and second, disruptive products tend to be simpler, cheaper, and more reliable and convenient than established products. Managers must understand these characteristics to effectively chart their own strategies for designing, building, and selling disruptive products. Even though the specific market applications for disruptive technologies cannot be known in advance, managers can bet on these two regularities.

1. The Weaknesses of Disruptive Technologies Are Their Strengths

The relation between disruptive technologies and the basis of competition in an industry is complex. In the interplay among performance oversupply, the product life cycle, and the emergence of disruptive technologies, it is often the very attributes that render disruptive technologies useless in mainstream markets that constitute their value in new markets.

In general, companies that have succeeded in disruptive innovation initially took the characteristics and capabilities of the technology for granted and sought to find or create a new market that would value or accept those attributes. Thus, Conner Peripherals created a market for small drives in portable computers, where smallness was valued; J. C. Bamford and J. I. Case built a market for excavators among residential contractors, where small buckets and tractor mobility actually created value; and Nucor found a market that didn't mind the surface blemishes on its thin-slab-cast sheet steel.

The companies toppled by these disruptive technologies, in contrast, each took the established market's *needs* as given, and did not attempt to market the technology until they felt it was good enough to be valued in the mainstream market. Thus, Seagate's marketers took the firm's early 3.5-inch drives to IBM for evaluation, rather than asking, "Where is the market that would actually value a smaller, lower-capacity drive?" When Bucyrus Erie acquired its Hydrohoe hydraulic excavator line in 1951, its managers apparently did not ask, "Where is the market that actually *wants* a mobile excavator that can only dig narrow trenches?" They assumed instead that the market needed the largest possible bucket size and the longest possible reach; they jury-rigged the Hydrohoe with cables, pulleys, clutches, and winches and attempted to sell it to general excavation contractors. When U.S. Steel was evaluating continuous thin-slab casting, they did not ask, "Where is the market for low-priced sheet steel with poor surface appearance?" Rather, they took it for granted that the market needed the highest-possible quality of surface finish and invested more capital in a conventional caster. They applied to a disruptive innovation a way of thinking appropriate to a sustaining technology.

In the instances studied in this book, established firms confronted with disruptive technology typically viewed their primary development challenge as a *technological* one: to improve the disruptive technology enough that it suits known markets. In contrast, the firms that were most successful in

commercializing a disruptive technology were those framing their primary development challenge as a *marketing* one: to build or find a market where product competition occurred along dimensions that favored the disruptive attributes of the product. [4]

It is critical that managers confronting disruptive technology observe this principle. If history is any guide, companies that keep disruptive technologies bottled up in their labs, working to improve them until they suit mainstream markets, will not be nearly as successful as firms that find markets that embrace the attributes of disruptive technologies as they initially stand. These latter firms, by creating a commercial base and then moving upmarket, will ultimately address the mainstream market much more effectively than will firms that have framed disruptive technology as a laboratory, rather than a marketing, challenge.

2. Disruptive Technologies Are Typically Simpler, Cheaper, and More Reliable and Convenient than Established Technologies

When performance oversupply has occurred and a disruptive technology attacks the underbelly of a mainstream market, the disruptive technology often succeeds both because it satisfies the market's need for functionality, in terms of the buying hierarchy, and because it is simpler, cheaper, and more reliable and convenient than mainstream products. Recall, for example, the attack of hydraulic excavation technology into the mainstream sewer and general excavation markets recounted in chapter 3. Once hydraulically powered excavators had the strength to handle buckets of 2 to 4 cubic yards of earth (surpassing the performance demanded in mainstream markets), contractors rapidly switched to these products even though the cable-actuated machines were capable of moving even more earth per scoop. Because both technologies provided adequate bucket capacity for their needs, contractors opted for the technology that was most reliable: hydraulics.

Because established companies are so prone to push for high-performance, high-profit products and markets, they find it very difficult not to overload their first disruptive products with features and functionality. Hewlett-Packard's experience in designing its 1.3-inch Kittyhawk disk drive teaches just this lesson. Unable to design a product that was truly simple and cheap, Kittyhawk's champions pushed its capacity to the limits of technology and gave it levels of shock resistance and power consumption that would make it competitive as a sustaining product. When very

high volume applications for a cheap, simple, single-function, 10 MB drive began to emerge, HP's product was not disruptive enough to catch that wave. Apple committed a similar error in stretching the functionality of its Newton, instead of initially targeting simplicity and reliability.

PERFORMANCE OVERSUPPLY IN THE ACCOUNTING SOFTWARE MARKET

Intuit, the maker of financial management software, is known primarily for its extraordinarily successful personal financial software package, *Quicken.* *Quicken* dominates its market because it is easy and convenient. Its makers pride themselves on the fact that the vast majority of *Quicken* customers simply buy the program, boot it up on their computers, and begin using it without having to read the instruction manual. Its developers made it so convenient to use, and continue to make it simpler and more convenient, by watching how

customers *use* the product, not by listening to what they or the "experts" say they need. By watching for small hints of where the product might be difficult or confusing to use, the developers direct their energies toward a progressively simpler, more convenient product that provides adequate, rather than superior, functionality.

[5]

Less well known is Intuit's commanding 70 percent share of the North American small business accounting software market.

[6] Intuit captured that share as a late entrant when it launched *Quickbooks*, a product based on three simple insights. First, previously available small business accounting packages had been created under the close guidance of certified public accountants and required users to have a basic knowledge of accounting (debits

and credits, assets and liabilities, and so on) and to make every journal entry twice (thus providing an audit trail for each transaction). Second, most existing packages offered a comprehensive and sophisticated array of reports and analyses, an array that grew ever more complicated and specialized with each new release as developers sought to differentiate their products

by offering greater functionality. And third, 85 percent of all companies in the United States were too small to employ an

accountant: The books were kept by the proprietors or by family members, who had no need for or understanding of most of the entries and reports available from mainstream accounting software. They did not know what an audit trail was, let alone sense a need to use one.

Scott Cook, Intuit's founder, surmised that most of these small companies

were run by proprietors who relied more on their intuition and direct knowledge of the business than on the information contained in accounting reports. In other words, Cook decided that the makers of accounting software for small businesses had overshot the functionality required by that market, thus creating an opportunity for a disruptive software technology that provided

adequate, not superior functionality and was simple and more convenient to use. Intuit's disruptive *Quickbooks* changed the basis of product competition from functionality to convenience and captured 70 percent of its market within two years of its introduction.

[7] In fact, by 1995 *Quickbooks* accounted for a larger share of Intuit's revenues than did *Quicken.*

The response of established makers of small business accounting software to Intuit's invasion, quite predictably, has been to move upmarket, continuing to release packages loaded with greater functionality; these focus on specific market subsegments, targeted at sophisticated users of information systems at loftier tiers of the market. Of the three leading suppliers of small business accounting software (each of which claimed about 30 percent of the market in 1992), one has disappeared and one is languishing. The third has introduced a simplified product to counter the success of *Quickbooks*, but it has claimed only a tiny portion of the market.

PERFORMANCE OVERSUPPLY IN THE PRODUCT LIFE CYCLE OF INSULIN

Another case of performance oversupply and disruptive technology precipitating a change in the basis of competition—and threatening a change in industry leadership—is found in the worldwide insulin business. In 1922, four researchers in Toronto first successfully extracted insulin from the pancreases of animals and injected it, with miraculous results, into humans with diabetes. Because insulin was extracted from the ground-up pancreases of cows and pigs, improving the purity of insulin (measured in impure parts per million, or ppm) constituted a critical trajectory of performance improvement. Impurities dropped from 50,000 ppm in 1925 to 10,000 ppm in 1950 to 10 ppm in 1980, primarily as the result of persistent investment and effort by the world's leading insulin manufacturer, Eli Lilly and Company.

Despite this improvement, animal insulins, which are slightly different from human insulin, caused a fraction of a percent of diabetic patients to build up resistance in their immune systems. Thus, in 1978, Eli Lilly contracted with Genentech to create genetically altered bacteria that could produce insulin proteins that were the structural equivalent of human insulin proteins and 100 percent pure. The project was technically successful, and in the early 1980s, after a nearly $1 billion investment, Lilly introduced its Humulin-brand insulin to the market. Priced at a 25 percent premium over insulins of animal extraction, because of its human equivalence and its purity, Humulin was the first commercial-scale product for human consumption to emerge from the biotechnology industry.

The market's response to this technological miracle, however, was tepid. Lilly found it very difficult to sustain a premium price over animal insulin, and the growth in the sales volume of Humulin was disappointingly slow. "In retrospect," noted a Lilly researcher, "the market was not terribly dissatisfied with pork insulin. In fact, it was pretty happy with it." [8] Lilly had spent enormous capital and organizational energy overshooting the market's demand for product purity. Once again, this was a differentiated product to which the market did not accord a price premium because the performance it provided exceeded what the market demanded.

Meanwhile, Novo, a much smaller Danish insulin maker, was busy

developing a line of insulin *pens*, a more convenient way for taking insulin. Conventionally, people with diabetes carried a separate syringe, inserted its needle into one glass insulin vial, pulled its plunger out to draw slightly more than the desired amount of insulin into the syringe, and held up the needle and flicked the syringe several times to dislodge any air bubbles that clung to the cylinder walls. They generally then had to repeat this process with a second, slower acting type of insulin. Only after squeezing the plunger slightly to force any remaining bubbles—and, inevitably, some insulin—out of the syringe could they inject themselves with the insulin. This process typically took one to two minutes.

Novo's pen, in contrast, held a cartridge containing a couple of weeks' supply of insulin, usually mixtures of both the fast-acting and the gradually released types. People using the Novo pen simply had to turn a small dial to the amount of insulin they needed to inject, poke the pen's needle under the skin, and press a button. The procedure took less than ten seconds. In contrast to Lilly's struggle to command a premium price for Humulin, Novo's convenient pens easily sustained a 30 percent price premium per unit of insulin. Through the 1980s, propelled largely by the success of its line of pens and pre-mixed cartridges, Novo increased its share of the worldwide insulin market substantially—and profitably. Lilly's and Novo's experiences offer further proof that a product whose performance exceeds market demands suffers commodity-like pricing, while disruptive products that redefine the basis of competition command a premium.

Teaching the Harvard Business School case to executives and MBA students about Lilly overshooting the market demand for insulin purity has been one of my most interesting professional experiences. In every class, the majority of students quickly pounce on Lilly for having missed something so obvious—that only a fraction of a percent of people with diabetes develop insulin resistance—and that the differentiation between highly purified pork insulin at 10 ppm and perfectly pure Humulin was not significant. Surely, they assert, a few simple focus groups in which patients and doctors were asked whether they wanted purer insulin would have given Lilly adequate guidance.

In every discussion, however, more thoughtful students soon begin to sway class opinion toward the view that (as we have seen over and over) what is obvious in retrospect might not be at all obvious in the thick of battle. Of all the physicians to whom Lilly's marketers listened, for example, which ones tended to carry the most credibility? Endocrinologists whose practices focused on diabetes care, the leading customers in this business. What sorts of patients are

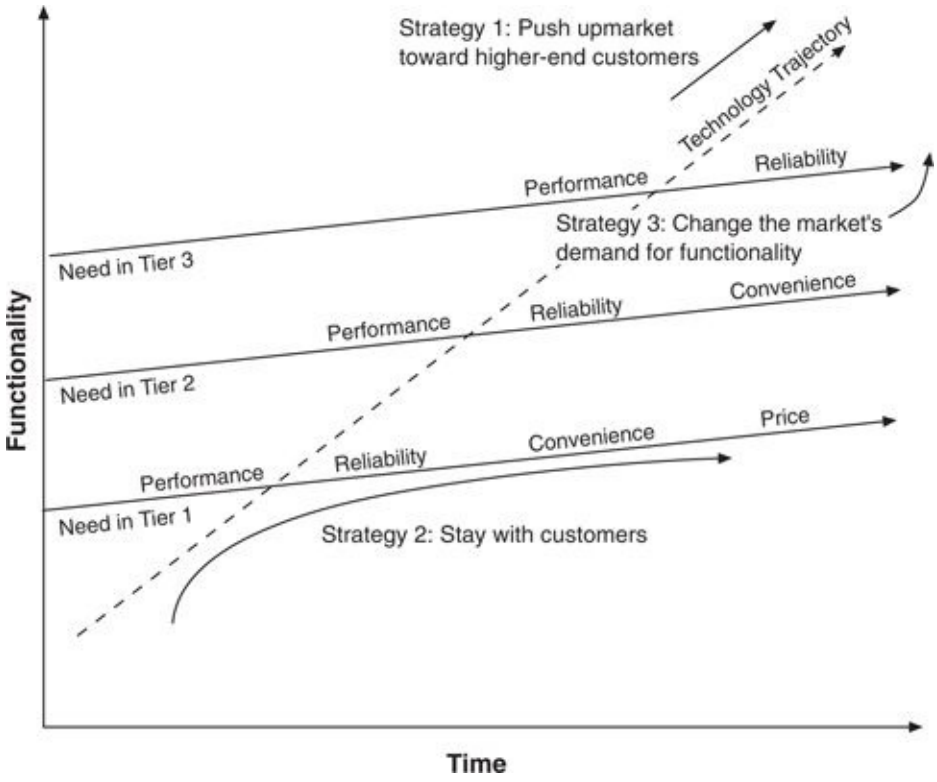
diabetes care, the leading customers in this business. What sorts of patients are most likely to consume the professional interests of these specialists? Those with the most advanced and intractable problems, among which insulin resistance was prominent. What, therefore, were these leading customers likely to tell Lilly's marketers when they asked what should be done to improve the next-generation insulin product? Indeed, the power and influence of leading customers is a major reason why companies' product development trajectories overshoot the demands of mainstream markets.

Furthermore, thoughtful students observe that it would not even occur to most marketing managers to ask the question of whether a 100 percent pure human insulin might exceed market needs. For more than fifty years in a very successful company with a very strong culture, greater purity was the very definition of a better product. Coming up with purer insulins had *always* been the formula for staying ahead of the competition. Greater purity had *always* been a catching story that the salesforce could use to attract the time and attention of busy physicians. What in the company's history would cause its culture-based assumptions suddenly to change and its executives to begin asking questions that never before had needed to be answered? [9]

CONTROLLING THE EVOLUTION OF PRODUCT COMPETITION

Figure 9.4 summarizes the model of performance oversupply, depicting a multi-tiered market in which the trajectory of performance improvement demanded by the market is shallower than the trajectory of improvement supplied by technologists. Hence, each tier of the market progresses through an evolutionary cycle marked by a shifting basis for product choice. Although other terms for product life cycles would yield similar results, this diagram uses the buying hierarchy devised by Windermere Associates, in which competition centers first on functionality, followed by reliability, convenience, and, finally, price. In each of the cases reviewed in this chapter, the products heralding shifts in the basis of competition and progression to the next product life cycle phase were disruptive technologies.

Figure 9.4 Managing Changes in the Basis of Competition



The figure shows the strategic alternatives available to companies facing performance oversupply and the consequent likelihood that disruptive approaches will change the nature of competition in their industry. The first general option, labeled strategy 1 and the one most commonly pursued in the industries explored in this book, is to ascend the trajectory of sustaining technologies into ever-higher tiers of the market, ultimately abandoning lower-tier customers when simpler, more convenient, or less costly disruptive approaches emerge.

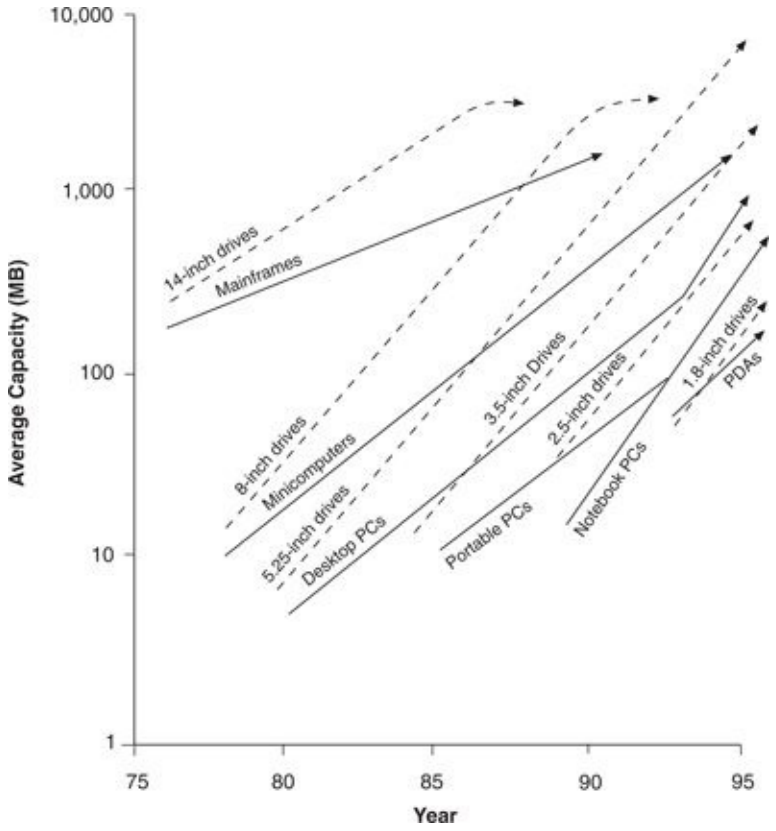
A second alternative, labeled strategy 2, is to march in lock-step with the needs of customers in a given tier of the market, catching successive waves of change in the basis of competition. Historically, this appears to have been difficult to do, for all of the reasons described in earlier chapters. In the personal computer industry, for example, as the functionality of desktop machines came to satiate the demands of the lower tiers of the market, new entrants such as Dell and Gateway 2000 entered with value propositions centered on convenience of purchase and use. In the face of this, Compaq responded by actively pursuing this second approach, aggressively fighting any upmarket drift by producing a line of computers with low prices and modest functionality targeted to the needs

line of computers with low prices and modest functionality targeted to the needs of the lower tiers of the market.

The third strategic option for dealing with these dynamics is to use marketing initiatives to steepen the slopes of the market trajectories so that customers demand the performance improvements that the technologists provide. Since a necessary condition for the playing out of these dynamics is that the slope of the technology trajectory be steeper than the market's trajectory, when the two slopes are parallel, performance oversupply—and the progression from one stage of the product life cycle to the next—does not occur or is at least postponed.

Some computer industry observers believe that Microsoft, Intel, and the disk drive companies have pursued this last strategy very effectively. Microsoft has used its industry dominance to create and successfully market software packages that consume massive amounts of disk memory and require ever-faster microprocessors to execute. It has, essentially, increased the slopes of the trajectories of improvement in functionality demanded by their customers to parallel the slope of improvement provided by their technologists. The effect of this strategy is described in Figure 9.5, depicting recent events in the disk drive industry. (This chart updates through 1996 the disk drive trajectory map in Figure 1.7.) Notice how the trajectories of capacity demanded in the mid-range, desktop, and notebook computer segments kinked upward in the 1990s along a path that essentially paralleled the capacity path blazed by the makers of 3.5-inch and 2.5-inch disk drives. Because of this, these markets have not experienced performance oversupply in recent years. The 2.5-inch drive remains locked within the notebook computer market because capacity demanded on the desktop is increasing at too brisk a pace. The 3.5-inch drive remains solidly ensconced in the desktop market, and the 1.8-inch drive has penetrated few notebook computers, for the same reasons. In this situation, the companies whose products are positioned closest to the top of the market, such as Seagate and IBM, have been the most profitable, because in the absence of technology oversupply, a shift in the stages of the product life cycle at the high end of the market has been held at bay.

Figure 9.5 Changed Performance Demand Trajectories and the Deferred Impact of Disruptive Technologies



Source: An earlier version of this figure was published in Clayton M. Christensen, "The Rigid Disk Drive Industry: A History of Commercial and Technological Turbulence," *Business History Review* 67, no. 4 (Winter 1993): 559.

It is unclear how long the marketers at Microsoft, Intel, and Seagate can succeed in creating demand for whatever functionality their technologists can supply. Microsoft's *Excel* spreadsheet software, for example, required 1.2 MB of disk storage capacity in its version 1.2, released in 1987. Its version 5.0, released in 1995, required 32 MB of disk storage capacity. Some industry observers believe that if a team of developers were to watch typical users, they would find that functionality has substantially overshot mainstream market demands. If true, this could create an opportunity for a disruptive technology—applets picked off the internet and used in simple internet appliances rather than in full-function computers, for example—to invade this market from below.

RIGHT AND WRONG STRATEGIES

Which of the strategies illustrated in Figure 9.4 is best? This study finds clear evidence that there is no one best strategy.

Any of the three, consciously pursued, can be successful. Hewlett-Packard's pursuit of the first strategy in its laser jet printer business has been enormously profitable. In this instance, it has been a safe strategy as well, because HP is attacking its own position with disruptive ink-jet technology. Compaq Computer and the trinity of Intel, Microsoft, and the disk drive makers have successfully—at least to date—implemented the second and third strategies, respectively.

These successful practitioners have in common their apparent understanding—whether explicit or intuitive—of both their customers'

trajectories of need and their own technologists' trajectories of supply. Understanding these trajectories is the key to their success thus far. But

the list of firms that have consistently done this is disturbingly short. Most well-run companies migrate unconsciously to the northeast, setting themselves up to be caught by a change in the basis of competition and an attack from below by disruptive technology.

NOTES

1. In disk drive industry convention, a mean time between failure measure of one million hours means that if one million disk drives were turned on simultaneously and operated continuously for one hour, one of those drives would fail within the first hour.
2. Three of the earliest and most influential papers that proposed the existence of product life cycles were Jay W. Forrester, “Industrial Dynamics,” *Harvard Business Review*, July–August, 1958, 9–14; Arch Patton, “Stretch Your Products’ Earning Years—Top Management’s Stake in the Product Life Cycle,” *Management Review* (38), June, 1959, 67–79; and William E. Cox, “Product Life Cycles as Marketing Models,” *Journal of Business* (40), October, 1967, 375. Papers summarizing the conceptual and empirical problems surrounding the product life cycle concept include Nariman K. Dhalla and Sonia Yuspeh, “Forget the Product Life Cycle Concept!” *Harvard Business Review*, January–February, 1976, 102–112; David R. Rink and John E. Swan, “Product Life Cycle Research: A Literature Review,” *Journal of Business Research*, 1979, 219; and George S. Day, “The Product Life Cycle: Analysis and Applications Issues,” *Journal of Marketing* (45), Fall, 1981, 60–67. A paper by Gerard J. Tellis and C. Merle Crawford, “An Evolutionary Approach to Product Growth Theory,” *Journal of Marketing* (45), Fall, 1981, 125–132, contains a cogent critique of the product life cycle concept, and presents a theory of product evolution that presages many of the ideas presented in this section.
3. Geoffrey A. Moore, *Crossing the Chasm* (New York: HarperBusiness, 1991).
4. The same behavior characterized the emergence of portable radios. In the early 1950s, Akio Morita, the chairman of Sony, took up residence in an inexpensive New York City hotel in order to negotiate a license to AT&T’s patented transistor technology, which its scientists had invented in 1947. Morita found AT&T to be a less-than-willing negotiator and had to visit the company repeatedly badgering AT&T to grant the license. Finally AT&T relented. After the meeting ended in which the licensing documents were signed, an AT&T official asked Morita what Sony planned to do with the license. “We will build small radios,” Morita replied. “Why would anyone care about smaller radios?” the official queried. “We’ll see,” was Morita’s

answer. Several months later Sony introduced to the U.S. market the first portable transistor radio. According to the dominant metrics of radio performance in the mainstream market, these early transistor radios were really bad, offering far lower fidelity and much more static than the vacuum tube–based tabletop radios that were the dominant design of the time. But rather than work in his labs until his transistor radios were performance-competitive in the major market (which is what most of the leading electronics companies did with transistor technology), Morita instead found a market that valued the attributes of the technology as it existed at the time—the portable personal radio. Not surprisingly, none of the leading makers of tabletop radios became a leading producer of portable radios, and all were subsequently driven from the radio market. (This story was recounted to me by Dr. Sheldon Weinig, retired vice chairman for manufacturing and technology of Sony Corporation.)

5. John Case, "Customer Service: The Last Word," *Inc. Magazine*, April, 1991, 1–5.
6. This information in this section was given to the author by Scott Cook, the founder and chairman of Intuit Corporation, and by Jay O'Connor, marketing manager for *Quickbooks*.
7. Cook recounts that in the process of designing a simple and convenient accounting software package, Intuit's developers arrived at a profound insight. The double-entry accounting system originally developed by Venetian merchants to catch arithmetical mistakes continued to be used in every available package of accounting software—even though computers typically do not make mistakes in addition and subtraction. Intuit was able to greatly simplify its product by eliminating this unneeded dimension of product functionality.
8. See "Eli Lilly & Co.: Innovation in Diabetes Care," Harvard Business School, Case No. 9-696-077. This case notes that although Lilly was not able to achieve premium pricing for its Humulin insulin, it benefited from the investment. Humulin protected Lilly against a possible shortfall in the pancreas supply, threatened by declining red meat consumption, and it gave Lilly a very valuable experience and asset base in the volume manufacturing of bioengineered drugs.
9. Once such minority opinions have been raised in class, many students then begin to see that institutions widely regarded as among the best-managed and most successful in the world may have overshot what their mainstream

markets demand. Intel, for example, has always measured the speed of its microprocessors on the vertical axis of its performance graphs. It has always assumed that the market demands ever-faster microprocessors, and evidence to the tune of billions of dollars in profit has certainly confirmed that belief. Certainly some leading-edge customers need chips that process instructions at rates of 200, 400, and 800 MHz. But what about the mainstream market? Is it possible that sometime soon the speed and cost of Intel's new microprocessors might overshoot market demands? And if technology oversupply is possible, how will thousands of Intel employees be able to recognize when this has occurred, accepting the change with enough conviction to completely alter the trajectory of their development efforts? Discerning technology oversupply is difficult. Doing something about it is even more so.