Focusing product technology for corporate growth (Part I)

Marc H. Meyer
Edward B. Robert

WHILE THE SUCCESS of high-technology companies is widely acknowledged, what accounts for that success has not yet been examined closely. The authors' research suggests that developing a distinctive competence in a core technology is critical to thee long-term growth of techonology-based firms. Managers responsible for technological innovation will be interested in the approach used to map out product-development strategy and to assess "newness" of product introductions. *Ed.*

DECIDING WHAT PRODUCTS to make and how to make them is a constant challenge to management, especially in technology-based companies. Companies operating in areas such as computers and computer components, optics, medical devices, telecommunications, and lasers are frequently and profoundly affected by rapid advances in their respective product technologies. If the rate of new product introduction is high, a stagnant research and development effort cannot succeed. It often seems difficult to turn good ideas into marketable products. Given that technology-based companies must innovate to survive, fundamental choices about their technology strategies must be made.

In this article we look at three aspects of formulating and implementing the technology side of product strategy for small-to-medium-sized companies. First, we express some strongly held convictions, which both influenced our later field research and were (we hope) enlightened by the studies. Next we describe a framework for envisioning a company's product history in a manner that may reveal its de facto technology strategy. This method was useful to us in gathering data on a number of New England computer-related companies and may also be helpful to managers trying to strategically assess a firm's position and direction. We illustrate the framework and its potential usefulness by describing three case studies. Third, we present some of the statistical results of our field study. These results support the importance o technological focus in new product development.

Some perspectives on products strategy and technology

During the 1970s especially, corporations were urged to develop diverse product portfolios in order to grow and prosper. The leading strategy consulting firms created techniques, such as the "market share/market growth" matrix of the Boston Consulting Group, to help management visualize product lines as pieces of a financial investment strategy, often premised on the diversification of risk. Buying and selling product lines and businesses were considered a pathway to achieving optimal portfolio mix. Intensifying or diminishing the internal investment in a business was a function of whether the product line was a "star" or a "cash cow". The technologies associated with these businesses were considered only peripherally, and rarely viewed as a separate strategic issue—they were most often just lumped in as an amorphous entity that came or went with a business-unit portfolio change. As a result, acquisitions and divestitures often preceded major reorganizations of a company's R&D effort. For managers, this resulted in an unstable engineering resource pool and often ineffective new product development programs.

In the 1980s the business community has generally come to appreciate that these earlier perspectives were both naive and wrong. Companies grow and prosper it they are "excellent" at something that the marketplace values, be it a stream of products or the delivery of certain services. Today, the underpinning of excellence in a product's performance is more clearly understood to lie in no small part with its technology, which had better be planned and managed effectively.

In planning the development of products, management has three basic choices in terms of technology. First, it may pursue a strategy of building a critical mass of technological skills for a closely related product portfolio, believing that the distinctive competence achieved in its *core* technology will become the basis of long-lasting competitive advantage. A second option once again stresses internal technology development, but targets multiple and perhaps unrelated technologies. A diverse set o products is created that does not depend upon the continuing importance of a single core technology. Third, a diverse portfolio of products may be created with a strategy of acquisition—buying into new technological fields by acquiring other technology-based companies, or at least their technologies, and avoiding the long-term effort of building the needed technological expertise internally. The third strategy can obviously be combined in varying degrees with either of the first two.

Which of these is most beneficial to the company. The answer no doubt depends on many factors specific to a company and its industry. However, while product diversity and acquisition have been attractive growth strategies in corporate America and may be effective for some large companies, our instincts and evidence strongly indicate that they are ill advised for emerging technology-based startups. We conclude that the building of an internal critical mass of engineering talent in a focused technological area, yielding a distinctive *core tecbnology* that becomes the foundation of the company's product development, offers the best opportunity for rapid growth of a young firm.[1]

In reaching this conclusion, we conducted field research that investigated the technology strategies of technology-based startups located in New England. We observed that companies that attermpted to build an overly diverse portfolio of products (through either internal development or acquisition) found themselves over extended periods with technologically mediocre products and diffuse marketing. Companies that concentrated on the internal development of a single technology or a closely relared set of technologies, and that focused on related market applications, achieved both technological product excellence and a deep understanding of their customers. These results agree with Cooper's recent findings from survey research on new product strategies by Canadian companies.[2] It became clear thar, withourt a defensible core technology, the technological venture typically had difficulty assuming a leadership role in its target markets and found itself playing catch-up with competitors. In contrast, companies that developed a strong core technology showed the ability to develop new products faster, with greater reliability and quality, than unfocused companies. With a core technology, these technological "winners" were more capable of responding to competitive events and in many cases were able to assume industry leadership by virtue of an exciting new product strategy. From a human resource management perspective, the company could more readily create a close-knit cadre of talented engineers and was more adept at hiring and training new engineers for its R&D group.

Developing a framework

There is no reliable way to see if a company has developed a distinctive core technology other than by looking at the technological content of its products.

We defined technological focus in terms of the rate of change or innovation between successive products according to the internally developed product technology of the company. To study technological content, we created a framework for evaluating the evolution of technology within a company that identified specific, tangible levels of change or advancement between successive products. When applied to the products created and marketed by a given company, this framework would provide a portrait of the company's de facto new product technology strategy. Building from concepts first presented by Johnson and Jones, our framework in fact treated both technological change and multidimensional market change of a firm's new products.[3] But we limit the discussion in this article to the technology considerations.

Every product made by a company is based on an identifiable engineering skill set, or what may be called a technology. Most products are in fact composed of multiple technologies, some of which are created within the company's R&D group, while others are licensed from outside sources or purchased as components. To assess technology strategy, we investigated in depth the internally developed technologies used in products. These technologies evolve within companies over time, finding their way into successive new products. As each new product emerges, the cumulative body of the company's technology experience expands. That broadened experience becomes the base for evaluating the "incremental newness" of the technology embodied in the next new product.

Tracking the evolution of technology in a company's products involves assessing the degree of improvement in or additions to the technology over time. In our research, we used four levels of change in product technology to evaluate more than two hundred products developed by twenty-six companies. The first and "smallest" level of technological change that we identified is a *minor improvement* to the company's existing product technology. This level of change is illustrated by one of the printer manufacturers that, having produced a series of 80-column dot-matrix printers for microcomputers, developed a 132-column printer. The project took less than six months and was introduced easily into the company's manufacturing and sales operations. Minor improvements can also include efforts as marginal as repackaging existing technology or customizing a product in response to customer requests. For example, a terminal manufacturer in our research base developed a series of terminals that contained new communications and terminal "emulation" capabilities so that they could more readily be tailored for use with computers produced by Digital Equipment, Data General, Burroughs (now Unisys), and so forth. Often, new products that embody minor technological improvements simply correct known problems. Not surprisingly, this was a common type of "new product" among our software companies, which seemed continually to release new versions of a basic product line with more "bug fixes" than genuine new features.

We called the second level of technological change a *major enhancement* to an existing product technology. Major enhancements incorporate a substantially larger effort in the improvement or advancement of a technology in which the company has developed expertise. Companies that can continually succeed with major enhancements often become the "standard setters" in an industry. For example, one of the photocomposition systems developers pioneered the application of color-imaging technology in the 1970s and now sells high-ticket, million-dollar systems to magazines, newspapers, and other publishers as a state-of-the-art production facility. A more recent new product allows the user to define extensive graphics "libraries" so that, for example, a digitalized photograph of a sailboat can be augmented with a "prestored" digital female figure, the designer's favorite bathing suit and sunglasses, and other graphic "objects" such as a dog, a beach ball, and a bottle of fine Chardonnay. Major enhancements tend to be sequenced in intervals of three to five years within specific product lines. For example, one printer manufacturer that has focused on high-speed line printers has, over the course of approximately ten years, upgraded its printing-head technology from early rotating "drum" devices in the late 1960s, to "linked-chain" printing heads in the mid-1970s, to soldered "band" technology in more recent years. Its line printers have been privately labeled for resale by a large number of established computer manufacturers. Among terminal manufacturers, we observed the development of high-resolution graphics terminals, more recently with color capability, as an extension of longstanding alphanumeric display technology. None of these major enhancements to an existing product technology took less than nine months in of our research essentially consisted of those two steps.

Three case studies

A high level of technological change is not synonymous with overall technological aggressiveness. Focused companies that exhibit low or moderate levels of change in product technology are hardly stagnant. Remaining competitive in dynamic technological fields required equal if not greater amounts of research and development on the part of the companies we studied as venturing into new and different technologies. The successful technologically focused company demonstrates a combination of aggresiveness and "working smart" to build a distinctive competence and generate a strong core technology. This is one of the key elements of effective management in product-development organizations.

We have found that the process of developing and displaying a plotted presentation of a company's technological history provides useful managerial perspectives. The application of our technology framework to one of the companies we studied is shown in Figure 1. This printer manufacturer has a clear technological focus; it has developed a strong coretechnology capability and competes effectively against Japanese as well as American companies.

Let's call the company "FastPrint." Notice that in Figure 1 the lowest number on the grid is "2," which represents the company's second product. In our methodology, the first products of companies are not scored on the grid, but are instead used as the baseline to evaluate the newness of the second and subsequent products. FastPrint has released a total of eighteen products since its founding in the late 1960s. It was started by several M.I.T. professors who, of all things, made one of the first eletronic-gambling systems for a Las Vegas casino. Requiring inexpensive printing stations and unable to find them on the market, these entrepreneurial academics then made one of the first small dotmatrix printers; it was the company's second product. From this point on, FastPrint's product strategy was focused on printing technology and it applications in the microcomputer marketplace. FastPrint scored its biggest success by making the first popular desktop dot-matrix printer, which was widely sold through retail stores along with the first popular Apple microcomputer system. The company's technology development has been continually aggressive, with repeated major enhancement efforts designed at providing faster speeds and batter dot-matrix printing at lower costs. The technology descriptions associated with the product numbers in Figure 1 demonstrate this pattern. We differentiated between minor improvements and major enhancements by working with the vice president of engineering to assess the time and resources allocated to each product. Major enhancement efforts that went into one product were often consolidated later with minor improvements in new product releases, either to reduce production costsor for repackaging. On other occasions, when FastPrint wanted to go into a new technological area, such as building a higher-speed line printer, it licensed products from other companies and refined them for its own purposes. This occurrend in products 6, 15, 16, and 17. In summary, FastPrint is a classic example of a technologically focused company; its distinctive core technology, developed over years by a fairly stable cadre of dedicated engieners, has been a key factor in the company's leading market position.

A contrast to this focused technology strategy is teh case of a newspaper-composition systems company that pursued many technologies. The product history of this company is shown in Figure 2.

Founded also by an M.I.T. professor, the company, which we will call "Techlabs", created one of the first "raster display" graphics terminals in the late 1960s, thus permitting time-shared minicomputers to have graphic displays. The initial product was sold directly to universities and other scientific institutions. Soon, however, Tektronix released its own (and now industry-standard) raster display graphics terminal and has since come to domminate the marketplace. Techlabs responded not with another terminal, but rather with a graphics tablet that could be attached to engineering workstations. This new technology was marketed exclusively through a large computer-afded design systems manufacturer. Techlabs then used the cash generated from this product to venture into yet another technological field, developing a text-editing workstation in the mid-1970s, complete with hardware and applications sofrware. In addition to direct sales, the company sought to contract with distributors to sell this product. In subsequent products, Techlabs undertook costly

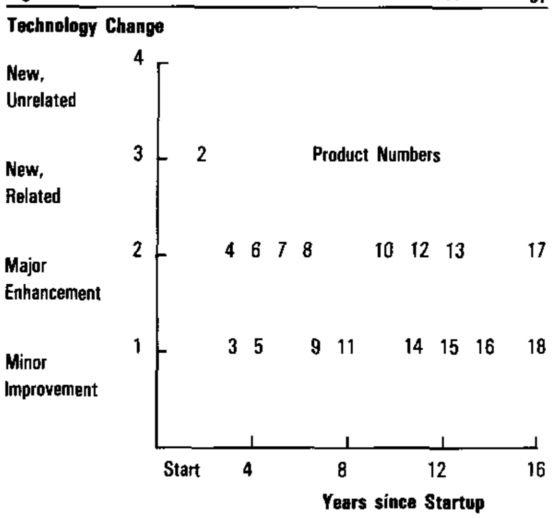
R&D, and some required two to three years of concentrated effort. At the same time, however, the companies were able to achieve both of these first two levels of technological change with a stable cadre of engineers, augmented periodically with new talent at the junior level, within the company's evolving core-technology skill set.

Our third level of technological change occurs when a company develops an entirely new technology that is integrated with an existing company technology in the final product. Here's an example. One of the terminal manufacturers in the study made transaction-processing terminals used by bank tellers. The smaller-than-usual terminals were loaded with communications software. In a move to expand upon both its technology and customer base, the company then created an automated teller machine. While its previous terminal screens and transaction communications software were employed directly for the screen displays of the automated teller machine, the company's engineers had to develop two additional technologies: the electromechanical technology for the cash withdrawal and deposit safebox inside the machine, and all the applications software for handling the dialogue with the bank user. At first the company employed the services of a software R&D contractor but, finding that approach too unreliable, was forced to hire a number of software engineers. In subtle ways, these software applications engineers represented a different culture or style than the company's traditional R&D group and presented a new challenge to management it terms of integration and control. When new technology was combined with existing company technology in this way, we labeled it *new, related technology*. Another example is a software company that had developed as a core-product technology a version of the Unix operating system for personal computers and then created as a new product a database management system that ran on its Unix operating system. Again, while some of the initial operating system engineers were shifted onto the database project, within a year a half-dozen new engineers were hired who had specific skills in database storage, query languages, and building screen interfaces for users. The skill set required for development of the commercial database management systems clearly separated it from operating system work; yet, since the product was designed for use with the earlier operating systems offering, for this company, the database management projet was a new, related technology effort.

The fourth level of technological change encompasses new core technologies that are not combined with existing product technology in the company. This *new, unrelated technology* is the highest level of change in a company's technology evolution. Why do companies undertake the risk associated with such diversity? One reason may be corporate survival. We studied several companies whose first product efforts failed commercially and, rather than cease business operations, management tried a new product technology for a different application. For example, one company initially implemented a cable television network for a local municipality. Today the cable business no longer exists, and the company has become a leading supplier of plastic card scanners used by banks for automated teller machines and by corporations and residential complexes for access control. An unfocused technology strategy may also be the result of engineering-oriented management that continually seeks "new hills to climb". A photocomposition systems company illustrates the point. Its founders (who are also professors at M.I.T.) have developed and sold optical character-recognition devices, a computer-based camera and image composition system, and a multiuser text-composition system, all for use in the newspaper industry. While the first two products were sometimes delivered as a single system to newspaper companies, the third was a standalone product, entailing the new core technology of the textcomposition applications softsware. Large-scale additions of different types of engineers were necessary to implement these new products.

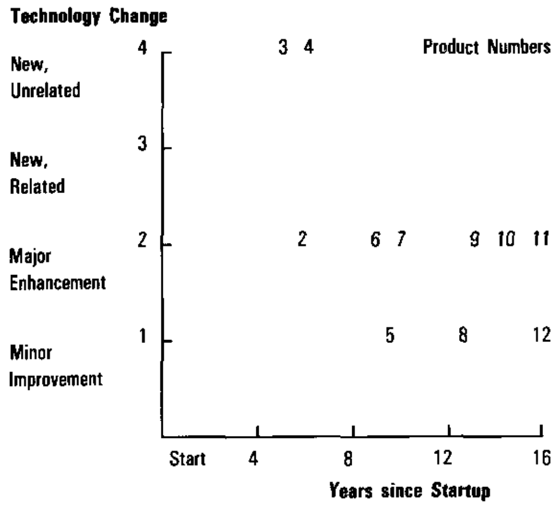
This taxonomy of four levels of technological change—minor improvement and major enhancement to an existing company technology, and the development of new technology that is either related or unrelated to existing technology—can be used to assess the technological diversity of any new product. This framework can also be used to develop a portrair of a company's technological evolution over its entire history; each product released by the company is evaluated and then all the technology scores are averaged to provide a general indicator of technological change. Obviously, by using measures of marketing change in each successive product, the same assessment can be made of a company's product-marketing history. The empirical part

Figure 1 ***The Products of FastPrint: A Focused Strategy***



Product Number	Technology Score	Product Description
1		Computer gambling machine for resort hotels.
2	3	*First dot-matrix printer;* used at first with gambling machine
3	1	First printer refined
4	2	Printer redesigned for cost reduction
5	1	Previous model refined
6	2	Higher speed, matrix-line printer
7	2	High-speed line printer acquired and enhanced
8	2	New generation of dot-matrix printers
9	1	Refined dot-matrix, low-cost version
10	2	Desktop printer underwent major redesign
11	1	Quick upgrade to smaller, less expensive dot-matrix printer
12	2	New desktop version of Number 10 with faster paper handling
13	2	Color capability added to dot-matrix line
14	1	Desktop line refined and repackaged
15	1	*Low-cost printer acquired and refined*
16	1	Another low-cost printer acquired and refined
17	2	A band-line printer: a new key technology, but acquired and enhanced
18	1	Paper handler and sheet feeder; simple peripheral technology development

Figure 2 ***The Products of Techlabs: An Unfocused Strategy***



Product Number	Technology Score	Product Description
1		High-resolution graphics "raster" terminal, among the first of its kind competing with Tektronix graphics terminal
2	2	Major upgrade of graphics terminal
3	4	Graphics tablet for CAD workstations
4	4	Text editor; hardware and software
5	1	Text-editing system made multiuser
6	2	Implemented new 16-bit chip set for the editor, purchased from National Semiconductor
7	2	New version of 16-bit editing station, using Intel chip set
8	1	Minor revision of software—tailored for newspaper text composition
9	2	New release of hardware workstation
10	2	Wire service package developed
11	2	Telecommunications package developed
12	1	*Classified advertisement package developed*

ware projects, in a sense pioneering microcomputer architectures for its own text-editing product line. With limited success, the company then focused on its text-editing software, releasing a series of packages aimed specifically at small newspaper companies. Its more recent products, for example, include packages for managing classified advertisements, newswire communications, and text composition. Outgunned in the domestic marketplace, Techlabs has recently sought to exploit the European marketplace through distributors that include graphics supply houses in various European countries. With such diversity in technology (requiring major engineering efforts in both hardware and software) the company cannot be clearly identified by a core technology. Its engineering pool has undergone numerous transformations in terms of skill content and emphasis. Further, the company's diverse products, each targeted to different types of customers for widely varying uses, has also yielded multiple distribution channels and marketing programs. When we interviewed managers of Tech labs recently, they were clearly struggling with this complexity; even though the company was experiencing little growth, hardits cash flow could not sustain current operations.

A company's technology strategy can also change dramatically. We observed instances in whick companies that were once highly focused and successful dissipated their core technology and, with a commensurate lack of market focus, found themselves very quickly in financial straits. A third case description illustrates this. "BestScreens" had risen to approximately $50 million in sales by supplying a highly reliable yet inexpensive family of alphanumeric terminals that could be used efficiently with a range of computer manufacturers' protocols, including those of Digital Equipment and Burroughs (now Unisys). These terminals were sold through original equipment manufacturers (OEMs) and dealers. BestScreens had also produced a very popular graphics terminal that could at the same time be used as an alphanumeric terminal. Thus, its product strategy had been classically focused: major enhancements to a single technology with market adaptation for a series of related customer groups.

Then BestScreens' management changed its orientation and sought to become a full-fledged computer company through both internal R&D and technology acquisition. BestScreens first acquired a small company that had made a portable microcomputer. Management established limited retail distribution for the new product. The product was a costly failure, particularly after IBM and Compaq, among others, released comparable products. Still maintaining its success with the longstanding terminal product line, management decided to have another go at diversification. BestScreens proceeded to develop inhouse a multiuser desktop minicomputer based on the new Intel 80286 chip. While designing and manufacturing the new computer internally with the best of its existing hardware engineers, the company also had to hire a number of operating systems software specialists needed to integrate the Unix operating system that the company had licensed from AT&T. The new computer was aimed at the Value Added Resellers distribution channel and, compared with previous products, targeted new applications. Unfortunately, BestScreens' second venture into diversification had a more telling impact than the previous one. This publicly traded company went into a tailspin, and within two years BestScreens sought legal protection from its creditors.

Northeastern University
Sloan School of Management, M.I.T.

investigación administrativa

Toda orden de suscripción y correspondencia relativa a suscripciones deberá ser remitida al Apartado Postal 4025, Sta. María la Ribera, Deleg. Cuauhtémoc, 06400 México, D.F., que es la dirección establecida para recibir este tipo de notificaciones.

No se aceptan suscripciones por períodos mayores a un año, requiriéndose los pagos por adelantado en moneda nacional para el país, remitidos a Investigación Administrativa en cheque o giro postal únicamente. No envíe efectivo.

Las suscripciones del extranjero deberán pagarse en dólares (USc), remitiendo las órdenes de pago a Investigación Administrativa. En el precio anual está incluido el porte correspondiente para su envío por vía aérea.

investigación administrativa Cupón de Suscripción

Apartado Postal 4025
Sta. Ma. La Ribera
Delegación Cuauhtémoc
06400 México, D.F.