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Managing the New Product Development Process: How Japanese Companies Learn and Unlearn

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Introduction

In our travels through corporate America several years ago, we found America in search of itself. "What went wrong?" many would ask. The talk would be about Rip van Winkle and about the past.

In our most recent travels through corporate America, we found it ready for action. "Can we do it?" many would ask. The talk would be about the future, about renaissance, renewal, and turnaround.

We heard a number of suggestions concerning how to bring about a more competitive future for corporate America. Not surprisingly, many emphasized innovation as the key missing link. For example:

- Abernathy, Clark, and Kantrow note that a change in the nature of innovation is both a sign of dematurity in process and, in competitive terms, its most far-reaching effect.[1]
- Lawrence and Dyer believe that a readaptive process—"the process by which organizations repeatedly reconcile efficiency and innovation"—is essential to renewing American industry.[2]
- Kanter argues: "As America's economy slips further into the doldrums, innovation is beginning to be recognized as a national priority. But there is a clear and pressing need for more innovations, for we face social and economic changes of unprecedented magnitude and variety, which past practices cannot accommodate and which instead require innovative responses."[3]

We were asked, by practitioners and researchers alike, to offer them clues on how the Japanese do it. How can Japanese companies be productive and innovative at the same time? How can they support such a rapid new product development program? How can they be so flexible in seeking out new technology and, at the same time, adaptive to changing market requirements?

It is with this kind of an orientation that we embarked on our investigation of the innovative behavior of Japanese companies with respect to new product development. Two dimensions of new product development were highlighted: (1) the speed with which new product development takes place, and (2) the flexibility with which companies adapt their development process to changes in the external environment. The basic rationale for treating speed and flexibility as the central issues of our research rests on our belief that they collectively lead to competitive advantages in the forms of increased productivity, reduced costs, improved quality, and higher market share, among others.

Methodology

To understand the dynamic process that enables certain Japanese companies to develop new products rapidly and with maximum flexibility, we selected five innovative models as our primary units of analysis. They include: (1) the FX-3500 copier made by Fuji-Xerox; (2) the City box-car made by Honda; (3) the Auto Boy lens shutter camera made by Canon (known as Sure Shot in the United States); (4) NEC's PC 8000 personal computer; and (5) Epson's MP-80 dot-matrix printer. These five models were selected with the following criteria in mind: market success, innovativeness of product features, strength of impact and visibility within the company as being a "breakthrough" development process, variety of product and process technology utilized, and spread of product categories along the product life cycle curve. See *Table 8-1* for a more detailed description of our units of analysis.

In-depth field research was conducted with the five manufacturers mentioned above, as well as with their affiliated companies and subcontractors. The latter group was included since product development in Japan cannot be viewed solely as an intrafirm activity. As is discussed below, an interorganizational network formed between the manufacturer and its outside suppliers plays an important role toward making speed and flexibility possible. As shown in *Table 8-2*, interviews were conducted with more than forty people from thirteen companies over a six-month period.

Table 8-1
Description of the Units of Analysis Used in the Study

Brand (Company)	*Product Description*	*Innovative Features*	*Life Cycle of Product Category*	*When Introduced*	*Approximate Peak Production Units per Year (peak year)*	*Share of Relevant Domestic Market*
1. FX-3500 (Fuji-Xerox)	Medium-sized plain paper copier	• One-half the cost of a high-speed copier • Speed of 40 copies/min. • Compact size	Growth	1978	30,000 (1978)	60%
2. City (Honda)	1200cc box-car	• "Tall and short" car concept • Large interior • Fuel efficient	Mature	1981	125,000 (1982)	12%
3. Auto Boy (Canon)	Lens shutter camera	• Fully automatic camera with automatic winding and rewinding	Mature	1979	1,400,000 (1982)	20%
4. PC 8000 (NEC)	8-bit personal computer	• First fully packaged personal computer introduced in Japan	Introduction/growth	1979	105,000 (1981)	45%
5. MP-80 (Epson)	Dot-matrix printer for personal computers	• Separate unit from computer • Compact	Introduction/growth	1980	700,000 (1981)	60%

Table 8-2
Interview List

Brand	*Company*	*No. of Interviewees*	*Total Interview Hours*
FX-3500	Fuji-Xerox[a]	7	16
	Dengen-Automation[b]	2	2
	Sanyo Seisakusho[b]	1	1
	Toritsu-Kogyo[b]	4	2
	Tesco Industrial Co.[c]	1	1
	Mitsuba Electronics[c]	1	1
City	Honda	8	12
	Masuda Manufacturing[b]	1	1
Auto Boy	Canon	6	5
PC 8000	NEC	5	7
MP-80	Epson[d]	4	7
	Shiojiri Kogyo[b]	1	1
	Standard Press[b]	1	1
		42	57

a. Joint venture between Xerox Corporation and Fuji Film.
b. Primary subcontractor.
c. Secondary subcontractor.
d. Independent subsidiary of Seiko Group.

Descriptive Model

The key to identifying the various factors that make speed and flexibility possible is to view product development as a dynamic and continuous process of adaptation to changes in the environment. Within this framework, which is presented in *Figure 8-1,* companies adapt to changes or uncertainties in the market environment through an iterative process of variety reduction[4] and "learning-by-doing." Even a seemingly minor change in competitive behavior or consumer preference forces a manufacturer to make choices and to engage in learning, as Abernathy et al. point out:

> For whatever reasons—a sudden shift, say, in the prices of substitute products—a demand may arise among buyers for new dimensions of product performance or for a different set of trade-offs among product attributes. If this demand is sufficiently unlike the one it supersedes, producers may need to seek out new technology, to revise design concepts, to reintroduce innovation as an important element in competition, and to undertake a new round of iterative learning.[5]

A large proportion of the differences in the product development process between Japanese and U.S. manufacturers can be explained by examining how variety amplification, variety reduction, and learning actually take place.

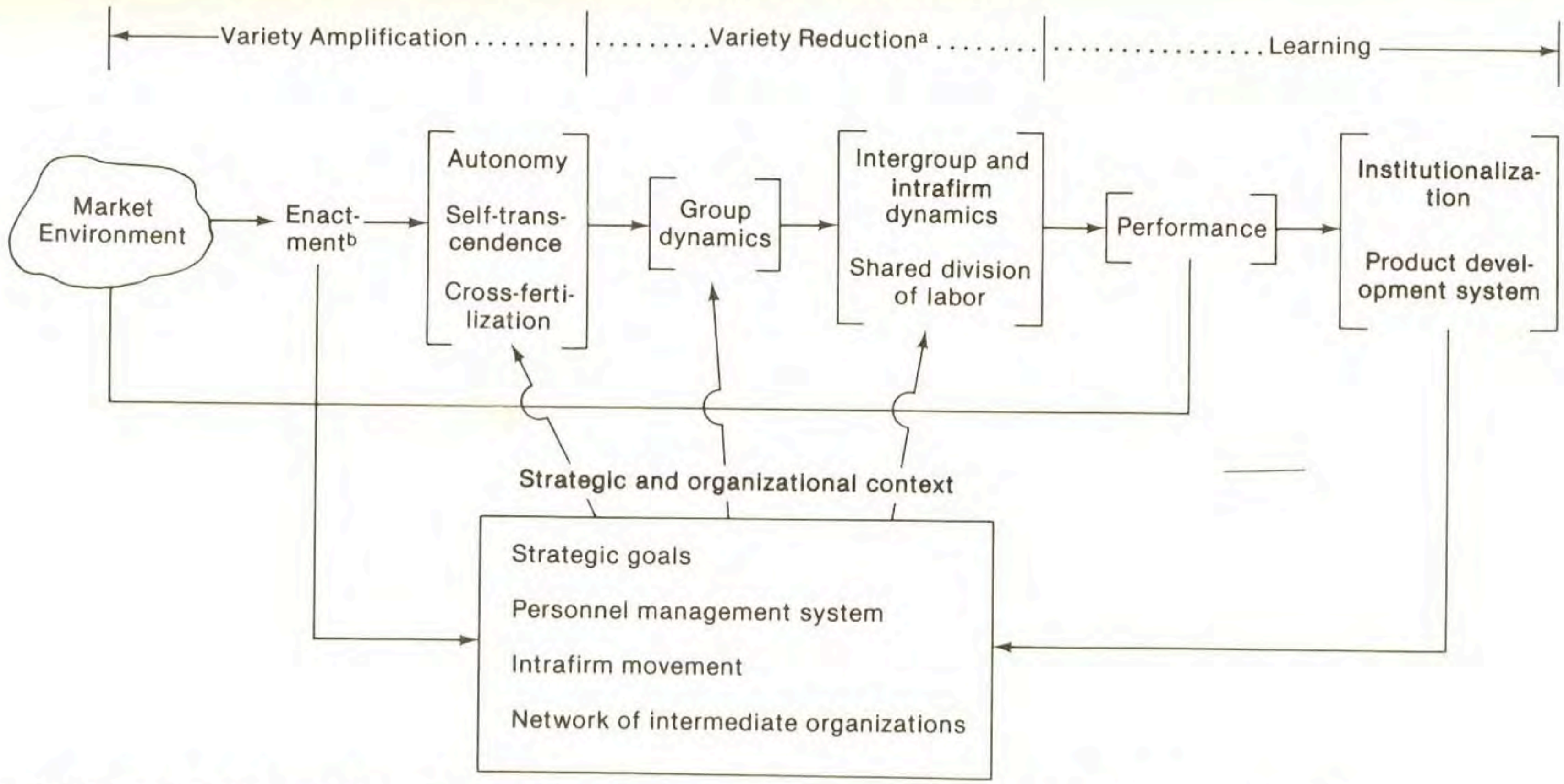
Intrafirm Process

This chapter consists partly of a seven-piece jigsaw puzzle. In this section, six of the pieces are identified and put into place; they all are factors supporting a speedy and flexible new product development process from the inside. The final and missing piece, which identifies the contribution of outside suppliers, is examined in the next section. Needless to say, only after all the pieces are put in place can the entire picture be appreciated.

The process of developing new products within Fuji-Xerox, Honda, Canon, NEC, and Epson itself resembles the way in which a jigsaw puzzle is put together. It requires an incremental and iterative process of what Abernathy calls "learning-by-doing" as opposed to "analytic-strategy-synthesis."[6] The "doing" sometimes comes before the "thinking" part. Or in the words of Weick, "How can I know what I think until I see what I say?"[7]

The two processes are also similar in other respects. Variety reduc-

Figure 8-1
Descriptive Model for New Product Development



a. Dotted lines indicate considerable degree of overlap among variety amplification, variety reduction, and learning.
b. Enactment is defined as subjective perception of the external environment.

tion occurs in jigsaw puzzles by "building up" the pieces from scratch. It is often easier to finish a puzzle if others chip in, especially if they see things differently. Learning takes place as well, as one moves on from a seven-piece set to a more challenging one, with more pieces, almost as a natural course of events.

The six intrafirm factors that contribute to a speedy and flexible development process are as follows:

1. Top management as catalyst
2. Self-organizing project teams
3. Overlapping development phases
4. Multilearning
5. Subtle control
6. Organizational transfer of learning

Top Management as Catalyst

Top management plays a key strategic role in new product development. It provides the initial kickoff to the development process by signaling a broad strategic direction or goal for the company. Top management rarely hands down a clearcut new product concept or a specific work plan. Rather, it intentionally leaves considerable room for discretion and local autonomy to those in charge of the development project. A certain degree of built-in ambiguity is considered healthy, especially in the early stages of development.

Top management decides on a broad strategic direction or goal by constantly monitoring the external environment—that is, competitive threats and market opportunities—and evaluating company strengths and weaknesses. Competitive threats from rival companies, for example, forced Fuji-Xerox and Canon to seek a *reactive* strategic direction:

- Prior to 1970, Fuji-Xerox was the only plain paper copier (PPC) manufacturer in Japan. But starting with the entry of Canon in the fall of 1970, Japanese manufacturers (such as Konishiroku, Ricoh, Minolta, Copia, and Toshiba) began to make inroads into the PPC market, especially at the low end. By 1977 Ricoh, which introduced a liquid dry PPC model called "DT 1200" in 1975, had overtaken Fuji-Xerox as the market leader in terms of units installed. Fuji-Xerox therefore launched the development of FX-3500 with a sense of urgency and a determination to regain market leadership.
- Canon was the undisputed leader in the medium-priced 35mm lens

shutter camera market in the 1960s, as a result of the 1961 introduction of Canonet, a lens shutter camera with an electric exposure capability. It also became the leader in the higher-priced 35mm single-lens reflex (SLR) market with the successful 1976 introduction of the AE-1, which was the first automatic exposure SLR camera with a built-in microprocessor. But while Canon was concentrating its effort on the SLR market in the mid-1970s, Konishiroku overtook it in lens shutter cameras, increasing its share of the Japanese market to over 40 percent by introducing two new Konica models, one with a built-in flash and the second with an automatic focus. It was this serious competitive threat from Konica that prompted Canon to redirect its development efforts behind Auto Boy.

An assessment of market opportunities and company strengths and weaknesses led Honda, NEC, and Epson to pursue more of a *proactive* strategic direction:

- Honda's top management felt a sense of crisis as its best-selling lines—Civic and Accord—were beginning to lose their appeal to the youth market. The City development project was initiated in 1978, just as the postwar generation (under thirty-three years at the time) began to outnumber the prewar generation. The City was targeted toward the youth segment and developed by a young project team, whose average age was only twenty-seven. As is described in greater detail below, this team was given full autonomy to develop "the kind of car that we, the young, would like to drive."
- NEC's strength in microprocessors led to the eventual development of its personal computer PC 8000. NEC began to mass produce microprocessors to reduce costs and, at the same time, broaden their application base. Mr. Watanabe, head of the PC 8000 development team, was originally asked by top management to create a market for microprocessors and to sell them by the bundle. He visited Silicon Valley and saw the successful launching of personal computer prototypes in the United States, which confirmed the large market potential of microprocessor applications within personal computers. As a result, TK 80, a training kit for hobbyists and the predecessor to PC 8000, was introduced in 1976.
- Ever since its establishment in 1961, Epson's history has been marked by what appears to be almost an obsession with creating a market for "products of the future." Epson, which was originally a parts manufacturing plant for Seiko, was the first company in Japan to enter the miniprinter market with its EP-101 just as elec-

tronic calculators were taking off in the late 1960s. Epson also developed an electronic printer (MP-80) just when the personal computer market was beginning to boom. And it introduced a letter-sized computer (HC-20) in 1982, opening up a market for handheld computers. Top management constantly keeps its watchful eye on tomorrow's growth opportunities and directs its development people to think the unthinkable.

Regardless of whether the strategic direction or goal is determined reactively or proactively, it is stated in rather nonspecific terms. For example, Canon's top management directed the Auto Boy team "to think of something new that will surpass all preceding competitive brands." Honda's top management told the City team "to create a radically different concept of what a car should be like." Top management at Fuji-Xerox instructed the FX-3500 team "to come up with a product head and shoulders above others." These directions or goals are intentionally left vague, to give the development team maximum latitude toward creative problem solving.

But, at the same time, top management is not at all hesitant about setting very challenging parameters. Canon's Auto Boy team, for example, was given a free hand to develop an auto-focus camera as long as it was done "on its own." Unlike all other front-runners, who licensed the auto-focusing technology from Honeywell, the challenge was to develop the new product using Canon's original core technology. Similarly, Honda's top management asked for a radically different concept within the constraints that City be a "resource-saving, energy-efficient, mass-oriented automobile." Fuji-Xerox's FX-3500 team was given two years to come up with a new product that could be produced at half the cost of the high-end line and still be equipped with similar performance standards. As a point of reference, it took five years for Fuji-Xerox to develop an earlier domestic model (FX-2200) and over four years for Xerox Corporation in the United States to develop a model comparable to the FX-3500 at that time.

Top management implants a certain degree of tension within the project team by giving it a wide degree of freedom in carrying out a project of great strategic importance to the company and by setting very challenging parameters. This creation of tension, if managed properly, helps to cultivate a "must-do" attitude and a sense of cohesion among members of the crisis-solving project team. Examples of how tension is created are described by top management in the following manner:

- Mr. Kawamoto, vice president of Honda in charge of development, remarked: "At times, management needs to do something drastic like setting the objective, giving the team full responsibility, and keeping its mouth shut. It's like putting the team members on the second floor, removing the ladder, and telling them to jump, or else. I believe creativity is born by pushing people against the wall and pressuring them almost to the extreme."
- Mr. Kobayashi, president of Fuji-Xerox, noted: "I kept on rejecting the proposals repeatedly for about half a year. In retrospect, I'm amazed how persistent I was about sending them back. Engineers can think up all kinds of reasons why something is impossible to do. But I was able to resist giving in because everyone in the company shared an acute sense of crisis."

Self-organizing Project Teams

A new product development team, consisting of members with diverse backgrounds and temperaments, is hand picked by top management and is given a free hand to create something new. Given unconditional backing from the top, this team begins to operate like a corporate entrepreneur and engage in strategic initiatives that go beyond the current corporate domain. Members of this team often risk their reputation and sometimes their career to carry out their role as change agents for the organization at large.

Within the context of evolutionary theory, such a group is said to possess a self-reproductive capability. Several evolutionary theorists use the word "self-organization" to refer to a group capable of creating its own dynamic orderliness.[8] A recent study by Burgelman found that a new venture group within a diversified firm in the United States takes on a self-organizing character.[9] Another study by Nonaka has shown that Japanese companies with a self-organizing characteristic tend to have higher performance records than others.[10]

The creation and, more importantly, the propagation of this kind of self-organizing product development team within Japanese companies represents a rare opportunity for the organization at large to break away from the built-in rigidity and hierarchy of day-to-day operations. It is quite difficult for a highly structured and seniority-based organization to mobilize itself for change, especially under noncrisis conditions. The effort collapses somewhere in the hierarchy. A new product development team is better suited to serve as a motor for corporate change because of its visibility ("we've been hand picked"), its legitimate power ("we have the unconditional support from the top to create something new"), and its sense of mission ("we're working to solve a crisis situation").

To become self-organizing, a group needs three qualifications. First of all, it has to be completely autonomous. Our case studies support this condition. For example:

- A Honda City design engineer recalled: "It is incredible how the company called in young engineers like ourselves to design a new car and gave us the freedom to do it our way." Mr. Kawashima, then the president of Honda, promised at the outset that he would not intervene with the City project. "Yes, we've given them freedom," commented Mr. Kawamoto, vice president in charge of development, "but we've also transferred a strong sense of responsibility to them."
- Mr. Watanabe, who headed the PC 8000 project for NEC, recalled: "We were given the go-ahead from top management to proceed with the project provided that we would work all by ourselves in developing the product and be responsible to manufacture, sell, and service the product on our own as well."

Second, given this autonomy, a group comes up with extremely challenging goals on its own and tries to keep elevating these goals. It does not seem to be content with incremental improvements alone and is in constant pursuit of a quantum leap. We observed this tendency toward "self-transcendence," or the creative overcoming of the status quo, in all of the development projects we analyzed. For example:

- Epson typifies a company with a never-ending quest for approaching the limit. Its corporate target is to have the next-generation model developed by the time the first-generation model is introduced on the market. There is an unwritten rule that the next-generation model be at least 40 percent better than the existing model.
- The self-motivating factor behind Canon's Auto Boy development team was to improve on the company's achievement with its AE-1 in the single-lens reflex camera market. "You weren't even considered human at that time if you weren't somehow associated with the AE-1," said one of the Auto Boy team members, half jokingly. "We wanted to challenge that legacy." The end result was a fully automatic lens shutter camera with an improved auto-focusing technology that became the top-selling brand immediately after introduction, despite a two-year lag in market entry.

- Both Fuji-Xerox and Honda challenged the status quo. Fuji-Xerox overcame the preconceived notion within the company that a new product normally be developed through conversion engineering (of a U.S. model) and undertook a self-development program. Similarly, Honda overcame what appeared to be an unshakable market preference for a "long and low" car and developed a "short and tall" City.

Third, a self-organizing group is usually composed of members of diverse functional specializations, thought processes, or behavior patterns. The total becomes much more than the sum of its parts when these members assemble and begin to interact with each other. Variety is amplified and new ideas are generated as a result. We found this phenomenon, which can be termed cross-fertilization, to be widespread among the companies interviewed. Cross-fertilization can be seen in the following examples:

- Honda's City development team members included representatives from product development (D), production engineering (E), and sales (S), as shown in *Figure 8-2*. Interactions across these functional boundaries were substantial. Throughout the City development project, which took three years, more than 2,000 visits from E to D and back were recorded by team members and other employees involved in the project. The two physical locations (Suzuka for E and Wako for D) were 300 miles apart, or five hours by train.
- Fuji-Xerox's FX-3500 was also developed by a multifunctional team, consisting of managers from planning, design, production, sales, distribution, and evaluation. Unlike City, these managers were physically located in one large room where open communication and sharing of information took place continuously.

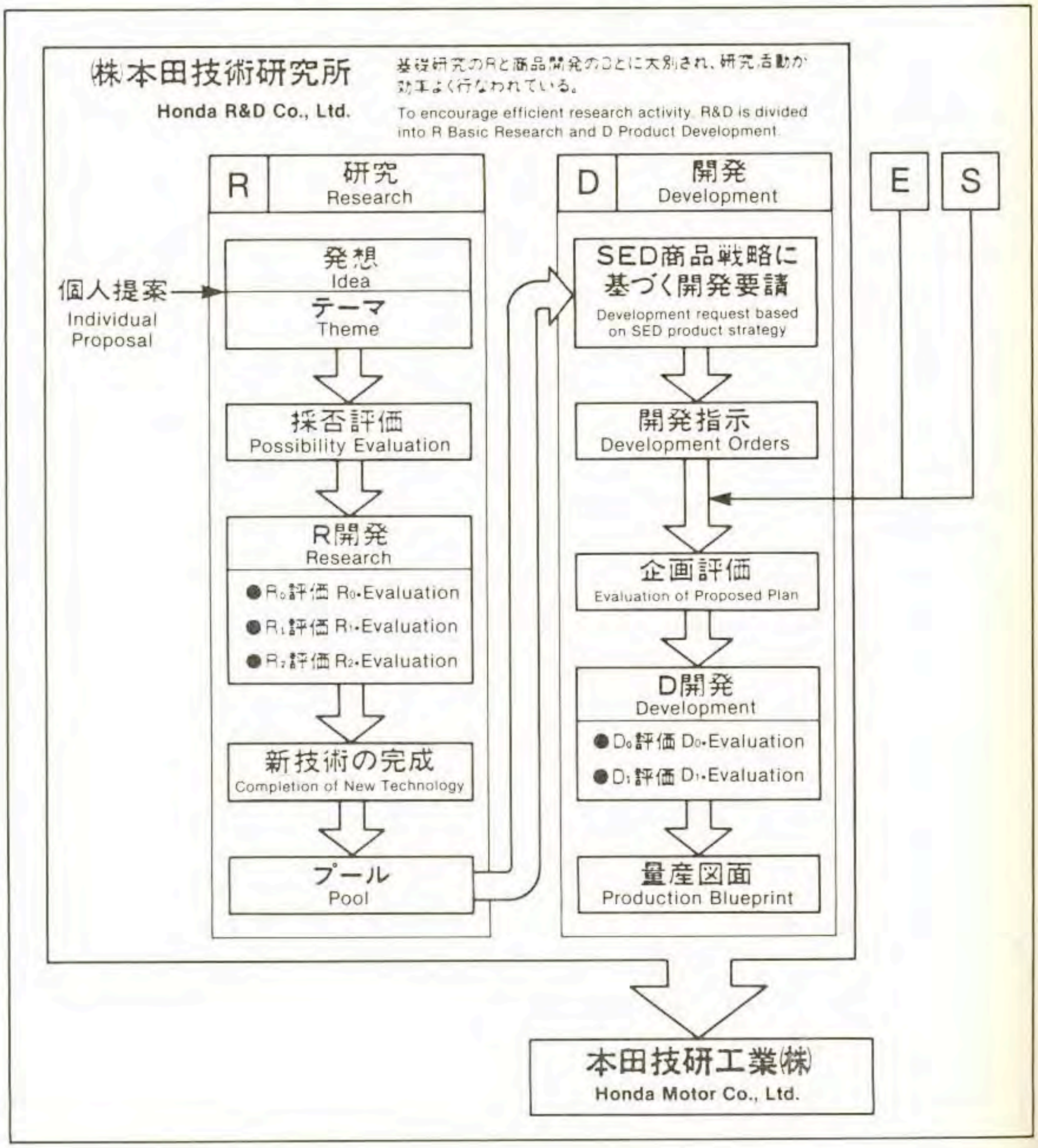
Figure 8-3 is a listing of the functional backgrounds of the key team members for the five development projects we analyzed.

Overlapping Development Phases

The group dynamics of the self-organizing team strongly influence the manner in which the development project proceeds. The autonomous, self-transcendent, cross-fertilizing nature of the group produces a unique set of dynamics. For example:

- Cohesion is promoted as team members face some challenging goals. The broad nature of the goals also helps to alleviate detailed differences.

Figure 8-2
Development System at Honda



- Ambiguity is tolerated, given the diverse backgrounds of the group.
- Overspecification is avoided, since it may impair creativity.
- Sharing of information is encouraged so as to become better acquainted with the realities of the market.
- Decision making is intentionally delayed to extract as much up-to-date information as possible from the marketplace and technical communities.
- Sharing of responsibility is accepted as the group embarks on a risk-taking mission.

Figure 8-3
Functional Background of the Key
New Product Development Team Members[a]

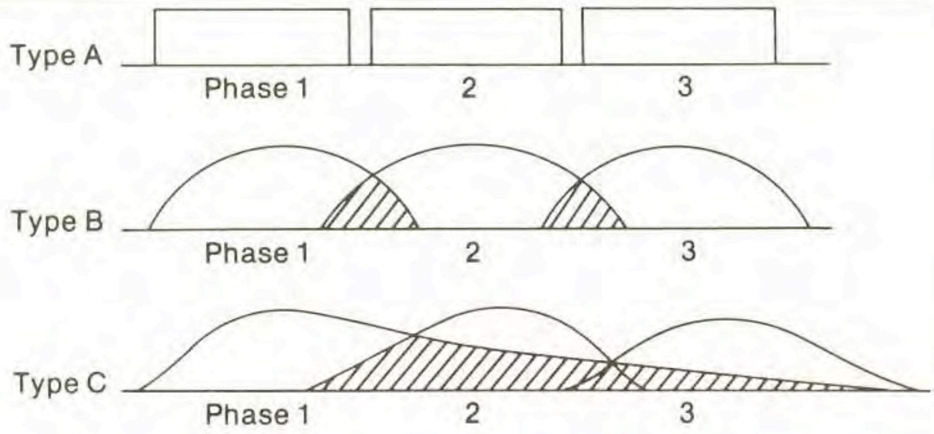
Company \ Functional Background[b]	R&D	Production	Sales	Planning	Service	Quality control	Others	Total
Fuji-Xerox	5	4	1	4	1	1	1	17
Honda	18	6	4	–	1	1		30
Canon	12	10	–	–	–	2	4	28
NEC	5	–	2	2	2		–	11
Epson	10	10	8	–	–		–	28

a. Numbers indicate number of key team members.
b. Designates the assignment prior to joining the new product development team.

These dynamics help to explain why phase management in the Japanese companies we investigated tends to be holistic and overlapping rather than analytical and sequential. Variety reduction is delayed as long as possible in these companies as the self-organizing team engages itself in the search for information—from both the marketplace and the technical communities—and in an iterative process of experimenting even at the very late phases of the development process. As mentioned earlier, variety reduction under the analytical/sequential approach is conducted more systematically, and as early as possible.

A simplified illustration of the overlapping nature of phase management is depicted in *Figure 8-4*. The sequential approach, labeled Type A, is typified by the NASA-type phased program planning (PPP) system adopted by a number of U.S. companies. Under this system, a new product development project moves through different phases—for example, concept, feasibility, definition, design, and production—in a logical, step-by-step fashion. The project proceeds to the next phase only after all the requirements are satisfied, thereby minimizing risk.

Figure 8-4
Sequential (A) versus Overlapping (B and C) Phases of Development



But, at the same time, a bottleneck in one phase can slow down the timetable of the entire development process. The overlapping approach is represented by Type B, in which the overlapping occurs only at the interface of adjacent phases, and Type C, in which the overlapping extends across several phases. The product development process at Fuji-Xerox and Honda is closer to Type C than to Type B.

The overlapping approach has its merits and demerits as well. The more obvious merits include: faster speed of development, increased flexibility, and sharing of information. It also leads to a more subtle, but equally important, set of merits dealing with human resources management. Among others, it helps to do the following:

- Foster the more strategic point of view of a generalist
- Enhance shared responsibility and cooperation
- Stimulate involvement and commitment
- Sharpen a problem-solving orientation
- Encourage initiative taking
- Develop diversified skills
- Create grounds for peer recognition
- Increase sensitivity of everyone involved to changes in market conditions

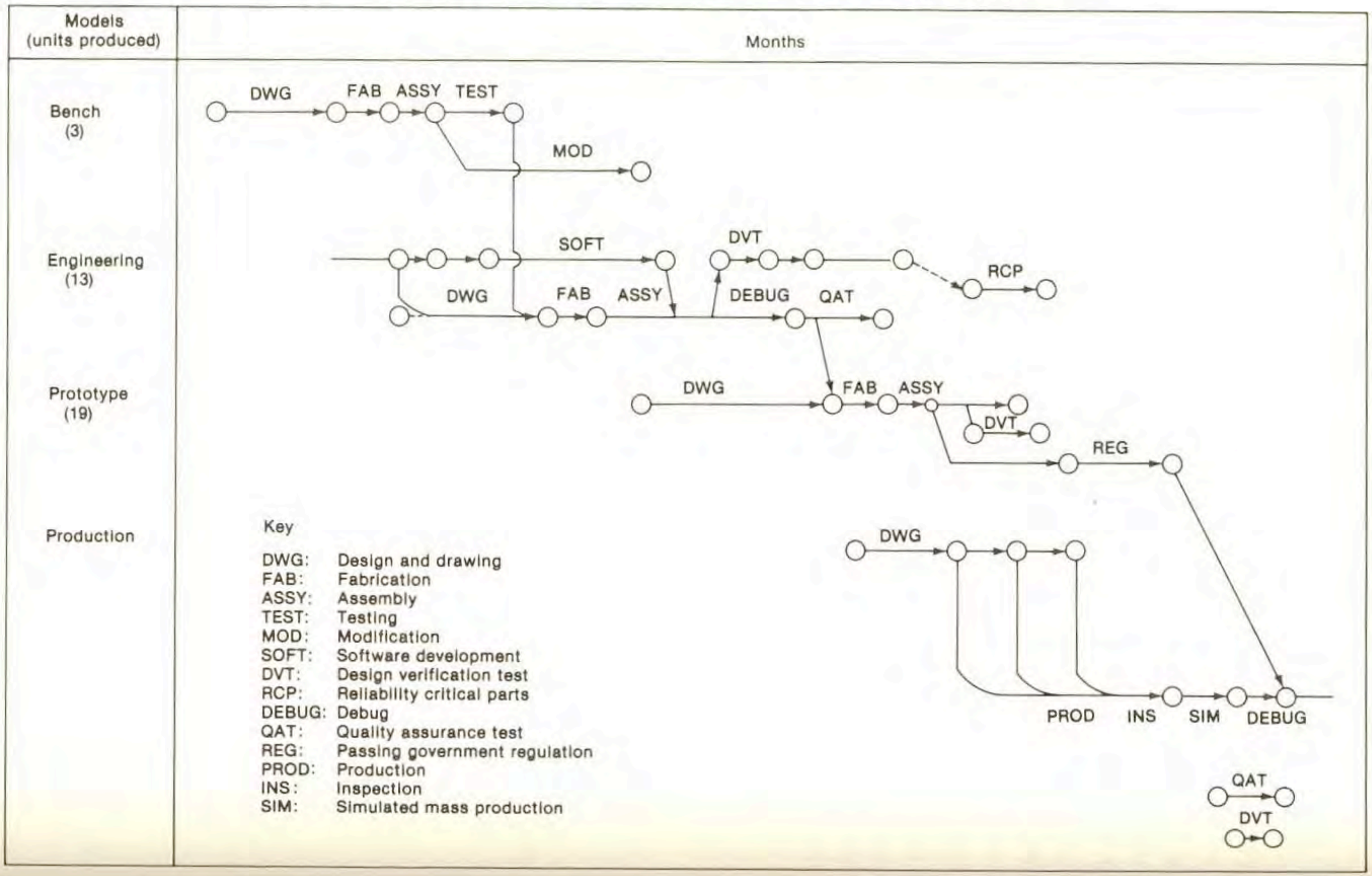
On the other hand, the burden of managing the process increases exponentially. By necessity, the overlapping approach amplifies ambiguity, tension, and conflict within the group. The burden of coordinating the intake and dissemination of information rises as well, as does the responsibility for management to carry out on-the-job training on an ad hoc and intensive basis.

The loose coupling of phases also makes division of labor, in the strict sense of the word, ineffective. Division of labor works well in a Type A system where the tasks to be accomplished in each phase are clearly delineated and defined. Each project member knows his or her responsibility, seeks depth of knowledge in a specialized area, and is evaluated on an individual basis. But such segmentalism, to use Kanter's terminology,[11] works against the grain of a loosely coupled system (that is, Type B and Type C) where the norm is to reach out across functional boundaries as well as across different phases. Project members are expected to interact with each other extensively, to share everything from risk, responsibility, information, to decision making, and to acquire breadth of knowledge and skills. Under a loosely coupled system, then, the tasks can only be accomplished through what we call "shared division of labor." This shared division of labor takes place not only within the company but also with outside suppliers. We witnessed varying degrees of coupling or overlapping among the Japanese companies:

- Fuji-Xerox revised the PPP system, which it inherited from the parent company, in two respects. First, it reduced the number of phases required to develop FX-3500 from six to four by redefining some of the phases and aggregating them differently. Second, a linear, sequential system was changed into what Mr. Kobayashi referred to as a "sashimi" system. Sashimi—or sliced raw fish—is served in Japan by tilting the slices and placing them on a plate with one piece overlapping another. (See *Figure 8-5* for a detailed graphic representation.) Such a system requires extensive social interactions on the part of all those involved in the project, as well as the existence of a cooperative network with suppliers. On this latter point, a project member in charge of design commented as follows: "We ask our suppliers to come to our factory and start working together with us as early in the development process as possible. The suppliers also don't mind our visiting their plants. This kind of mutual exchange and openness about information works to enhance flexibility. Early participation on the part of the supplier enables them to understand where they are positioned within the entire process. Furthermore, by working with us on a regular basis, they learn how to bring in precisely what we are looking for, even if we only show them a rough sketch. When we reach this point, our designers can simply concentrate on work requiring creative thinking." As a result of these efforts, Fuji-Xerox was able to shorten the development time from thirty-eight months on a similar prior model to twenty-nine months for FX-3500.

Figure 8-5

Overlapping Nature of the Development Schedule at Fuji-Xerox



- Canon experienced several conflict situations as the Auto Boy development proceeded with an extensive degree of overlapping. One project member recalled: "Someone from development thinks that if one out of 100 is good, that's a clear sign for going ahead. Someone from production thinks that if one out of 100 is not good, we've got to start all over. That gap has to be narrowed. But both sides have absolutely no question in their minds that the conflict can be resolved." Conflict induces high levels of social interaction, which in turn gives rise to creative solutions, according to the same project member: "The design people keep a watchful eye on the entire project to make sure that their original design becomes converted into a truly good product at the very end. The production people, on the other hand, try to come to grips with what the designer had in mind by asking themselves, 'Why did he do it this way?' Creative solutions are born by each side intruding on the turf of the other." This mutual "reaching out" enabled Canon to remain flexible even under intense conflict situations.
- Honda's City team adopted what we decided to call a "rugby" approach toward product development. Mr. Watanabe explained: "I always tell my team members that our work cannot be done on the basis of a relay. In a relay someone says, 'My job is done, now you take it from here.' But that's not right. Everyone has to run the entire distance. Like in rugby, every member of the team runs together, tosses the ball left and right, and dashes toward the goal." The important point to remember here is that critical problems occur most frequently at relay points within the sequential approach. The "rugby" approach smoothes out the process by involving everyone in the development project. Individual initiative is also a prerequisite, argued Mr. Kawamoto: "If each and every one of us does his or her job well, then we basically won't need a structure." In fact, we found that Honda's project members deviated freely from the step-by-step structure for product development, shown in *Figure 8-2*.

Multilearning

The five Japanese companies in our study have another commonality that became increasingly clearer as our study progressed. They possess an almost fanatical devotion to learning—both within organizational membership and with outside members of the interorganizational network. To them, learning is something that takes place continuously in a highly is neither new nor original. Lawrence and Dyer, for example, point this out as follows: "Japanese management does not now need to be convinced, if it ever did, that their organizations are learning and social systems as well as production systems."[12]

What is somewhat new and original is the discovery that learning plays a key role in enabling companies to achieve speed and flexibility within the new product development process. Continuous interactions with outside information sources, for instance, allow them to respond rapidly to changing market preferences. The iterative process of trial-and-error or learning-by-doing gives considerable degrees of freedom in responding to outside challenges or to challenging goals emanating from within. The constant encouragement to acquire diversified knowledge and skills also helps to create a versatile team capable of solving a wide array of problems in a relatively short period of time.

Broadly speaking, learning manifests itself within the organization along two dimensions: across multiple levels, and across multiple functions. We decided to refer collectively to these two types of intrafirm learning—that is, multilevel and multifunctional—as "multilearning."

We witnessed Japanese companies promoting learning at three levels—individual, group, and companywide. Examples of each are described below:

- Epson encouraged learning at the individual level to develop as many generalists within the company as possible. Mr. Aizawa, executive vice president in charge of R&D, stressed this point when he said: "I have been telling my development staff members that they need to be both an engineer and a marketer in order to be promoted within our firm. Even in an engineering company like ours you can't get on top without the ability to foresee future developments in the market."
- Honda fostered learning within the production group by establishing a special corner within the factory where the rank-and-file workers could experiment with work simplification ideas during normal working hours, using tools and materials provided by the company. Referred to as the "handmade automation" program, it has been instrumental in elevating the skill levels of workers in the manufacturing group and in positioning automation within the minds of the workers as a positive force that could make their work simpler and safer.
- Fuji-Xerox utilized the TQC (Total Quality Control) movement on a companywide basis as a means of learning how to bring about a

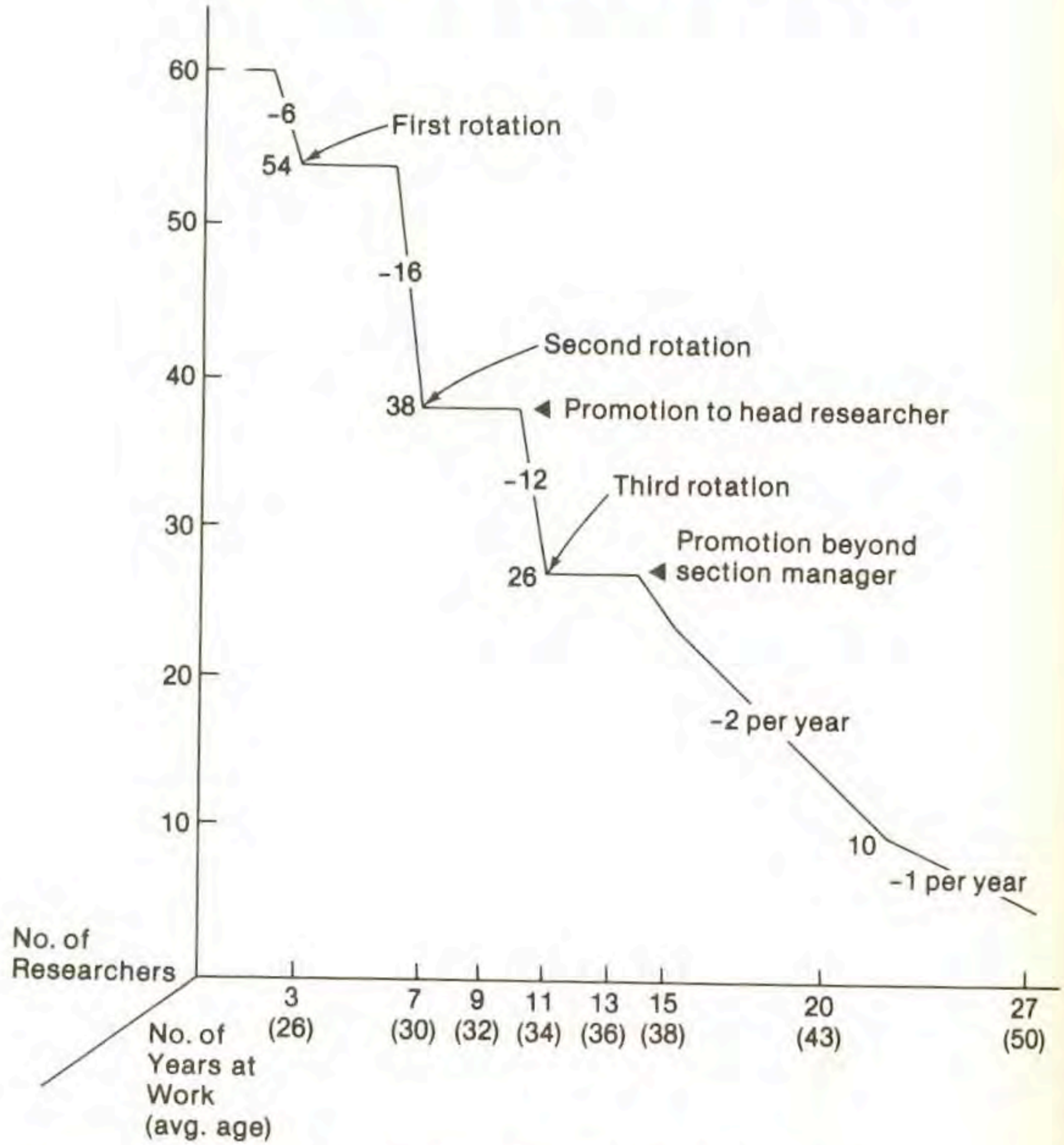
more creative and speedy new product development process. The switch from the PPP system to the "sashimi" system came about as a result of the TQC movement.

We also witnessed Japanese companies treating "learning in breadth," or learning across functional lines, as the cornerstone of their human resources management program. Several examples of this very pervasive practice include the following:

- All of the project members who developed Epson's first miniprinter (EP-101) were mechanical engineers. They knew very little about electronics at the start of the project. In fact, Mr. Aizawa, also a mechanical engineer by training, returned to his university and studied electrical engineering for two years as a special researcher while trying to serve as the project leader of the EP-101 team. All project members were well versed in electronics by the time EP-101 was completed.
- A small group of sales engineers from the Electronic Devices Division, who originally sold microprocessors, were responsible for developing NEC's PC 8000. They acquired much of the necessary know-how by (1) putting TK 80, a computer kit, on the market two years prior to the PC 8000 introduction; (2) setting up an NEC service center called BIT-IN in the middle of Akihabara, a consumer electronics center in Tokyo, soon after introducing TK 80; (3) stationing themselves for about a year, even on weekends, at BIT-IN; and (4) interacting with hobbyists who frequented BIT-IN, which almost became a "club," and extracting as much useful information from them as possible.
- Mr. Nakamura, who had recently become a department manager of the assembly line operation at Honda's motorcycle plant in Suzuka, said that the recent lateral move took him by surprise. He admitted: "After all, I was in the painting operation for twenty-two years. I guess management wanted some change. But for me, it meant learning everything all over again from scratch."

Honda also has a so-called "practical training" program in which all department managers, like Mr. Nakamura, are asked to select a functional area in which they have never worked before and to spend one week every two years "getting their hands dirty." NEC enhances mobility across functional lines by transferring technical people from its R&D center to its divisions. As Mr. Miya, director of R&D, noted: "When a researcher starts producing results, the division comes to us and says, 'Give us that person.' Our current president started out in

Job Rotation Plan of R&D Researchers at NEC[a]



a. Job rotation of newly hired graduates with a master's degree.

R&D and was transferred to the division." NEC's rotation plan, shown in *Figure 8-6,* calls for a transfer of more than half of the newly recruited researchers (holding a master's degree) from R&D to the divisions at the end of about ten years and more than 80 percent after twenty years. Canon also utilizes similar programs of employee exchange and job rotation to encourage its employees to become "U-shaped" individuals—that is, individuals with a broad base of skills and knowledge.

Other personnel policies commonly found in Japanese companies—such as long-term employment and group evaluation—also foster multifunctional learning. Long-term employment makes the rotation of valuable lessons from the past possible. Since people do not leave the company, members of a project team can easily seek out past "stars" and extract words of wisdom from them. Group evaluation enhances interactions within the group and fosters sharing of skills and know-how among each other.

From management's point of view, a new product development project offers an ideal springboard for creating a group of employees with broad skills and knowledge and an organizational climate conducive to bringing about change. But from the team members' point of view, multilearning requires an extraordinary amount of effort and dedication. Of course, it helps to have the rails already laid out (in the form of personnel policies that facilitate multilearning). It also helps to be working with a self-organizing team, a crisis situation, and an overlapping system of development. But management did not happen to find these supporting factors by chance. Rather, management made them happen.

Subtle Control

Some checks are needed to prevent looseness, ambiguity, tension, or conflict from getting out of control. These are manifested within the five companies we studied in subtle forms of control, rather than in more formal or systematic forms. Consistent with the self-organizing nature of the team, the emphasis is on self-control and on control through peer pressure or "control by love." More specifically, management uses selection of team members, openness in working environment, sharing of information, group-oriented evaluation, and sharing of values as a mechanism for implanting subtle control within the product development process. Each of these mechanisms is discussed below.

First, management implants the seeds of control by selecting the right people onto the project team, constantly monitoring the balance in team membership, and adding or deleting specific members if deemed necessary. For example:

- Honda handpicked team members mostly in their twenties to develop the youth-oriented City. As Mr. Kawamoto noted: "It's our responsibility to assign the right individuals to the appropriate positions. We also need to monitor the project closely and transfuse new blood midstream into the project. An elderly or conservative member may be added to the team when the balance shifts too dangerously toward a radically new approach. Or an engineer with a different technical background may be added when the project appears to have hit a stalemate."[13]

- Mr. Yoshino, who supervised the FX-3500 project, recalled: "When the design manager was assigned, I told him to give me the names of people he'd like to have. It wasn't 100 percent, but we were able to uproot the people we wanted with a probability of about 90 percent. And if we thought that someone was not living up to our expectations, I'd send the word out to have that person replaced midstream in the process."

Second, subtle control is exercised in the form of an open and visible working environment. For example:

- Honda enhances visibility by holding meetings in a large room with glass walls. "We can see what other people are up to," commented a City team member. This philosophy is also reflected at the executive level, where all the top executives have desks in one large room and hold meetings (among themselves and with those reporting to them) around three round tables situated in the center of that large room.
- Fuji-Xerox also espouses this so-called "large-room" system. Mr. Suzuki, a project member for FX-3500, gave the rationale for this system as follows: "When all the team members are located in one large room, someone's information becomes yours even without trying. You then start thinking in terms of what's best or second best for the group at large and not only about where you stand. If everyone understands the other person's position, then each of us is more willing to give in or at least try to talk to each other. Initiatives emerge as a result."

Third, management implants seeds of subtle control by encouraging team members to extract as much information from the field—from customers and competitors—and, more importantly, to bounce them off other members. This sharing of information helps to keep everyone up to date, build cohesion within the group, and act as a source of peer pressure:

- Fuji-Xerox encourages its design people to go out into the field to talk with users and suppliers during slack periods. A member of the design team commented: "We go out into the field to listen to the voice of our customers, study our competitors' models, or search for any useful research findings. As a result, we are in a better position to finalize the product concept as we see fit and to respond to what a planner has to say about quality, cost, or delivery time.

We try to digest what we sensed in the field and have it reflected in the design. This exposure helps in a lot of ways. For example, a designer may be tempted to take the easy way out at times, but he may reflect on what the customer had to say and try to find some way of meeting that requirement. Even if we get into an argument, we can go back to what we saw and heard in the field and build a consensus around our common experience. As you can see, we're constantly trying to find ways of feeding back the demands from the field into the design of the product."

- Sharing information about competition also helps to push the project to a higher level. As the same member of the Fuji-Xerox design team observed: "The development process in Japan is characterized by a daily influx of information about competition. This information exerts pressure which, in turn, acts as a driving force for us to do better. I wonder if this kind of pressure we feel in Japan—i.e., pressure every day by every member of the team—is felt in the U.S. as well."

Fourth, the Japanese evaluation system, which is based on group rather than individual performance, serves as another form of subtle control. Such a system encourages the formation of a self-organizing team and fosters multilearning among the team members. It also helps to build trust and cohesion, on the one hand, and peer pressure, on the other.

Lastly, management exerts subtle control by establishing some overriding values shared by everyone in the organization. These values or basic beliefs give people within the organization a sense of how to behave and what they ought to be doing. The shared value at NEC is "C & C," which stands for "Computer and Communication." NEC, which started out as a communications company, has made major inroads into the computer business under this slogan. The shared value at Canon is to become a "superior company." It is now in the second phase of the "superior company" plan, whose core theme is the strengthening of its R&D capability. The shared value at Epson, which is "thinking the unthinkable," sets a very aggressive pattern for product development, as exemplified by the unwritten "40 percent improvement" rule.

Organizational Transfer of Learning

We noted earlier that all those involved in the development project are engaged in a constant process of learning, across both levels and functions. The know-how accumulated at the individual level is transferred to other divisions or to subsequent projects within the organization and becomes institutionalized over time. Lawrence and Dyer describe this process as follows:

> It is true. . .that members of an organization cannot only learn as individuals but can transmit their learning to others, can codify it and embody it in the standard procedures of the organization. In this limited sense, the organization can be said to learn. When certain organizational arrangements are in place, an organization will foster the learning of its members and take the follow-up steps that convert that learning into standard practice. Then it is functioning as a learning system, generating innovations.[14]

We observed the process of institutionalization most vividly within Fuji-Xerox and Canon:

- The FX-3500 project was instrumental in making self-development the standard practice within Fuji-Xerox. Prior to this project, new product development was synonymous with conversion engineering, in which a basic U.S. model was converted into a Japanese one through minor engineering modifications. As mentioned earlier, self-development was accompanied by major process improvements, including the condensing of phases from six to four.
- Canon established a model for new product development through the AE-1 project and refined it in the Auto Boy project. Prior to these projects, Canon did not have a standardized format for new product development. One former member of the Auto Boy project team recalled: "When we were developing Auto Boy, we used to meet once a month or so to exchange notes on individual subprojects in progress, and once in three months or so to discuss the project from a larger perspective. We didn't know it at the time, but the pattern became institutionalized into monthly and quarterly progress reviews later." The know-how accumulated in these two camera projects was transferred to the Business Machines Group when it developed PC-10, a personal or microcopier introduced in 1982. Project members for the PC-10 sought out previous leaders of the AE-1 and Auto Boy projects to extract as many live lessons as possible.

The importance of having a role model within the organization is emphasized by Mr. Kawamoto of Honda as well: "Leave the organization somewhat untidy and leave sufficient room for self-growth to emerge. Everyone will be able to see that one team is doing something outstanding. There's no need for everyone to be doing it, but one outstanding example will set the standards for others." But since these teams are dissolved after the product is developed, whatever learning takes place is carried over to the next generation through individual team members. Mr. Kawamoto continued: "If the factory is up and running and the early-period claims are resolved, we dismantle the project team, leaving only a few people to follow through. We only have a limited number of very able people, so we turn them loose to another key project immediately."

Besides passing down "words of wisdom" from the past and establishing standard practices within the organization, we also noticed a simultaneous attempt on the part of Japanese companies to "unlearn" the lessons of the past and to engage themselves in a continuous process of what Schumpeter called "creative destruction." This process of unlearning helps to prevent the development process from becoming too rigid. It also acts as the springboard for making further incremental improvements. For example:

- Fuji-Xerox has been reviewing and refining its "sashimi" approach toward product development. Compared with the days of the FX-3500, the manpower required to develop a comparable new product today has been reduced to about one-half and the product development cycle to twenty-four months. Among other things, it allowed suppliers to participate from the early stages of development and eliminated the prototype production phase from the development process.
- Mr. Aizawa of Epson described the continuous nature of the development process as follows: "We have this constant fear that we're going to be left behind. That's why we want to have a product in test production when a new product is being introduced in the market." Epson always approaches a new product idea from two opposing points of view. One idea is pitted squarely against another even when developing the next generation model of a successful product already on the market. This approach opens the door for unlearning to take place and helps to maximize flexibility within the development process.
- Honda had to unlearn the lessons from the past to develop a totally new concept of cars. Mr. Watanabe recalled: "At one point in time, we had a choice between a modified version of Civic or a totally different 'short and tall' car. We opted for the latter, knowing full well the risks involved."

We also observed that much of the unlearning is triggered when a new crisis from the market environment confronts the organization.

What used to work in the past is no longer valid, given the changes in the external environment. To adapt to these changes, the challenge is to retain some of the useful learning accumulated from the past and, at the same time, throw away that portion of learning which is no longer applicable. In this regard, we agree with Levitt, who says that "translation of knowledge into results is almost surely a matter of 'tinkering' and, more importantly, a matter of management."[15]

Interorganizational Network

Six intrafirm factors that lead to speedy and flexible new product development processes in Japan have now been examined. To use a mundane analogy, we have just completed looking at the inside of the house we are interested in buying. To stop here is like deciding to buy a house without even looking at the outside. This section of the paper examines the impact of the outside—that is, outside suppliers and the interorganizational network surrounding our five companies—on new product development. Our study shows that interorganizational factors make just as important a contribution as intrafirm factors in speeding up the new product development process, as well as in making it more flexible.

What do we mean by an interorganizational network? The concept may still be somewhat foreign to many U.S. executives, although Schonberger observes the following: "In the past few years U.S. executives have been exposed to news stories on the Japanese success phenomenon, including stories on the Japanese tendency. . .to rely heavily on extensive networks of suppliers."[16]

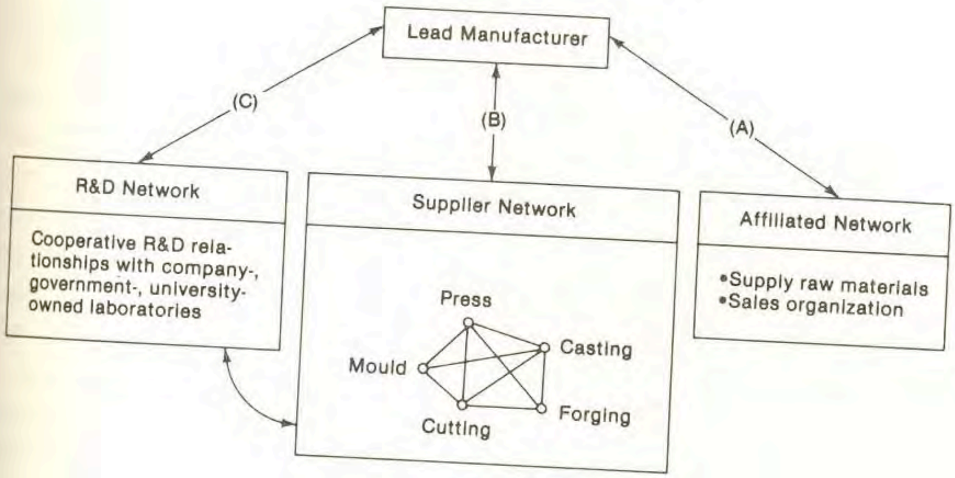
Most of the large Japanese companies in the machinery business, including our five sample firms, utilize an interorganizational network similar to the one presented in *Figure 8-7*. The overall framework consists of three separate networks:

(A) Affiliated network: consists of affiliated companies that supply raw materials and parts or serve as sales organizations. Honda, for example purchases parts from outside vendors, such as Nippon Denso, but also buys from its affiliated companies such as Keihin Seiki and Yachiyo Kogyo.

(B) Supplier network: consists of small- and medium-sized companies that manufacture and process parts. These companies are also starting to take the initiative of developing and test-producing their own parts.

(C) R&D network: consists of research institutions (either com-

Figure 8-7
Interorganizational Network



pany-, government-, or university-owned) with a cooperative relationship on R&D.

Of these three, we will focus our attention on the supplier network in this chapter, since it has the most direct impact on the speed and flexibility of new product development.

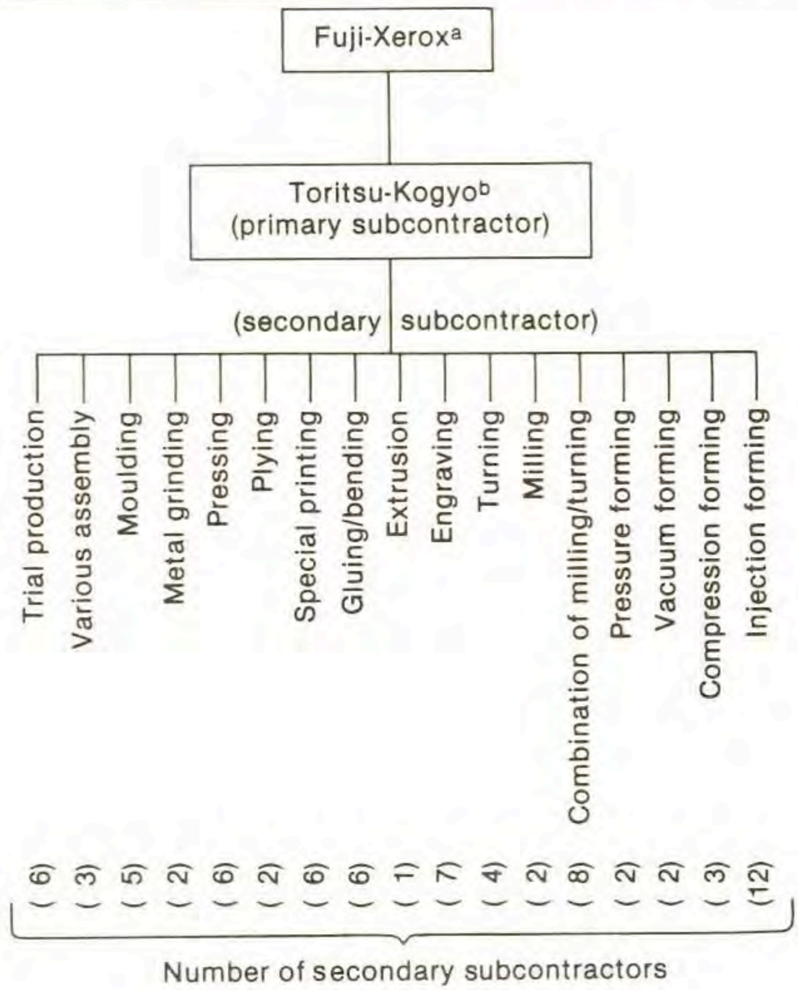
To cite a specific example on how a supplier can speed up product development, consider the progress made by two vendors of Fuji-Xerox in shortening the delivery time for some parts, as shown in *Table 8-3*. Both vendors have been able to reduce the delivery time at least by one-half between 1978 and 1983.

To illustrate how flexibility can be achieved, consider how the supplier network is structured for Fuji-Xerox (see *Figure 8-8*). Toritsu-Kogyo, one of its primary subcontractors, operates a factory of its own

Table 8-3
Time Required to Deliver Parts to Fuji-Xerox

	Model/Year			
Vendor/Part	*Model 3500 1976*	*Model 4800 1978*	*Model 4370 1981*	*1983*
Dengen Automation, Inc.				
Bench model	10 mos.	6 mos.	—	3–4 mos.
Feasibility model	4 mos.	4 mos.	2 mos.	2 mos.
Sanyo Seisakusho, Inc.				
Specific part (A)		1.5 mos.	1 mo.	3 wks.
General part (B)		4 wks.	3 wks.	2 wks.

Figure 8-8
Interorganizational Network for Fuji-Xerox



a. Has other primary subcontractors.
b. Serves as subcontractor for other manufacturers.

and utilizes seventy-seven secondary subcontractors. A large number of these subcontractors are located within walking distance from Toritsu-Kogyo. Toritsu-Kogyo is a fairly large subcontractor, by Japanese standards, with sales of about 7 million and fifty employees, while most of the secondary subcontractors have fewer than ten employees. A clear-cut division of labor sets in as each secondary subcontractor tries to differentiate itself from the rest according to two criteria. The first differentiation occurs on the basis of the seventeen skills shown in *Figure 8-8*. The second differentiation takes place on the basis of products handled. The six secondary subcontractors in pressing, for example, may each handle a different-sized product.

Because of this division of labor, each secondary subcontractor acquires a high level of technological skill in one specialized area, as well as a high level of competence in problem-solving. Thus, secondary subcontractors can respond very quickly to special requests made by either Toritsu-Kogyo or Fuji-Xerox, and can adapt very effectively to changes in the environment.

Fuji-Xerox can consider these secondary subcontractors as highly specialized and skilled task forces possessing up-to-date information who can be called into the product development process when necessary. All seventy-seven of these task forces can be mobilized very quickly since they are physically located in one general area. They can be mobilized in any combination or in any sequence as Toritsu-Kogyo selects and coordinates the most appropriate secondary subcontractors for the job at hand.

An understanding of how the network is structured is a prerequisite for studying the dynamic process by which speed and flexibility are achieved within the supplier network. The general conceptual framework for analyzing the intrafirm process presented earlier (*Figure 8-1*) applies, to a large extent, to the interorganizational process as well. Suppliers also adapt to changes and uncertainties in the market environment through an iterative process of variety reduction and learning-by-doing. The similarities as well as some differences are discussed below to further understanding of how a supplier network can contribute to new product development.

Self-organizing Network

Various supplier networks emerged in Japan during the postwar economic boom as a natural response to the expansion in the market size for goods and services. One similarity of these interorganizational networks to the intrafirm development teams is the self-organizing manner in which they both emerged. For one thing, supplier networks are made up of autonomous firms that gathered around the lead manufacturer's plants, most of which were located in Tokyo because of its development in the postwar period as the focal market for most goods and services. So it was only natural for the suppliers to locate in Tokyo as well, since that proximity would bring several mutual benefits, such as shorter delivery time, lower inventory carrying costs, lower transportation costs, and improved communication.[17]

The number of these Tokyo-based suppliers grew rapidly, as expert machinists with an entrepreneurial flair left their positions in larger companies to start up their own ventures. Each supplier, equipped with a unique set of skills, would initially enter the market in a small way by finding a particular niche. As these ventures grew, some of the more talented employees would create spin-offs by developing new skills or mastering a new technology. Since these employees were usually treated like members of the extended family, their former bosses viewed these spin-offs as a natural course of events, like a child leaving home to become independent. Some would even go as far as lending financial support.

These spin-offs are also viewed positively by the lead manufacturer. They generally raise the overall level of skills and technology within the network as each start-up company enters the market with some sort of incremental improvement. As the number of narrowly focused firms proliferates, they also give the lead manufacturer a greater degree of freedom in selecting a subcontractor.

In addition to being autonomous, these small firms possess a strong motivation to constantly upgrade their skills or technology, thereby satisfying the second qualification for self-organization (self-transcendence). Most of the suppliers pride themselves on running a flexible operation capable of producing special-order or experimental items at short notice. But each time the lead manufacturer makes very tough demands—shorter delivery time or higher technical content—the suppliers have to overcome the status quo and reach out for something higher.

The third qualification for cross-fertilization is also evident as suppliers with differentiated functional skills, technological backgrounds, and behavior patterns are assembled in one general location to form a loosely coupled network. Although these suppliers are autonomous units, we observed substantial degrees of social interaction, open communication, and information exchange taking place among them.

Shared Division of Labor

Self-organization fosters variety amplification as the number of start-ups and spin-offs proliferates within the process. Variety reduction takes over as these autonomous units form a loosely coupled network and begin to exercise shared division of labor. Recall how members of the development team reached out across functional boundaries, interacted with each other, and shared risk, responsibility, and information among themselves. A similar phenomenon occurs among members of the supplier network as well.

Each supplier knows that it cannot survive on its own. Its survival is very much a function of how well it can coexist with others within the network. To coexist, each supplier has to think of the common good and behave like a team player. But coexistence alone does not ensure growth. Each member has to sharpen its own skills, and at the same time, mutually support the continuity of the network at large. Mutual support is enhanced through tightly knit interactions among the members on a day-to-day basis to exchange relevant business information and ideas. Continuity is maintained by establishing a system of shared division of labor among the network members.

The Fuji-Xerox network, presented in *Figure 8-8*, shows how seventy-seven secondary subcontractors are organized to perform seventeen separate functions for Toritsu-Kogyo. A clear-cut division of labor is in place as each of the seventy-seven specializes either on the basis of function performed or product type handled. The Toritsu-Kogyo example may suggest that the network is composed only of subcontractors with very specialized skills. But a separate group of subcontractors who handle standardized processing is also in existence. Such nonspecialized subcontractors take part in the division of labor by working on evenings or holidays to speed up the overall process.

The shared nature of division of labor can be graphically represented by taking the static organization chart shown in *Figure 8-8* and overlaying horizontal lines interconnecting the seventy-seven subcontractors. In other words, these subcontractors are mutually dependent and are in constant interaction with each other. A considerable amount of reaching out takes place as they try to share risk, responsibility, and information. For the entire network to be effective (or to put it differently, for each subcontractor to survive), the subcontractors need to run together like a rugby team, maintaining cohesiveness and balance.

A company's new product development project benefits from the existence of an interrelated group of specialized suppliers on the outside. It is in a position, for example, to invite specific suppliers to join the project team in the early phases of the program to develop or test produce some parts. In the case of Fuji-Xerox, 90 percent of the parts used during test production are manufactured outside. In the later phases of the project, including mass production, it can rely on the primary subcontractor to select and control the right number of qualified secondary subcontractors. This delegation of authority to someone outside adds another level of flexibility to the new product development process. All of the Japanese companies in our study rely heavily on outside suppliers to produce parts at the mass production stage. The percentage of parts produced outside for our units of analysis (that is, FX-3500, City, and so forth) were roughly 90 percent for Fuji-Xerox, between 70–75 percent for Honda, about 65 percent for Canon, over 70 percent for NEC, and 70 percent for Epson.

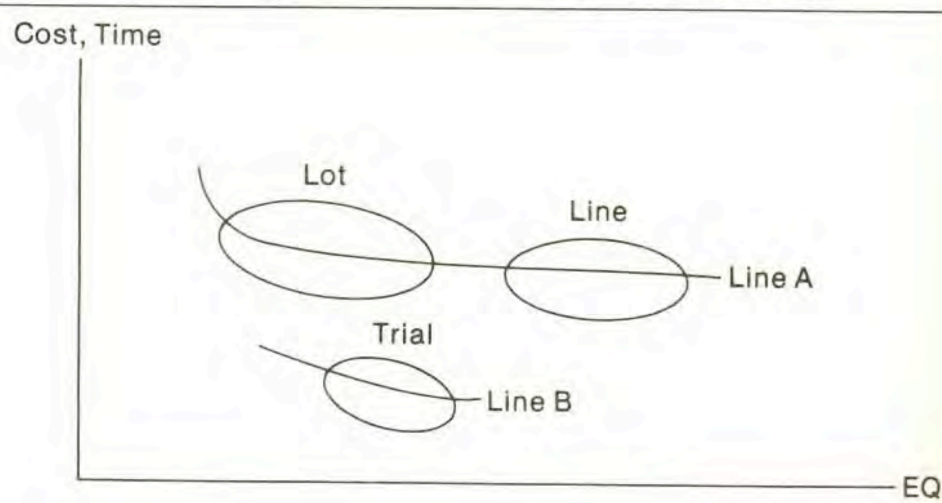
We noted earlier that learning at the intrafirm level played a key role in enabling companies to achieve speed and flexibility within product development. The same conclusion can be drawn about learning at the interorganizational level, although the nature of learning is quite different at the two levels. In the former, learning (or multilearning as we called it) has a strong human resources management orientation, whereas learning at the latter has a straightforward economics orientation.

We know that learning takes place within the production process in the form of lower costs as the production volume increases over a given period of time. This so-called "learning curve effect" takes place, albeit to a lesser extent, among subcontractors as well. We observed a learning curve among them, both for lot production and for line production, indicated by line A in *Figure 8-9*.

Can we expect a similar learning curve effect during trial production? In general, the answer is no, since requests for a bench model or a prototype come a little at a time and trial production volume is low. But subcontractors within the supplier network are an exception. They are able to realize a learning curve effect even for bench models.

This exception is made possible through what we call "learning in arrangement." Although numerous companies order bench models and their specifications call for different shapes and sizes, many of the orders require the same production technology and skill. So the basic difference boils down to the materials used and the arrangement of work flow. Thus, if learning can take place in how to arrange the work flow effectively, some savings in cost and time are possible. Even if

Figure 8-9
Learning Curve Effect among Subcontractors



different types of bench models are being produced, the production process can be made to run continuously without having to halt every time a new bench model is introduced.

A supplier network facilitates learning in arrangement for the following reasons. First, several suppliers that specialize in prototype production exist within the network. In the supplier network for Fuji-Xerox, six such subcontractors were present (see *Figure 8-8*). Second, since each of these six specialized further according to the types of products handled, members of the network knew which type of prototype to send to whom. Third, this specialization allows the subcontractors to receive the same kinds of orders from numerous sources, thereby giving them some advantage in volume. Fourth, the geographic concentration of these specialized subcontractors in or near Tokyo prompts referrals from other companies outside the network.

Lower costs and time—achieved through learning at an early phase of product development—have a positive impact on the overall process. The manufacturer is induced to experiment with a wide variety of prototypes, thereby keeping flexibility at the maximum. At the same time, it speeds up the development process.

Information Exchange

As noted earlier, members of the supplier network try to build mutual support by actively interacting with each other and exchanging as much useful information as possible. These exchanges help them to keep abreast of the most recent developments in the marketplace and the technical community. They also expedite the development process, as suppliers can have vital parts ready just in time for the manufacturer.

Information exchange takes place both laterally and vertically. Lateral exchange in the case of Toritsu-Kogyo occurs among its seventy-seven secondary subcontractors. These subcontractors share several commonalities that facilitate the flow of information. First, they all work for the same primary subcontractor. Second, their factories are located within walking distance from each other in downtown Tokyo. Third, most of the owners live there as well, which means that they can be in touch with each other even after working hours. Fourth, almost all of the owners are machinists by training and, therefore, share similar backgrounds. Fifth, they tend to share a trait typical of downtown Tokyo when communicating with each other—to use few words and be as straightforward as possible.

Lateral flow of information is also intensified as a result of the "weak tie nature of the way in which the secondary subcontractors are organized. Previous research has shown that a weak tie makes a faster and broader exchange of information possible.[18] Those who emit the information feel free to say whatever they please on a wide variety of topics; they feel it is the responsibility of those receiving the information to screen out and digest what they have heard. Contained in this kind of free-wheeling exchange is "leading-edge" information on what is happening in the marketplace and the technical community, as well as hints on how to improve existing products or what new products to develop in the future.

Vertical information exchange occurs within the three levels of hierarchy—the lead manufacturer, primary subcontractor, and secondary subcontractor. The "strong tie" nature of the organization of the vertical network gives rise to a more orderly and planned exchange of information. For example, both top-down flow and bottom-up flow of information are funneled through the primary subcontractor, which plays an important role as the link between the lead manufacturer and the secondary subcontractor.

But the tie is not so strong as to prevent direct exchange of information from taking place. A division or department manager of the lead manufacturer may visit a secondary subcontractor on occasion to learn as much from "the man on the spot" as possible. The reverse also takes place when a secondary subcontractor visits the lead manufacturer to participate in a new product development project or to discuss specific ideas on quality improvement. The most frequent exchange, of course, is undertaken between the engineers from both sides who can talk freely about technical matters without having to go through middle managers or the salespeople. This direct linkage not only saves time but makes the subcontractor far more a part of the new product development team than an outside vendor.

Reciprocity

Information is only part of what members of the network give and take. Many of the business transactions that take place within the network are also based on a give-and-take relationship. Two such transactions are highlighted here.

First, the lead manufacturer may sometimes push its subcontractors very hard to have some part delivered by a certain deadline but compensate them well when the task is accomplished. For example:

- Fuji-Xerox decided to change the basic design of a certain part midway in the development process and made an extremely tough demand of one of its subcontractors about when the delivery should be made. The subcontractor complied with this "utterly insane" request by working at night and completing the assignment on time.

Fuji-Xerox reciprocated later by paying the subcontractor handsomely. Mr. Kawamoto of Honda summed up this reciprocal relationship when he said, "We're buying time with money."

Second, where market conditions are unfavorable, a lead manufacturer may sometimes make a quite unreasonable demand on the subcontractor about the purchase price of a certain part. It tries to make up for whatever opportunity loss the subcontractor may have incurred by giving it very attractive margins when conditions turn favorable at a later date.

There is no guarantee that the lead manufacturer will return the favor in the future. Written contracts are unheard of. But if the lead manufacturer delivers, a trusting relationship begins to develop. In the long run, this kind of relationship leads the subcontractors as a group to accept the lead manufacturer as the legitimate leader and establish a strong cooperative system in support of it. A set of "shared network norms" is established over time, laying out a basic understanding of how business should be conducted within the network. Such a norm may tolerate an unreasonable demand made by the lead manufacturer during times of competitive crisis.

Subcontractors are willing to make sacrifices in the short run because they understand that their own survival is largely dependent on how well the leader performs in the market. They also know that certain new product development projects are a matter of life or death for the leader and, therefore, go out of their way to help. "Unreasonable demands are easier to swallow during wartime than peacetime," commented one subcontractor.

Conclusion

We embarked on this study by observing the dynamic process by which new products are developed within five Japanese companies. We then tried to put some order to what we observed by identifying seven commonalities in the process. This section compares and contrasts what has been learned from these Japanese companies with what is known about the new product development process in the United States.

Our conclusions are speculative at best since we have not conducted a comparable in-depth interview of U.S. companies. But our involve-

United States and Japan[19] has given us a basic understanding of how U.S. companies approach the development process. Our exposure to corporate America and to leading U.S. researchers in this field has given us further insights. With this limitation in mind, we highlight three major differences between the United States and Japan.

First of all, the process itself is viewed differently. In general, new product development within U.S. companies is viewed more as an analytical and systematic process. Many companies utilize a sequential approach involving some variation of the phased program planning system. Variety reduction within such a system takes place in a top-down manner, with as many uncertainties as possible removed upstream in the process.

In contrast, Japanese companies view new product development as a trial-and-error process (learning-by-doing) and resort to a considerably looser format of phase management. Top management keeps goals purposely broad and tolerates ambiguity to encourage an iterative process of information-seeking and solution-seeking to emerge in a bottom-up manner. Variety reduction is conducted on a more ad hoc basis and is more spread out across the overlapping phases. This allows a more flexible response to last-minute feedback from the marketplace.

Second, a different kind of learning takes place. In the United States, product development is undertaken by a highly competent and innovative group of specialists. Most of the learning is done by an elite group of technical people, largely on an individual basis, within a narrow area of specialization. Thus an accumulation of knowledge based on "learning in depth" takes place.

In contrast, product development in Japan is often undertaken by a team of nonexperts who are encouraged to become generalists by interacting with each other throughout the development process. The development project may be headed by a nontechnical person, as in the case of the FX-3500 made by Fuji-Xerox, or by a sales engineer from a different division, as in the case of NEC's PC 8000. Everyone participating in the development process is engaged in learning, even outside suppliers. Learning also takes place across all phases of management and across functional boundaries. It is this kind of "learning in breadth" that supports the dynamic process of product development among Japanese companies. This learning emanating from the development process, in turn, serves as the trigger to set total organizational learning in motion. In this sense, new product development is the particular device that fosters corporatewide learning.

new product development is an important strategic tool that enables companies to adapt to changes in the external environment by taking advantage of market opportunities or responding to competitive threats. As such, it plays a central role in strategy formulation.

In addition to its impact on strategy, product development in Japan takes on another important role. It serves as a change agent for reshaping corporate culture. Product development breaks down the hierarchy or rigidity normally associated with Japanese organizations—such as the seniority system or lifetime employment. Management gives the development team very broad but challenging goals as well as full autonomy to come up with something new. It uproots a competent middle manager from the hierarchical organizational structure and assigns innovative young talents to the team. Management gives unconditional support and legitimizes these unconventional moves by declaring a state of emergency or crisis. As mentioned earlier, organizational members and outside suppliers are willing to "swallow" more during times of war than during peacetime. The multilearning that takes place during wartime often breaks down the traditional ways of doing things. These changes are institutionalized within the entire organization until another crisis situation forces it to unlearn the lessons of the past. In a sense, management entrusts to the new product development team the mission to bring about an iterative process of learning and unlearning within the entire organization.

Caveats

Some final words of caution are in order. First, the Japanese approach toward product development has some built-in limitations, among which are the following:

1. It requires an extraordinary effort on the part of all project members during the entire span of the development process. Monthly overtime of 100 hours during the peak and 60 hours during the rest of the time is not uncommon.
2. It may not apply to breakthrough projects requiring a truly revolutionary innovation, as in the areas of biotechnology or chemistry.
3. It may not apply to mammoth projects, as in the aerospace business, where extensive face-to-face interactions are limited by the sheer scale of the project.
4. It may not apply within organizations where new product development is carried out by a genius at the top who makes the inven-

tion and hands down a well-defined set of specifications for people below to follow.

Second, we can expect our findings to be relevant in the short run; but given the evolutionary nature of the new product development process in Japan, they may soon be outdated. Extensive reliance on CAD/CAM, for example, may have far-reaching implications for how product development is managed within the organization. Externally, recent developments in telecommunications may make an interorganizational network based on geographical proximity obsolete. In fact, a recent study by Imai has already documented the rise of a telecommunications-based network in Japan.[20]

Finally, we must recognize that generalizations are misleading. For lack of better terminology, we labeled what we observed in the five Japanese companies as the "Japanese approach." Such a generalization may not necessarily apply when the sample size is enlarged, although our instincts tell us otherwise. We have also generalized about U.S. companies, describing their approach as analytical and sequential. For some companies, such a description may be very far from reality. For example, we see a flexible approach in place among a few U.S. companies that have established such systems as internal corporate ventures,[21] product champions,[22] skunkworks,[23] and others. The difference between the United States and Japan, therefore, may not be so much a "difference of kind" but more a "difference of degree."

Notes

1. William J. Abernathy, Kim B. Clark, and Alan M. Kantrow, *Industrial Renaissance* (New York: Basic Books, Inc., 1983), 107.
2. Paul R. Lawrence and Davis Dyer, *Renewing American Industry* (New York: The Free Press, 1983), 8.
3. Rosabeth Moss Kanter, *The Change Masters* (New York: Simon and Schuster, 1983), 19.
4. Variety is defined as the number of distinguishable elements, as used in cybernetics. A company reduces the number of options available by making choices on an iterative basis.
5. Abernathy et al., *Industrial Renaissance,* 27.
6. William J. Abernathy, abstract to "The Anatomy of the Product Development Cycle: An Historical Perspective," Colloquium on Productivity and Technology, Harvard Business School, March 1984, 27–29.
7. Karl E. Weick, *The Social Psychology of Organizing* (Reading, Mass.: Addison-Wesley, 1979), 133.
8. See Eric Jantsch, "Unifying Principles of Evolution," in *The Evolutionary Vision,* ed. E. Jantsch (Boulder, Colorado: Westview Press, 1981); Devendra Sahal, "A Unified Theory of Self-Organization," *Journal of Cybernetics* 9 (1979): 127–42.

9. Robert A. Burgelman, "A Model of Internal Corporate Venturing in the Diversified Major Firm," *Administrative Science Quarterly*, June 1983, 223–44.

10. Ikujiro Nonaka, "Evolutionary Strategy and Corporate Culture" (in Japanese), *Soshiki Kagaku* 17, 3 (1983): 47–58.

11. Kanter says segmentalism obstructs innovation and change in the following manner: "Segmentalism sets in when people are never given the chance to think beyond the limits of their job, to see it in a larger context, to contribute what they know from doing it to the search for even better ways. The hardening of organization arteries represented by segmentalism occurs when job definitions become prison walls and when the people in the more constrained jobs become viewed as a different and lesser breed." Kanter, *Change Masters*, 180–81.

12. Lawrence and Dyer, *Industry*, 262.

13. A similar finding is reported by Quinn who responds in the following manner to the question, How do executives cross-sectionally coordinate the various interacting subsystems in the decision dynamic? "In addition to selecting people with the technical skills most likely to be relevant over the time horizon of the strategy, most top executives tried consciously to team different management styles together: a 'tough' manager with a 'people-oriented' manager, a conceptualizer with an implementer, an entrepreneur with a controller, and so on." James Brian Quinn, *Strategies for Change: Logical Incrementalism* (Homewood, Ill.: Richard D. Irwin, 1980), 138–39.

14. Lawrence and Dyer, *Industry*, 263.

15. Theodore Levitt, *The Marketing Imagination* (New York: The Free Press, 1983), 164.

16. Richard J. Schonberger, *Japanese Manufacturing Techniques* (New York: Free Press, 1982), 175.

17. This supplier proximity to lead manufacturer plants also took place in the United States in the heavy-industry region around the Great Lakes and Ohio. According to Schonberger (ibid., 173), "Independent machine shops and foundries abound, locating near to buyer plants that make farm machinery, autos, machine tools, and so forth."

18. Mark S. Granovetter, "The Strength of Weak Ties," *American Journal of Sociology* 78 (1973): 1360–80; Everett M. Rogers, *Diffusion of Innovations*, 3d ed. (New York: The Free Press, 1983), Chapter 8, 293–303.

19. Tadao Kagono, Ikujiro Nonaka, Kiyonori Sakakibara, and Akihiro Okumura, *An Evolutionary View of Organizational Adaptation* (Tokyo: Nippon Keizai Shinbun, 1983). An English translation is forthcoming from North-Holland.

20. Ken-ichi Imai, *Japanese Industrial Society* (Tokyo: Chikuma Shobo, 1983), in Japanese.

21. Burgelman, "Internal Corporate Venturing."

22. Thomas J. Peters and Robert H. Waterman, Jr., *In Search of Excellence* (New York: Harper & Row 1982).

23. Thomas J. Peters, "The Mythology of Innovation, or a Skunkworks Tale Part II," *The Stanford Magazine*, Fall 1983, 11–19.