Companies must introduce more products, faster, to more markets, using more technologies. How?

Commercializing Technology: What the Best Companies Do

by T. Michael Nevens, Gregory L. Summe, and Bro Uttal

Just as quality and manufacturing excellence were key to competitiveness in the 1980s, superior commercialization of technology will be crucial in the 1990s. In the coming decade, businesses will rise and fall depending on whether they discipline their commercialization efforts. Some companies – like Canon, Philips, and Merck – already have the capability to bring sophisticated technology-based products to market faster and more often than competitors that treat commercialization as a purely intuitive, creative process. Most other companies will be compelled to develop this capability if they are to thrive.

> Getting good at commercialization takes discipline – not inspiration.

Over the past year, we have examined the difference between leaders and laggards in commercialization in the United States, Japan, and Europe. Our study found that leading companies...

☐ commercialize two to three times the number of new products and processes as do their competitors of comparable size

☐ incorporate two to three times as many technologies in their products

☐ bring their products to market in less than half the time and

☐ compete in twice as many product and geographic markets.

These differences are not one-time occurrences that reflect specific product introductions, nor are they limited to certain nations. The study found that the critical differences between high-performing companies and low-performing companies...

☐ were sustained over multiyear periods and

☐ were as great in Japan as in America or Europe.

As part of the study, managers were asked to describe their commercialization processes. An interesting pattern emerged. Companies that are good at commercialization did not describe processes that are idiosyncratic to their organizations. Rather...

☐ high performers explained their success in strikingly similar terms and

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□ low performers did not describe their businesses in the terms high performers used.

In short, the study found large differences among companies' abilities to commercialize technology, and the good companies seemed to be doing certain things that the poor companies were not. While many businesses treat the commercialization process as a series of separate steps or an inherently creative task that should not be tightly managed, the good companies view commercialization as a highly disciplined system. They apply to the total commercialization process the basic principles for improving manufacturing quality: they establish it as a top priority, set measurable goals for ongoing improvement, develop the necessary organizational skills, and encourage managers to take aggressive action. They see it as management's job to ensure that handoffs and communication are rapid and smooth, and they pay relentless attention to improving the process (see the insert "The Commercialization Process" for more about this).

Further, the study found a strong linkage between an organization's competitiveness and its ability to commercialize technology. In many markets – such as copiers, facsimile machines, computers, automobiles, semiconductor production equipment, and pharmaceuticals – industry leadership clearly depends on superior commercialization skill. In these and a growing number of industries, companies that are first to market with products based on advanced technologies command higher margins and gain share. Companies that spin out variants more rapidly and leverage their core technologies across more markets earn higher returns. Superior commercialization skill is, then, among the most important competitive challenges managers will face in the coming decade.

The Commercialization Imperative

The ability to commercialize technology, to move a product from concept to market quickly and efficiently, is crucial in light of changes in the business environment. First among these now-familiar trends is the increasing proliferation of new technologies and the speed with which they render previous technologies obsolete. Empirical evidence of this trend is abundant and includes the shrinking life cycles of many products.

Typewriters are one example. The first modern generation of typewriters was mechanical and dominated the market for some 25 years, but subsequent generations of typewriters have had progressively short lives: 15, 7, and 5 years. That is, it took 25 years for sales of mechanical typewriters to fall below sales of electromechanical ones; 15 years for electromechanical models to give way to entirely electric ones; 7 years for sales of electric models to be overtaken by sales of microprocessor-controlled machines; and 5 years for sales of first-generation, microprocessor-controlled models to be exceeded by sales of second-generation machines.

Injectable cephalosporins – drugs that are prescribed for various bacterial infections – followed the same pattern in the West German hospital market. The first generation of these drugs was introduced there in 1965. Not until 1977 did sales of second generation cephalosporins surpass those of the original products. But a fourth generation began to overtake the third in only one year.

Technological innovations also are spreading very rapidly, a result in part of the growth of research consortia and international suppliers. Indeed, it is difficult to point to an important technology breakthrough in recent years that was – and remained – truly proprietary.

And technology is increasingly expensive. Perhaps the most powerful and familiar example of the rapid cost inflation of developing base technologies is the silicon process technology used in DRAM production. The process technology for a 256K DRAM, which was state-of-the-art in 1985, cost about $100 million to develop and required a $100 million capital investment in the production facility. The next generation of DRAMs had a 1Mb capacity, cost about $250 million, and required a $200 million capital investment. The generation after that, 4Mb DRAMs, will end up costing close to $500 million and requiring a manufacturing investment of nearly half a billion dollars.

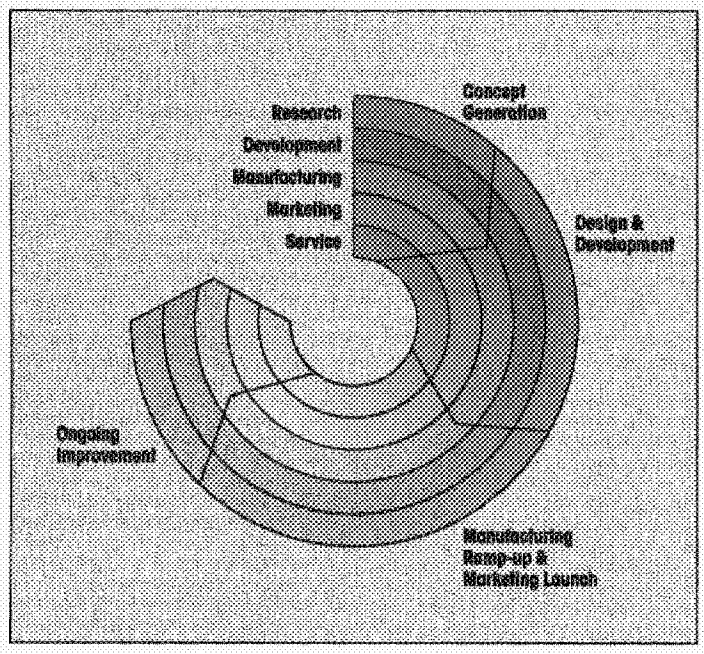
Another factor driving the increased importance of commercialization capability is the fragmentation of markets – the result of higher real per capita incomes and more sophisticated consumers. In the U.S. automobile market, for instance, the number of segments rose by one-third in seven years – from 18 in 1978 to 24 in 1985 (see the exhibit "The Number of Market Segments Is Increasing"). Many of these market segments remain untapped until a company introduces a product offering that is tailored to that niche.

These competitive realities make the capability to commercialize technology at least as important as traditional sources of advantage such as scale, skilled labor, possession of proprietary technology, and access to capital. Companies that possess the capability to bring technology to the market can often drive out competitors. Companies that lack it may see even prominent market positions quickly erode. Xerox

The Commercialization Process

Commercialization begins when a business identifies a way to use scientific or engineering advances to meet a market need. The process continues through design, development, manufacturing ramp-up, and marketing, and includes later efforts to improve the product. While it is often viewed as a linear process – a series of steps performed by people in different functions – companies with strong commercialization capability see the process as a series of overlapping phases that involve many business functions simultaneously.

Take Hewlett-Packard's development of the DeskJet printer. In the mid-1980s, H-P's Vancouver, Washington division, which specializes in printers for personal computers, needed a blockbuster. Market research had shown that PC users would welcome a relatively slow-speed device that printed as clearly as a laser printer but sold for less than half the $2,000 price. In late 1985, a team of researchers, engineers, and marketers formed to explore the feasibility of such a product.



In conceptualizing the product, the team defined customers' needs precisely and clarified the drawbacks of existing low-cost printers. It sized up the proposed product's technical feasibility by reviewing H-P's thermal-ink-jet technology, which uses electrical current to vaporize ink and shoot it onto paper in patterns of microscopic dots. Although earlier printers using that technology required specially coated paper and created narrow, blurred characters, the DeskJet team concluded that given sufficient resources, H-P's InkJet Components Operation in Corvallis, Oregon could refine the technology enough to produce patterns as dense and clear as those from a laser printer.

Still in the concept-generation phase, the team brought manufacturing engineers into the process to verify that the company could produce the print head and the printer. Then the team submitted a formal plan, which Vancouver management approved.

Next, the team had to design a manufacturing prototype that could be tested for performance, reliability, producibility, and product cost. It started with a breadboard prototype, an assemblage of components handwired to printed circuit boards that represented the technical core of the printer. As soon as the breadboard proved technically feasible and appropriate for the market, H-P augmented its project team with specialists in component sourcing, mechanical design, and control software. Six months later, the expanded group released several working prototypes, complete with cabinet, control software and panel, and paper-handling mechanism, and let consumers try them. The team improved print quality based on feedback from the trials, and the DeskJet was ready for manufacture.

While the DeskJet team was designing and developing the product, the printer factory in Vancouver and the print-head factory in Corvallis had been constructing pilot production lines. At the same time, marketing had developed distribution, promotion, sales, and service plans and had primed the sales force and scheduled an advertising blitz.

H-P officially launched the DeskJet in February 1988 – just 26 months after the Vancouver division first explored the idea. It rang up strong sales almost immediately.

Most DeskJet team members transferred to other projects after the launch, but several key engineers and marketers stayed on to oversee ongoing improvements. As customers asked for greater printing speed and more typefaces, the team went back to the concept-generation stage and executed a short version of the commercialization effort. In April 1989, they launched a faster, more flexible, less expensive version of the original printer, and in July 1989, a model that would work with Apple's Macintosh.

and certain Japanese microcomputer printer manufacturers learned this lesson the hard way.

Xerox dominated the copier market for many years, but in the mid-1970s, its four- to seven-year development cycle cost it that lead. In 1976, competitors like Canon began introducing mid-range plain-paper copiers in quick succession. Between 1976 and 1982, more than 90 new models reached the market, most of them mid-range machines, and Xerox's 82% share of the total market fell by half. Since Xerox had no competitive mid-range model of its own, it embarked on a crash program to develop one. But the company's commercialization process faltered under extreme pressure. The resulting product – the 3300 model – was unreliable and too expensive. Moreover, Xerox was unable to introduce variants quickly enough to position the 3300 as part of a product family covering several segments of the mid-range market.

Canon, on the other hand, had developed great skill at commercializing technology. It produced a number of technology innovations and launched four low-end and mid-range copiers in quick succession with speeds, respectively, of 12, 20, 30, and 40 copies per minute. It gained a solid position in the mid-range market, mostly at Xerox's expense.

Xerox has since strengthened its commercialization skills. During its turnaround in the early 1980s, the company cut development cycles from seven to as little as two years, and it introduced more than six major technical innovations in the five models that comprise its "10 series." It achieved a three-year lead over competitors in these technologies and began to reverse its decline in market share.

Just as Xerox dominated the copier market in the early 1970s, Japanese companies practically owned the microcomputer-printer business in the early 1980s. But in the mid-1980s, Hewlett-Packard used its ability to commercialize technology to take share away from the entrenched players. In quick succession, H-P introduced a broad line of printers based on innovative laser, ink-jet, and software technologies. Over the past six years, it has seized a significant share of the market, including nearly 60% of the U.S. market for desktop laser printers.

Measuring Commercialization Capability

Companies like Hewlett-Packard that have the capability to manage the commercialization process differ from other organizations in four respects. They get products or processes to market faster, use those technologies in products across a wider range of markets, introduce more products, and incorporate a greater breadth of technologies in them. Thus time to market, range of markets, number of products, and breadth of technologies are good measures of a company's ability to commercialize – and to compete.

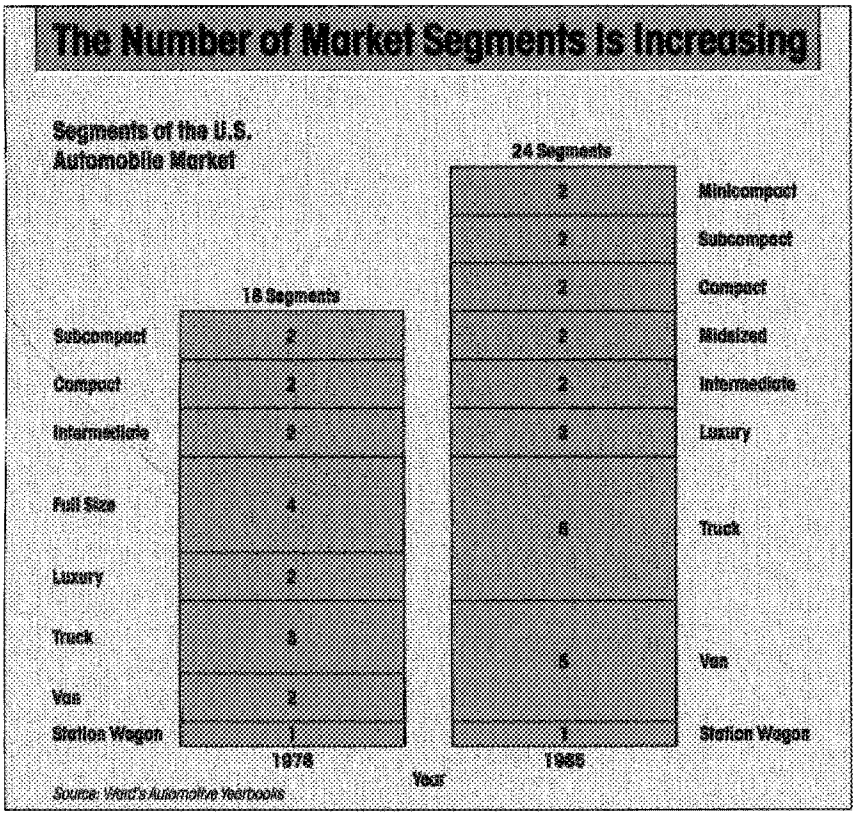
Time to Market. When base technologies are widely available and product life cycles are short, getting to market quickly is essential. For one thing, the company that is first to market often can command premium pricing because of its de facto monopoly. In the European market for car radios, for example, the first to market typically can charge 20% more than a competitor that introduces a comparable product a year later.

Those early premiums are important since prices decline rapidly as soon as competition arrives. Companies typically try to offset the price declines by improving production efficiency, but the resulting savings are not necessarily enough to compensate for sliding prices and to recover high development costs.

Early entrants also achieve volume break points in purchasing and production sooner than laggards, and they gain market share. In some industries, like prescription pharmaceuticals, the market-share rewards for being first are especially great. In that industry, the regulatory process imposes irreducible delays, and physicians' prescribing habits tend to be slow to change, which makes it difficult for later entrants to catch up.

Many managers fail to acknowledge the benefits of getting to the market first. The same program managers who know to the penny what an additional engineer will cost and what profits will be lost if the company misses manufacturing cost targets seldom can quantify the losses associated with a six-month slip in the development process. They willingly slow down the development process to contain the project budget or to hit their cost targets. What they don't know is the overall economics: assuming that the market grows 20% a year, that prices drop 12% a year, and that the product life cycle is five years, launching a laser printer six months behind schedule can reduce the product's cumulative profits by one-third. In contrast, under the same set of assumptions, a development cost overrun of 30% will trim cumulative profits by only 2.3% (see the exhibit "How Problems Developing a Printer Affect Profits").

Range of Markets. The cost of developing technologies is high – and rising. Companies that incur these costs must spread them across as many product and geographic markets as possible. Otherwise, they will be unable to recover costs, maintain price



parity, and renew development efforts – all of which are essential to competitiveness. For example, the telecommunications industry spent a total of $1.2 billion on R&D for telephone switches in 1983 and $1.9 billion in 1988. That represents a 10% compound yearly increase over the five-year period. The increases reflect existing companies' attempts to add new features to their software systems – not new entrants to the market. At the same time, prices for central office switches declined about 8% a year. Obviously, there was intense pressure to find ways to recover that spending.

One way to spread costs is to leverage core technologies across multiple product and geographic markets. In the late 1970s, Northern Telecom anticipated that developing the software for its digital switch was going to be expensive, so it made an aggressive drive to spread the technology across many markets at the same time. To compensate for limited marketing resources, it formed international alliances with partners that could tailor the switch to national markets where Northern Telecom's own distribution networks were relatively weak. Northern Telecom also used part of the software in several product areas like PBXs, hybrid analog-digital switches, and fully configured central-office switches.

Honda, too, spreads the costs of innovation over several product markets. When it invested heavily to develop multivalve cylinder heads with self-adjusting valves, for example, it applied the technology to motorcycles, cars, lawn mowers, and power-generation equipment. Similarly, Canon exploits its basic investments in optics and lens grinding across the markets for photolithography, cameras, and copiers. It has used the miniaturized motors from its photolithography equipment in its cameras and is now incorporating them in copiers. Hewlett-Packard uses technology from its instrumentation business in half a dozen highly differentiated markets, from oscilloscopes to cardiac analyzers.

Joint ventures, technology cross-licensing, and marketing relationships are effective solutions for companies that lack the ability to spread technology costs. International marketing alliances have worked well for drug companies.

Number of Products. Market fragmentation creates opportunities for companies that can easily adapt products to appeal to market niches. As long as the models have meaningful differences and the boundaries around the niches are real and sustainable, total sales volume correlates with the number of models produced.

The market segments of the automobile industry are widely discussed, but even in mature industrial markets like machine tools there is the opportunity to gain share by developing models offering different trade-offs among ease of setup, throughput, flexibility, and price. Making products aimed at these niches means going through the commercialization process not just once but three and four times and incorporating incremental changes – not necessarily big breakthroughs – in each new release.

Leading companies serve many more market segments than do followers. Over a ten-year period, Casio, the industry leader in the Japanese market for hand-held calculators, introduced 2.5 times as many products as Sharp, the follower. In the world market for point-and-shoot 35mm cameras, the gap between leader and follower is now two times. In mid-range UNIX computer systems, the gap is nearly four times.

Breadth of Technologies. In many markets, products incorporate an increasing number of technologies, and companies must be able to master – or to

acquire and integrate – all of them if they are to compete. The copier market illustrates the point.

Ten years ago, copiers simply coordinated the light source and a toner system with a moving piece of paper, requiring technology for three things: to mechanically move the paper, to coordinate and focus the lens and the light source, and to apply and fuse toner. Competing in that market meant pushing for innovation in mechanical paper movement, optics, and fusing systems. Competence in those technologies is still needed but is no longer enough. Companies also need to be at the cutting edge of other technology areas: control hardware and software, organic photoreceptors, and panel displays. Companies that fall behind in any one area risk producing an uncompetitive product.

The situation is the same in many industries. Automobiles now include a range of new control electronics, braking systems, structural materials, and engine materials. Semiconductors involve innovations not just in process technology but also in packaging, testing, and interconnect technologies. Manufacturers of DRAMs have had to keep up with ever more complex production processes. The number of process steps needed to manufacture state-of-the-art DRAMs has increased from 230 in 1985 to 550 today, and the variety of equipment needed for manufacture has risen 20%. Even in pharmaceuticals, which has always been interdisciplinary, the need to stay current in chemical, biological, and biomedical technologies has grown over the past ten years as understanding of disease mechanisms and genetic engineering has grown.

Building Commercialization Capability

The best commercializers do more than understand the importance of getting the right product to the market repeatedly and quickly. They take steps to ensure that the organization can achieve that result reliably and quickly, even if it means changing the way they do business. Canon's efforts typify the manner in which high-performing companies strengthen their commercialization capability.

Canon is widely recognized as a leader in optical and imaging technologies, electronics assembly, software, and high-precision assembly of small parts. It has used this leadership to build and grow successful businesses in cameras, copiers, office automation, and medical equipment. The company's revenues have grown as a result, from ¥200 billion in 1981 to ¥1 trillion in 1988. In 1981, Canon was about the same size as Nikon. It is now four times as large.

Canon had always valued its ability to bring technology to the market, but as competition intensified in the mid-1980s, company president Ryuzaburo Kaku decided to act. Shrinking product life cycles and an increasing dependence on suppliers for key subsystems, which competitors could buy as well, led him to conclude that Canon's future lay in becoming a market leader with its own unique technologies. Kaku established superior commercialization as a high priority and expressed that priority in two clear objectives: "winning with our own technology" in optics, electronics, and precision manufacturing and "50% down" (cutting product development cost and time in half). To reinforce these goals, the company built a highly automated lens-grinding plant and created a central lab to feed improved optical technologies to the plant. Management also supported the objective of "50% down" by encouraging divisional managers to be readily accessible to project managers. Everyone in the company learned that delays caused by waiting for management approval were acceptable no longer.

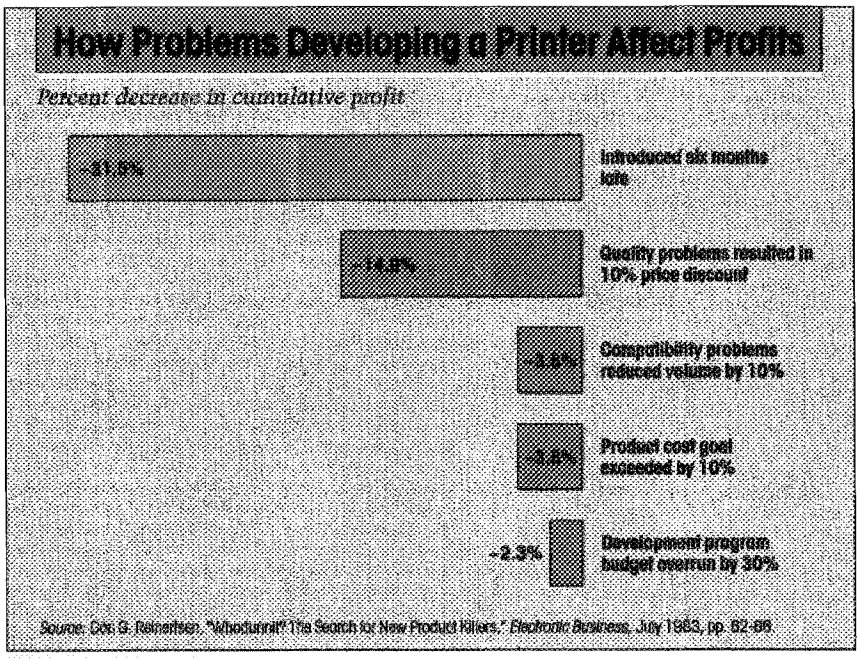
> Canon makes commercialization a priority and sets tough goals – like making a quality product for half the going price.

The focus on commercialization capability had different but important effects on the ways Canon's managers thought and acted. The semiconductor-equipment division, which produces photolithographic systems, was already skilled at commercialization. It had been staffing new project teams with experienced members who could transfer learning from previous projects, organizing primarily around products rather than functions to ease coordination and involving customers in subsystem testing to discover problems early. But the division saw the president's message as a challenge to be even more aggressive. It set the ambitious goal of cutting six months off the development time for new equipment. To achieve that goal, it used computer-aided-design tools to eliminate some phases of project management, and it overlapped other phases.

The streamlined commercialization process cut development costs by 30% and time to market by 50% and enabled the division to launch two generations of equipment in the time it took competitors to introduce one. Canon could also offer upgraded versions of

each generation every one-and-a-half years, while its toughest competitor took three years. Canon's share of the world market for photolithographic equipment rose from 16% in 1978 to 25% in 1988. One of its main competitors, which made little effort to strengthen commercialization capability, saw its share drop from 51% to 23% in the same period.

Canon's camera division also revitalized its commercialization processes. In 1985, Minolta challenged Canon's top standing in the market for 35mm single-lens-reflex cameras by launching the first autofocus model, which incorporated novel electronic controls and a miniaturized motor. The model opened a whole new market of consumers who wanted the sharpness of 35mm photographs without having to master complex focus controls. Minolta quickly followed up the original autofocus model with two different models aimed at smaller segments of the new market. And by 1986, with 36% of the market, Minolta eclipsed Canon as the 35mm market leader.



Spurred by top management's call for aggressive action and drawing on the company's research in optics, Canon's camera division retaliated by introducing two products that exploited a breakthrough in lens technology: sonically driven motors mounted in the lens to allow 50% faster focusing. By the end of 1986, Canon had pulled even with Minolta, and over the next 15 months it battled to remain at the top by hammering out three other models that covered additional segments.

To strengthen their commercialization capability, high-performers like Canon do the following: make commercialization capability a top-management priority; set goals to focus the effort; develop skills; and get managers directly involved in the commercialization process to speed actions and decisions.

Make Commercialization a Priority. However obvious it seems, top managers at successful companies explicitly put commercializing technology high on the corporate agenda. Average performers fail to make this simple effort, sometimes because they equate commercialization with R&D and think they can improve it by spending more money. But consider the fate of one high-technology company whose top managers recognized the importance of commercialization but failed to make it an explicit priority.

In the mid-1980s, this U.S. semiconductor company was performing well. Its revenues and profits had been growing steadily. In several of its markets, it controlled nearly 50% of the business, and it had excellent relationships with its leading customers. By 1986, however, the U.S. semiconductor industry was in a worldwide competitive struggle, and this company was in the thick of it. After much thought and debate, top management promulgated a set of initiatives designed to maintain the company's leadership position.

The initiatives emphasized improved quality, world-class manufacturing, and excellent customer service. The managers consciously decided not to include commercialization, innovation, or technological leadership on the list of corporate priorities. They thought those objectives were obvious. As the CEO explained, "We felt that better use of technology and more effective product development was the essence of our business. We're a high-tech company, after all. We didn't need to put those priorities on the list."

Over the next three years, though, the company began to slip. Margins declined, and market shares fell in several businesses the company had once dominated. Top management assigned task forces to study the failing businesses, and in each case, the findings were the same: the competition was "outcommercializing" them. Competitors were marketing more products in a shorter time, developing a lead in new product and process technology, gaining share, increasing their margins, and feeding money back into their commercialization efforts.

In 1989, the besieged semiconductor company amended its corporate priorities and put leadership

in technology commercialization at the top of the list. In retrospect, the CEO says that overlooking that priority in 1986 was the worst decision he had made in his 25-year career. He now emphasizes whatever is fundamental to the business, not just what needs the most improvement.

This company's problems are understandable, given the way organizations work. People at lower levels of the organization are not privy to discussions among top executives and have no way of knowing why things are or are not on the priority list. They naturally direct their resources toward studying, training for, and measuring progress against top management's explicit objectives.

If commercialization is truly important, business leaders must send clear signals. Canon's corporate goal of "winning through our own technology" and Hewlett-Packard's objective of "making a needed and profitable contribution" sound innocuous but are actually important drivers of behavior at all levels of these organizations.

Set Goals and Benchmarks. Simply identifying superior commercialization capability as a priority does not suffice. Leaders of successful commercializers also translate this priority into objectives others can act on, and they create incentives for them to do so. For instance, they specify key technologies in which the company must lead or set targets for price or product features, and they spur action by making those goals aggressive.

When Canon was developing its personal copier, it aimed for copy quality as good as that of IBM's office copiers, a price of less than $1,500 – as opposed to $3,000 for the lowest priced model on the market – and a weight below 20 kilograms – versus 35 kilograms for the lightest competing model. Because the goals were so specific, the project team knew exactly what it had to accomplish. Because the goals were aggressive, managers were forced to find novel ways to reach them. They looked everywhere for opportunities: product and process design, manufacturing, marketing, and service. The management team achieved the quality, price, and weight goals in part by developing a replaceable module that combined critical parts of the image-transfer and fusing systems and by going outside Canon and the copier industry for technology to manufacture the module.

> Good commercializers stress coordination, not functional skill.

Establishing benchmarks based on competitors' products is another good way to encourage managers to improve the commercialization process. Information about competitors is widely available, and companies that are good at commercializing technology routinely use it to advantage. Customers, suppliers, employees hired from competitors, and joint-venture partners can provide valuable insight into how other companies are performing. Companies should track data on the four dimensions that measure commercialization capability – time to market, range of markets, number of products, and breadth of technologies – as well as cost, delivery time, and service.

When a company that makes a filtering device for radio-transmission equipment wanted to know how it compared with competitors, it went directly to its suppliers and asked, "How are we as a client?" The vendor responded, "You guys are hard to do business with. You overspecify and overconstrain us, so it costs us more." The company subsequently improved its relationship with the supplier and cut its costs by allowing the supplier to do more of the component-design work.

Several Xerox managers credit competitive benchmarking with producing the shock that created the will and energy the company needed to overhaul its copier business in the early 1980s. The analysis forced Xerox to realize that, compared with competitors, its design cycles were long, its technologies old, and its product line limited.

Hewlett-Packard's use of competitive benchmarks saved it in at least one product market. Its radio-frequency analyzer dominated the market, but when H-P engineers tore down a competing Japanese product, they discovered that it was superior to their own design. While H-P used separate wires to connect components, the Japanese company had redesigned the chassis to allow the use of a wire harness to replace separate connections. This difference in design made the Japanese product cheaper and more reliable than H-P's own, more popular, product. H-P quickly turned its attention to improving its design and was able to preserve its market position.

While successful commercializers use goals and benchmarks, they are careful to select only a handful and to use the same ones for several years. In a turnaround effort, one troubled company set 25 challenging goals, but because managers down the line could not follow up on all of them, they made little progress on any one of them. The company abandoned all 25 within a year. Honda, on the other hand, set a single goal for the team that developed the City car for the Japanese market – "Do something different enough to capture the youth market" – and stuck with it for

About the Study

This study of commercialization was conceived and conducted by McKinsey & Company to better understand the difference between leaders and laggards in commercializing technology and the links between improved commercialization and competitive success.

To formulate hypotheses to test, McKinsey commissioned a survey of the academic and management literature and reviewed its client work in this area. Then, between December 1988 and April 1989, McKinsey interviewed managers at 19 companies in the United States, Europe, and Japan to find out how they commercialize technology. The number of interviews at each company ranged from as many as 50 to as few as 5, and interviews were conducted with managers at all organizational levels, from chairman to first-line supervisor. The companies were selected to include leaders and laggards in commercialization in industries where commercialization is important, where many companies compete, and where competitive leadership has changed hands in the last decade.

The authors would like to acknowledge the assistance of their colleagues Lorraine Harrington and Roland Wolfram, who conducted many of the interviews and contributed to the analysis; Richard Foster, who guided the effort with his experience and advice and helped shape the conclusions; and Charles Ferguson of MIT's Center for Technology, Policy, and Industrial Development, who conducted the literature search. The authors also appreciate the cooperation and advice throughout this project of the Council on Competitiveness and its chairman, John Young.

three years, frequently sending the project team back to its drawing boards. This demanding, enduring goal eventually drove the team to develop the "tall boy" concept: a car shorter, taller, and lighter than most, a packaging concept that promised a roomy interior, superior acceleration, and miserly fuel consumption. Both the initial City car and a follow-on turbocharged model were big hits.

Build Cross-Functional Skills. People cannot improve the commercialization process without the necessary skills. High-performing companies emphasize a set of skills notably different from their less successful counterparts. They value cross-functional skills, while other companies pride themselves on their functional strengths. High performers boast, "We've got the best project managers in the world." Low performers say, "We've got the best circuit designers."

Building excellent cross-functional skills is a challenge, especially because structures and habits work against them. People identify with their profession and usually want to get better at what they do. And most day-to-day work is function specific.

But functional excellence alone does not ensure that a company will be competitive. Compare the testing procedures of a European pharmaceuticals company with that of its U.S. partner. The two companies had entered a joint venture to develop and market a particular drug, but the European company kept falling behind in the development cycle. The drug required two tests – one chemical, one biomedical. The European company was effective in both areas, but separate groups of people in buildings three miles apart conducted the tests. There was little communication between them, and no one took responsibility for coordinating their efforts.

The U.S. company, on the other hand, organized its activity not by scientific discipline but by development phase. It had one manager assigned to oversee the development process, and it performed the testing in one lab with one group of researchers. While the slower company needed six weeks to complete the chemical analysis, the faster company took just three days. The European partner had so much trouble changing its testing procedures that it actually found it more expedient to send samples to the United States and get results shipped back to Europe.

Many companies try to smooth the transitions between separate functions through programs like "design for manufacturability," which links R&D and manufacturing, or "quality function deployment," which links marketing and manufacturing. Superior commercializers also use these programs, but they go far beyond them. They strive to build an extensive network connecting R&D, manufacturing, sales, distribution, and service, and they organize around products, markets, or development phases rather than functions. For them, cross-functional teams are standard practice.

Training can go a long way in blurring functional lines and easing coordination. When Epson, the Torrance, California high-tech manufacturer, was preparing to develop its first personal copier, it sent the mechanical engineer assigned to lead the project back to school for two years of electrical engineering courses.

Job rotation is another way to cross-train. Companies that transfer design engineers to the factory floor during production ramp-up find that it lessens the finger-pointing between them and the manufacturing engineers. Other companies rotate engineers throughout their careers. At NEC, another good com-

mercializer, fewer than half the engineers who start in the research department remain there after ten years. The rest are scattered across various functions within the same business unit.

Promote Hands-on Management to Speed Actions and Decisions. Priorities tend to fade if high-level managers don't act on them. At high-performing companies, top managers maintain a visible presence to reinforce the importance of commercialization. Regardless of the company's management style, executives must be interventionist if the rest of the organization is to take commercialization seriously.

> Executives should be interventionist; they should feel free to meddle in the commercialization process.

Even at companies like 3M and Hewlett-Packard that are known for being decentralized and divisionalized, management feels free to go in and meddle in issues crucial to the commercialization process.

It is impossible to guarantee that the organization will always do the right things, but asking hard questions and demanding honest answers about technical performance, cost, and alternative technologies can help prevent big mistakes. Managers at one successful European electronics company ask questions throughout the development cycle: When will the proposed product's price-performance ratio make it competitive with existing technologies? How far down the road is the technology, and how much money do we need to push it into the market? Where could we go wrong? What's the evidence for that conclusion?

Senior managers at high-performing companies promote commercialization in other ways as well—by acting as tiebreakers for disputes at the project level, keeping up to date on the progress of key commercialization efforts, clearing their calendars when serious problems arise, speeding decision making, and making sure the right people and the right information come together. When comparing two quite similar office equipment companies, we observed that senior managers at the company that demonstrated stronger commercialization capability were able to resolve project-level disputes in as little as one day. Senior managers at the other company took up to six weeks to make such decisions.

Inspired genius and scientific breakthroughs will remain essential elements in competitive success. But they are not enough. Increasingly, competitive success hinges on the coordinated efforts of scientists, engineers, manufacturing staff, and marketers building on breakthroughs with ongoing improvements in products and processes. This might mean redesigning a machine tool to incorporate a new motor to serve a new application and doing so faster than competitors, even when the motor was not developed in-house.

Consistently outexecuting competition on this dimension—being better at commercializing technology—requires a disciplined approach. Improvement starts with top management setting the right priorities along with ambitious goals. Then management throughout the company must follow through with initiatives to build cross-functional skills and to remove obstacles to quick decisions and actions on commercialization projects. Those companies that take this approach will prosper. Those that do not will fall by the wayside.

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