Product Development Performance

Strategy, Organization, and Management in the World Auto Industry

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We dedicate this book to the memory of William J. Abernathy. He started us down this path, and the quality, depth, and originality of his work on the auto industry has been our inspiration. He was our mentor, colleague, and friend. We have tried to write a book that would make him proud.

Preface and Acknowledgments

This book is about the development of new products in a turbulent, demanding, and exciting environment: the world automobile industry. The work has taken shape over the past five years, but its roots go back even further. Our first collaborative research effort was a grueling three-week visit in the summer of 1981 to twenty-five automotive research laboratories, engineering departments, and manufacturing facilities in Japan. Working under the direction of the late Professor William Abernathy, we sought an understanding of the sources of superior performance in manufacturing quality and productivity, and of the dramatic changes in technology and competition sweeping through the industry in the early 1980s. Our field research with Professor Abernathy in Japan in 1981 played an important role in the development of the argument and evidence presented in *Industrial Renaissance,* published in 1983.

The work on *Industrial Renaissance* and subsequent field studies in Japan, Europe, and the United States convinced us of the central role that product development would play in the 1980s. The worldwide market was becoming more international and technology more diverse. Moreover, it appeared that an important part of the Japanese manufacturing advantage lay in the way products were designed and developed. These factors argued that effective development of new products was likely to be a critical dimension of competition and a source of advantage. We therefore made plans to study the effects of strategy, organization, and management on product development performance; by 1985, we had launched intensive field research.

It has been a fascinating experience. No one had ever been inside all of these companies at the same time or been granted such access to information about the inner workings of the product development process. The logistics were especially daunting: twenty companies in six countries on three continents; repeated, extensive visits; massive amounts of data. Our field work has been highly interactive. We not only developed information in the companies, but also returned to share preliminary insights and findings in presentations and discussions. Doing this would have been impossible without the cooperation of hundreds of people.

Many people from numerous disciplines and departments in the companies we studied gave of their time and experience, sharing valuable information in interviews, filling out questionnaires, and digging out old documents and reports. We promised people confidentiality, and for that reason (and because they are far too numerous) we cannot mention everyone by name, but we are grateful for their support.

Outside the companies there were several people who helped us find and interpret data. We are particularly indebted to: Shoichi Suita, Mikio Matsui, and colleagues at Mitsubishi Research Institute; Professor Koichi Shimokawa of Hosei University, who visited companies with us and generously advised us on the work; Yoshiro Ikari, freelance writer; Ryuji Fukuda and members of the Japan Association for Research on Automotive Affairs; Yu Okawa, former editor, *NAVI* magazine, and his associates.

Our research on product development evolved through a series of paper and seminar presentations, and we benefited greatly from the many comments and suggestions we received. Special thanks go to the Mitsubishi Bank Foundation for the opportunity to present a paper at the International Conference on Business Strategy and Technical Innovation in August 1987, and to Moriaki Tsuchiya, Henry Mintzberg, Michael Cusumano, Ikujiro Nonaka, and Kiyonori Sakakibara and other conference participants for their advice and encouragement. We also received comments from seminar and conference participants at The Brookings Institution, the University of Michigan, MIT, UCLA, Wharton, Northwestern, Brigham Young University, the Operations Management Association, the Strategic Management Society, the Society of Automotive Engineers, and the American Society of Mechanical Engineers.

Our colleagues at the Harvard Business School have generously helped us throughout the years of research and writing. Dean John McArthur urged us to set our sights high, invested his time and resources in opening doors for us, and provided strong and unwavering support in what turned out to be a six-year project. Jay Lorsch, director of the Division of Research, funded our work, encouraged us at every turn, and made the system work. Bob Hayes, chair of the Production and Operations Management area during much of this time, not only stimulated our thinking, but also shouldered extra administrative tasks and kept us focused on the research.

Several members of the POM area and the Science and Technology Interest Group at Harvard played a central role in the intellectual development of our work. Our biggest debt is to Steve Wheelwright, who taught courses with us, wrote cases with us, and shaped our thinking through his own work on product development. We are also grateful to Paul Lawrence for his help in linking our work to organization theory; to Bruce Chew for collaboration on one of the early papers from the project and for his assistance with empirical work; to Oscar Hauptman for helping with the conceptual framework; to Dave Garvin for his insights on concepts and measurement of total product quality; to Marco Iansiti for sharing the fieldwork; and to Earl Sasser for his help in linking product development to competition and strategy.

Both Phil Barkan of Stanford University and Jan Benson read our initial draft and offered valuable suggestions for improvement. In the field interviews, data analysis, writing, preparing, graphics, and editing we received great support from great people. Frank Dubinskas, Karen Freeze, Brandt Goldstein, and Elaine Rothman, research associates at the Harvard Business School, provided outstanding research support. John Simon, our editor, worked tirelessly and with great skill to turn our drafts into a readable manuscript. Dick Luecke, Natalie Greenberg, and many others at the Harvard Business School Press watched over us, prodded us, and made the book happen. Kathy Peterson and Rosemary Harkins kept the office focused and organized amidst all the flurry of activity. Jean Smith was responsible for the manuscript itself. She typed drafts, designed and executed graphics, handled revisions, managed the authors and the editor, found things we had lost, and did it all with consummate skill and good spirits.

Finally, we want to thank our families for their love, support, and interest ("Why do you write books, Daddy?," "Isn't it done yet?") in our work. We want to recognize especially the late Gunji (George) Fujimoto, a race car driver, mechanic, and repair shop owner in the early years of this century, and the late Takahiro Fujimoto, an entrepreneur in various auto-related businesses. They have had a decisive influence.

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Chapter 1

Product Development and the New Industrial Competition

New products have long been a source of fascination and excitement. Novel industrial artifacts displayed in the famous Crystal Palace at the Great Exhibition in London in 1851 generated great enthusiasm. Three-quarters of a century later, Henry Ford's introduction of the long-awaited Model A made front-page news as it created near riots outside dealer showrooms. Today, Gillette's Sensor razor receives extensive coverage in national papers such as *The Wall Street Journal* and *USA Today*, and even plays on the evening television news.

But though new products still evoke fascination, in the competitive environment of the early 1990s their role goes well beyond curiosity and excitement. The development of new products has become a focal point of industrial competition. For senior managers around the world, developing better products faster, more efficiently, and more effectively is at the top of the competitive agenda. Evidence is mounting that effective design and development of new products have a significant impact on cost, quality, customer satisfaction, and competitive advantage.

THE DRIVING FORCES BEHIND THE NEW INDUSTRIAL COMPETITION

The new industrial competition that focuses so heavily on product development is driven largely by three forces that have emerged over the past two decades in many industries worldwide. The emergence of intense international competition; the creation of fragmented markets populated by demanding, sophisticated customers; and diverse transforming technological change have combined to push new product development to the center of the playing field in the competitive game.

INTENSE INTERNATIONAL COMPETITION

The 1980s have witnessed the internationalization of many markets and industries. Though important regional and local differences persist in many industries, growing similarity in product concepts and the emergence of global product segments have paved the way for more intense competitive interaction across national boundaries. The number of players capable of and actually playing in the international arena has increased. Where competition was once among the few with a strong regional orientation, it now occurs among many more players across an international stage. Direct rivalry among products of different regional origins is observed more often as brand selection has become increasingly cosmopolitan.

International players possess similar basic skills but bring different backgrounds and experience, and thus different approaches, to the international market. With a growing number of competing brands and more capable and diverse players, it is increasingly important to counter competitor moves quickly with well-differentiated products.

FRAGMENTED MARKETS AND SOPHISTICATED CUSTOMERS

Customers have not been passive participants in the process of industrial evolution.[1] Accumulated experience has sensitized customers to subtle differences in product dimensions that go beyond technical performance and superficial design features to the degree to which a total product concept fulfills customer needs at a deeper level. For consumers the deeper fit is with lifestyle and values; for industrial customers it is with other components that make up a system or with a larger production process. The effect is to make customer expectations more holistic, complex, demanding, and diversified, and to increase opportunities for and the necessity of subtle differentiation.

This is true not only for custom-built capital equipment that has always catered to customer differences (though here the demands are greater and the criteria more valid), but also for products that have achieved a good measure of standardization in technical terms. Discerning customers for whom nuances of design and subtle physical differences in products are important create an opportunity to compete successfully through targeted, differentiated product development even in apparently mature industries.

Customers who expect something more than price and basic performance do not ignore a product's fundamentals. Good fundamentals simply become a necessary precondition for even participating in the competitive game. Here too product development has proved to be a powerful tool for improving performance. Research aimed at finding ways to improve manufacturability has led to greater understanding of the power of the design and development processes to affect manufacturing performance. Experience in a variety of industries suggests that a significant fraction (as much as 80 percent in some cases) of total product cost is established during the product engineering stage of development.[2] Product quality and reliability may be determined to a similar degree by the product engineering stage. Pressure for continual improvements in cost and quality has led to a focus on effective management of engineering design.

DIVERSIFIED AND TRANSFORMING TECHNOLOGIES

Technological change makes possible the increased differentiation demanded by more sophisticated customers. Novel technologies and new understanding of existing technologies yield a broader and deeper base of knowledge about the phenomena underlying particular applications. For example, in pharmaceuticals developments in biochemistry and molecular biology have created new processes for discovering and synthesizing proteins with potentially important therapeutic properties. At the same time, new understanding in these fields and developments in chemistry make it possible to improve the efficacy of and reduce the side effects associated with pharmaceuticals developed from traditional chemical synthesis. Deeper and broader knowledge thus creates new options for tailoring products to meet the needs of an increasingly diverse and demanding market.

Technical development has reinforced the drive for new products in another way. The growth of scientific and engineering capability worldwide has resulted in many centers of expertise in a given field. Perhaps the most dramatic example of this is the many laboratories worldwide that were immediately able to participate in research on high-temperature superconductivity when the first developments were announced in 1987. Such widespread expertise makes it much more difficult for a company to build competitive advantage solely on the basis of a unique technology. Patent issues notwithstanding, other

firms often can either duplicate a technology or find alternative means to achieve similar results.

We have a new paradox: at a time when technology has never been more important, it has become more difficult (although not impossible) to build advantage around technology alone.[3] Except in very young high-tech industries, product development is no longer synonymous with technology development. Technology may be necessary, but it is generally not sufficient for new product success. Successful product development requires capabilities that extend well beyond technical skill in the R&D laboratory. Competitive advantage accrues to firms that can bring a technology into the marketplace in a product that meets customer needs efficiently and in a timely manner. Experience, illustrated by three examples from as many industries, suggests that effective product development makes a difference.

The VCR (video cassette recorder). Sony launched its Betamax VCR for the mass consumer market in 1975. JVC introduced its VHS version of the VCR in 1976.[4] JVC's response was both fast and technologically distinctive. Its parent company, Matsushita, moved quickly to introduce a new product based on VHS technology. The Matsushita/JVC team eventually won the "VCR war." Though its financial performance was affected by this loss, Sony struck back with a stream of new video-related products that included a compact video camera with built-in VCR using 8-mm video cassette technology and a combined small TV and VCR (a "video walkman"). While this second VCR war continues among the Japanese producers, the main players are already preparing for the next war: the development of a digital VCR.

The Dutch firm Philips, a frontrunner in VCR technology, was too slow in responding to competitors; its first VCR, comparable to Sony's Betamax, reached the market five years later. Ampex, the original innovator of the video recorder, also failed to keep up with the rapid pace of product introductions in this highly competitive market.

The single-lens reflex (SLR) camera—Canon EOS versus Minolta Alfa Series. The Canon AE-1 had been the top seller

for nearly a decade in an SLR camera market that was fairly stable and mature in the early 1980s. Then came a new product concept: auto-focus SLR. First introduced commercially by Minolta, then a mediocre player in the SLR market, the auto-focus concept changed the industry completely, propelling Minolta past Canon and into market leadership in 1985.

Canon faced a tough choice: to develop a me-too product within one year or a well-differentiated product line with a completely different technical concept (lens-in-motor auto-focus versus Minolta's motor-in-body concept). Considering Canon's past development schedule, the latter alternative might have taken three years. Canon decided to develop a technically distinctive product within two years—a major challenge that it met through new organization and processes. Canon regained market leadership with its motor-in-lens auto-focus SLR camera, called EOS, only to lose it again as Minolta struck back quickly with an improved product. A stream of new products followed from other companies, and a see-saw game in new product introduction followed.

Jet engines for commercial aircraft. As of July 1989, 63 percent of commercial airliners used engines manufactured by Pratt and Whitney (P&W). The main strength of the long-time leader in jet engines for commercial aircraft lay in better fuel economy.[5] But for engines under construction and in backlog, the picture changes completely: General Electric engines are outselling P&W engines by a margin of 51 percent to 31 percent. Many industry observers ascribe this turnaround to efficient product development; GE responded flexibly to the recent needs of airline and aircraft companies for product variety (e.g., engines for long-body and wide-body craft) by introducing a series of modular engines that shared a basic design, so that a variety of engines with very different thrusts could be created with dramatically shorter lead time and at less cost.

In each of these examples, and in many more that we could cite, success or failure of product development has had increasingly serious

effects on companies' long-term market performance. For a company with a broad product line, the isolated disappointment with a new product need not bode ill for the firm as a whole, unless that new product is targeted at a rapidly growing segment, in which case failure can have serious long-term consequences. Failure that is part of a recurring pattern across many products and market segments may significantly affect the fortunes of the firm. This is particularly true in the industrial environment of the last quarter of the twentieth century, which has been characterized by intense competition, demanding customers, and rapidly changing technology. In short, in the new industrial competition, product development matters.

THE CHALLENGE OF PRODUCT DEVELOPMENT

Effective product development is difficult. In a host of industries—including major appliances, semiconductors, televisions, VCRs, pharmaceuticals, medical instruments, industrial controls, machine tools, automobiles, lighting products, engineering workstations, printers, chemicals, advanced ceramics, hospital products, software, copiers, cameras, steel, and aluminum—we have found managers and engineers struggling with new products that are too slow to market, have failed to meet cost or performance objectives, are beset by rampant engineering changes and quality problems, or have found no market at all.[6] We have also found firms that have done extremely well. Indeed, as the examples above illustrate, product development makes a difference in the long-term competitiveness of a firm and its products. The promises associated with developing a successful new product—increased market share, new customers, lower cost, and higher quality—are exciting, but the reality of managing product development is sobering. Many firms can point to one or another product that worked well, but only a few seem to achieve excellent development performance consistently. Because doing it well matters so much, consistently successful product development holds significant competitive leverage and affords the few firms that achieve it an important advantage.

RESEARCH ON THE SOURCES OF SUPERIOR PERFORMANCE

What makes long-term success in product development so

difficult? What explains such wide differences in performance among firms in the same industry? What are the underlying principles that govern superior performance in the technical and competitive environment of the 1990s? These are the questions that motivated the research reported in this book. We offer no easy answers, no "three steps to high-performance development." Effective development cannot be achieved simply by increasing expenditures on research and development, though this may be part of the answer for some firms. Nor does it lie in finding a breakthrough technology or introducing new tools and techniques, important though these may be. Effective product development is not a question of getting the right project planning system, implementing quality function deployment (QFD), installing an advanced computer-aided design (CAD) system, or incorporating simultaneous engineering. Such practices and equipment are valuable, but not sufficient.

What seems to set apart the outstanding companies in product development—and this is a central theme of our book—is the overall pattern of consistency in their total development system, including organizational structure, technical skills, problem-solving processes, culture, and strategy. This consistency and coherence lie not only in the broad principles and architecture of the system, but also in its working-level details. Consistency in performance results from consistency in total organization and management.

The importance of consistency and detail in organization and management has implications for how we do research on product development. Above all, it means we must have depth. To gain insight into the sources of outstanding performance, we need a good comparative perspective among several companies. Finally, to understand product development in the context of the new industrial competition, we must study companies that are facing intense international competition and changing markets and technology. These requirements—the need for depth, for comparison, and for a turbulent environment—have led us to examine closely a single, global industry, one in which there are many companies in different countries developing similar products for similar markets in direct competition with one another. This focus on a single industry brings the issues of organization, management, strategy, and competition into sharp relief.

All of the data, observations, interviews, and anecdotes in this book come from the world automobile industry. In studying major

development projects in twenty automobile companies worldwide over the past six years, we have tried to develop a consistent base of data that includes both measures of performance and patterns of organization and management. We have probed and checked and double-checked to ensure that we had an accurate, credible account of the development process and its performance, and we have used a variety of methods—including structured and unstructured interviews, questionnaires, and statistical analysis—to get at the sources of superior performance.

This focus on a single industry, though it gives us the power to grasp patterns of consistency in the total development system, raises questions about the generalizability of our insights and conclusions. Readers outside the automobile industry must draw implications and insights from our work indirectly by way of analogy.

LEARNING FROM THE AUTOMOBILE INDUSTRY— A FRAMEWORK FOR COMPARISON

The world automobile industry is a microcosm of the new industrial competition. In 1970, only a handful of companies competed on a global scale with products across the full range of market segments. Today the number of capable, world-scale players numbers more than twenty, and once-dominant companies like General Motors face serious competitive threats in all markets. At the same time customers have grown more discerning, sophisticated, and demanding. Though growth has slowed, the number of models has multiplied. Technology has become more complex and, especially in the United States, more diverse. Twenty years ago, the American car buyer had to look long and hard to find a model with anything but a traditional V-8 engine with rear-wheel drive. Today, the variety of engine-drive train combinations is large—4, 5, 6, 8, and 12 cylinders, multivalves, front-wheel drive, and four-wheel drive. Looking at other parts of the car, we find new technology in brakes and suspensions, engine control systems, and materials and electronics. In this environment, product development has become a focal point of competition and managerial action. Speed, efficiency, and effectiveness have become critical issues as automobile manufacturers in North America, Europe, and Japan search for new approaches to managing product development in order

to be more responsive to customers and competitors.

Product development in the automobile industry has peculiar characteristics. A car is a complex, "fabricated-assembled" product, comprising a large number of components, functions, and process steps. Moreover, the product is complex from the buyer's perspective, giving rise to a number of important performance dimensions. Although the automobile has a long history and customers generally have a good deal of experience with it, buying one involves a very complicated evaluation of many criteria—some highly subjective, subtle, multifaceted, and holistic—and all of which change over time, sometimes in unpredictable ways.

A project to develop a new car is complex and long lived; it may involve hundreds, even thousands, of people over many months. Planning and design are complicated by changing markets, long lead times, and a multiplicity of choices. Engineering complexities include the numbers of parts and components, demanding levels of cost and quality, the number of competing objectives, and inherent ambiguity in the customer's evaluation of the product.

These characteristics make the development of a new car a fascinating arena in which to study the management of product development. We are confident that much of what there is to learn is translatable to other industries. For one thing, the auto industry is so rich that it cannot help but share some basic patterns with other industries. For another, many of the frameworks we develop and the basic conceptual themes that emerge out of our work deal with general problems. Comparison with case studies and discussions with senior managers in other industries suggest that the principles reported here have broad application among firms that face the conditions of the new industrial competition. For example, many of the critical problems in developing a new car—integrating engineering and manufacturing, establishing links between technical choices and customer requirements, and establishing effective leadership—show up in the development of most "fabricated-assembled" products. Even in process-intensive industries such as steel, aluminum, and engineered plastics these problems are sufficiently general that analysis of the auto industry can provide useful insights.

No matter what the industry, the challenge is to modify and adapt insights gained from the auto study to particular circumstances. The auto study, for example, does not deal with all the important issues