9 Technology and Competitive Advantage

9-1 Competitive Strategies for Technological Transformation

1 Industrial Maturation and Technological Innovation

1.1 Abernathy “The Productivity Dilemma”

Development Pattern of Product/Process

◆Abernathy, W.J. (1978), *The Productivity Dilemma ―Roadblock to Innovation in the Automobile Industry*, The Johns Hopkins Univ. Press

◆As a result of technological progresses, though productivity enhances, innovation turns out high in cost and hard to come by.

◆Pattern of technological innovation and progress in product/process

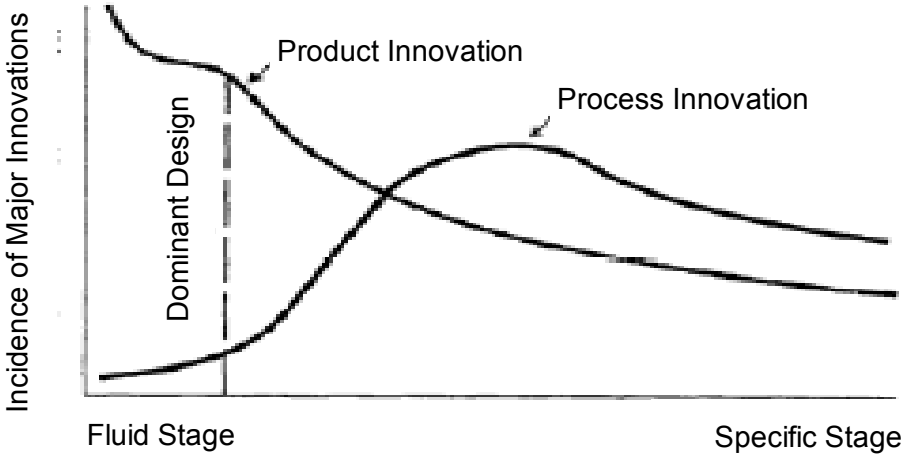
◆Analysis on American auto industry, particularly on Ford in detail

◆Analytical unit: “Productive Unit” = to capture a product and its process as one unit

◆Productive unit develops from a “fluid stage” to a “specific stage”.

1.2 Development of Productive Unit

Diagram 3.2 Fundamental Pattern of Life Cycle of Product/Process



Origin: Abernathy,W., *Productivity Dilemma*, Johns Hopkins University Press.

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Origin: Fujimoto, Takahiro (2001), *Introduction to Production Management* Ⅰ, p.58, with partial modification by Writer

		fluid stage →	stage transitorium	→ specific stage
innovation	focus	maximization of product function	⟶	cost reduction
	resource	information on users' needs	⟶	outside machine-tool sector, devastating external factor
	novelty radicalness	high	⟶	low, effect being summative
	mode	product innovation >process innovation	⟶	both product innovation & process innovation being incremental
	frequency	high	⟶	low
status of manufacturing process	organization	flexible, inefficient	⟶	efficient, systematic, captal-intensive
	scale	small	⟶	large
	equipment	general-purpose machine	⟶	specialized machine
	cost of change	small	⟶	large
	input element	commonly available	⟶	dedicated raw materials →advance in vertical integration
	product	frequent change, custom design	⟶	commodity, non-differentiation

◆Age of Product Innovation

-Products of the new concept (radio, TV) came onstage based on the new technology.

-In experimental stages, the products were used in many ways.

-Product innovation is realized by taking users' voices into consideration.

-Firms with ideas on product innovation make their entries in the industry.

-Each firm with its unique product competes in the area of the product function. (Radical product innovations)

◆Appearance of Dominant Design

-Appearance of the masterwork which has compiled various product innovations = "Dominant Design"

-Computer = IBM360; Automobile = Model T Ford; Propeller aircraft = DC3; Jet engine airplane = 747

-Dominant designs have become the standard product specs in respective industry. (Radical product innovations turning out less)

-Those specs are for the basics and peripherals are for the differentiation. (Incremental product innovations)

◆Age of Process Innovation

-Focal point has come to be how to manufacture at low cost those products conforming to the dominant design.

-Progress in production technologies owing to process innovations; A reversal of the product innovation and the process innovation.

◆Maturation Period

-Stagnation in the demand growth. Each firm possesses a standard production process, and wishes for neither a product innovation nor a process innovation.

-Nonetheless, an incremental innovation comes up, thereby quality enhances and cost decreases.

- →While productivity can be enhanced, an uprise of any major innovation is not easy.
= the Productivity Dilemma.

-Major technological innovation that can change a whole concept of certain industry comes forth from the outside of that industry.

Example: Vacuum valve → Semiconductor

1.3 Case Example of Automobile Industry

◆Age of Product Innovation

-A variety of product forms exists as objects of the rich's dissipation, and so does a wide range of choice with respect to basic technologies. Examples: Steam engine, internal combustion, electric motor

◆Appearance of Dominant Design

-Model-T Ford: Internal combustion, the engine installed in the front, the circular steering wheel

◆Age of Process Innovation

-Emergence of "Ford system" in order to produce Model-T Ford cheaply

-Cf. the experience curve of Model-T Ford (**1.3** of **Vol. 5_1**: Notanda on Application of Experience Curve)

◆Maturation Period

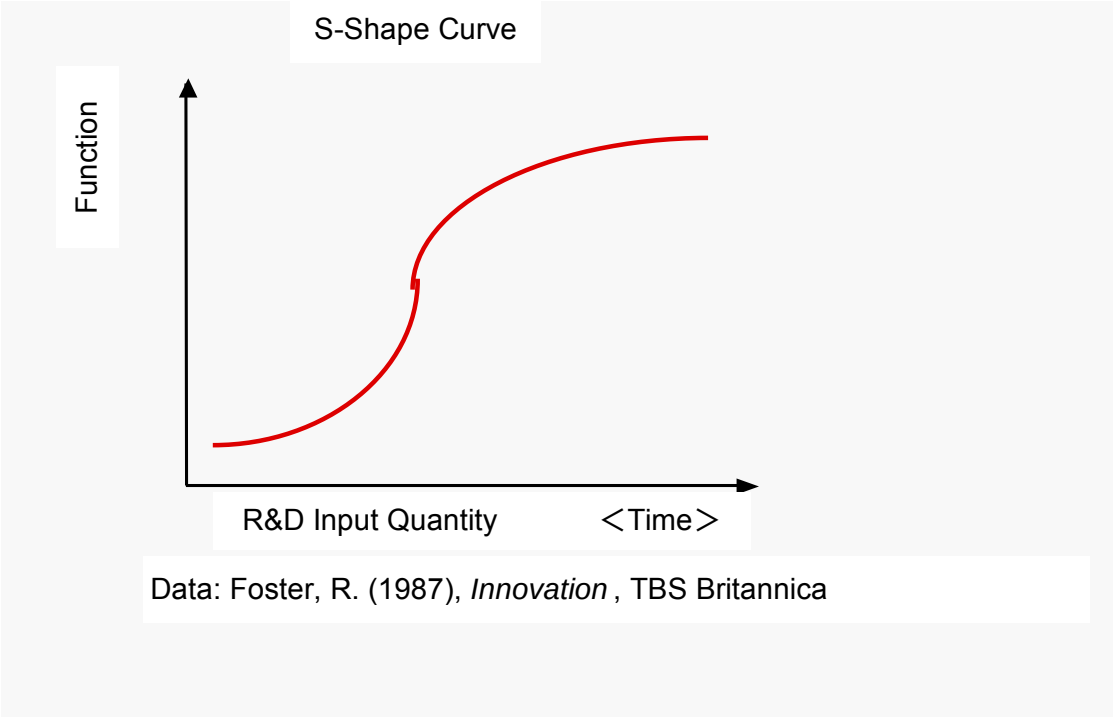
-There has not been any major technological innovation in product or process since the 1930s.
Just about automatic transmission only

-Nonetheless, with an accumulation of various improvements, the manufacturing cost has come down and the quality has enhanced.

1.4 Fruits of Technological Innovation: Functional Enhancement and Cost Reduction

◆Function of certain product enhances drawing an S-shape curve.

S-Shape Curve to Describe Functional Enhancement

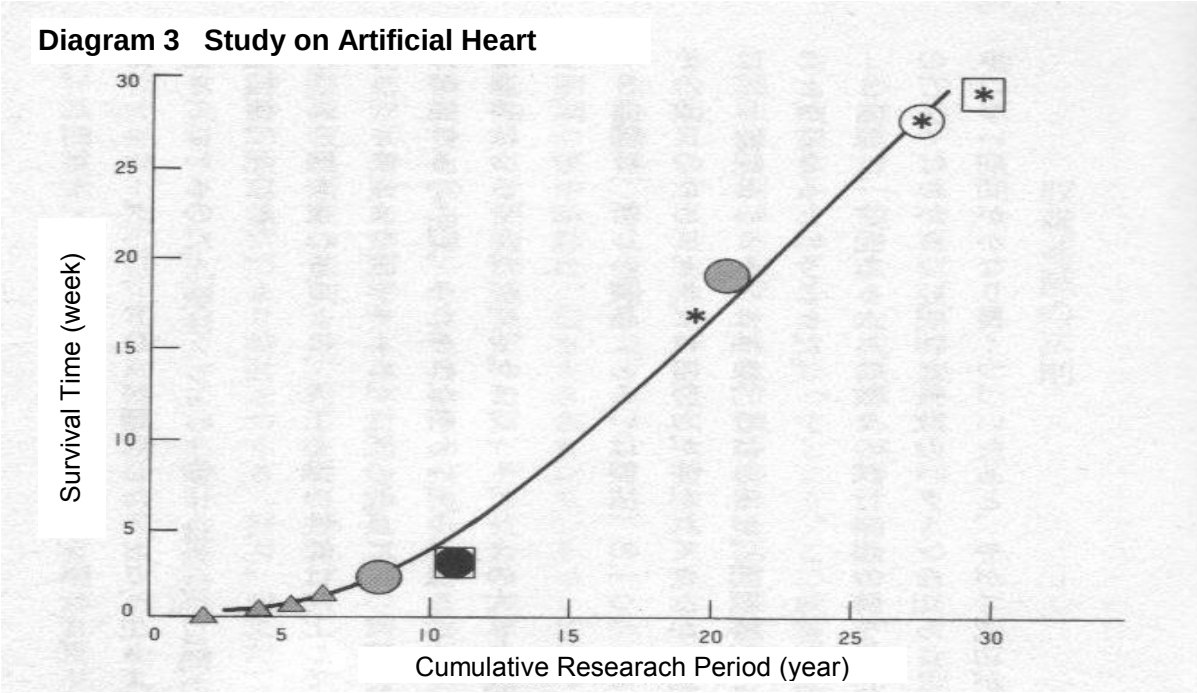


Data: Foster, R. (1987), *Innovation* , TBS Britannica

S-Shape Curve of Artificial Heart

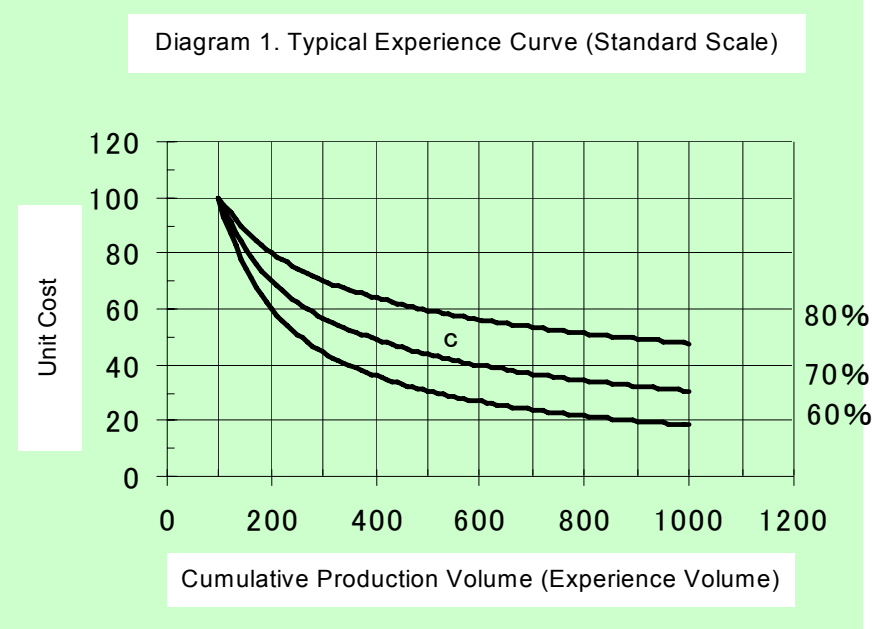
(Foster, R., *Innovation*, TBS Britannica, 1987, p.89)

Diagram 3 Study on Artificial Heart



The initial stage of S-shape curve indicates tests and faults inherent in any R&D.

◆Along with an increase in the accumulated production volume, cost drops away drawing an S-shape curve (Experience Curve).



2 De-Maturity of Industry

2.1 Technology Transformation: Changes in Basic Technology in Industry

Product Field	Old Technology	New Technology
home VCR	VHS/β systems	S-VHS/8mm → digital VCR
animation camera	8mm movie camera	video camera
still-image camera	silver-salt film photo	electronic still camera
music-playback device	LP-record player	CD player → DCD
recording media	cassette tape	DCC/MD
data-storage media	floppy disc	magnetic optical disk
electronic switch parts	vacuum bulb	transistor → IC → LSI
facsimile	G1/G2	G3 → G4
cash register	mechanical system	electronic system
character input/output device	typewriter	word processor
television	NTSC/PAL/SECAM	HDTV
medical diagnosis device	X-ray	CT scanner
aircraft	propeller airplane	jet-engine airplane
ship	steamboat	turbine boat
detergent	natural detergent	synthetic detergent
fiber	natural fiber	chemical fiber → synthetic fiber

◆Submergence of Thomas W. Lawson (R. Foster's *Innovation*)

-The ship sank in offshore Scilly Isles in English Channel before dawn of Dec.13, 1907 (built in

1902)

-Lashed by gust while at anchor

-Survived by the captain and one crew only

-“As if it had been a whaleback…a huge belly of the ship lying on its side appeared on the waves.”

-Fast freight vessel in rivalry with steamboats

-Cruising speed at 22 knots

-Steerage sacrificed for speeding up

-Technological limit of sailboats (around 1950)

-Toward the age of steamboats

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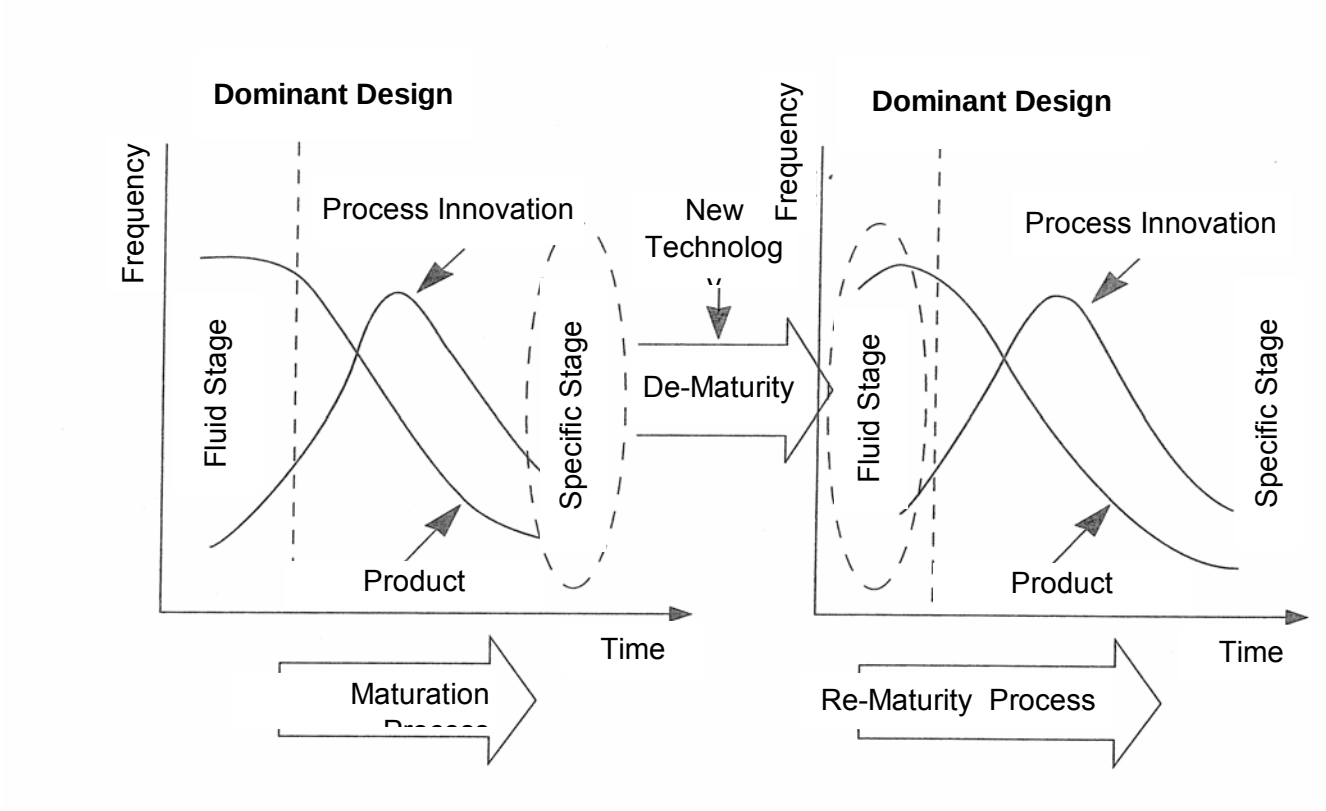
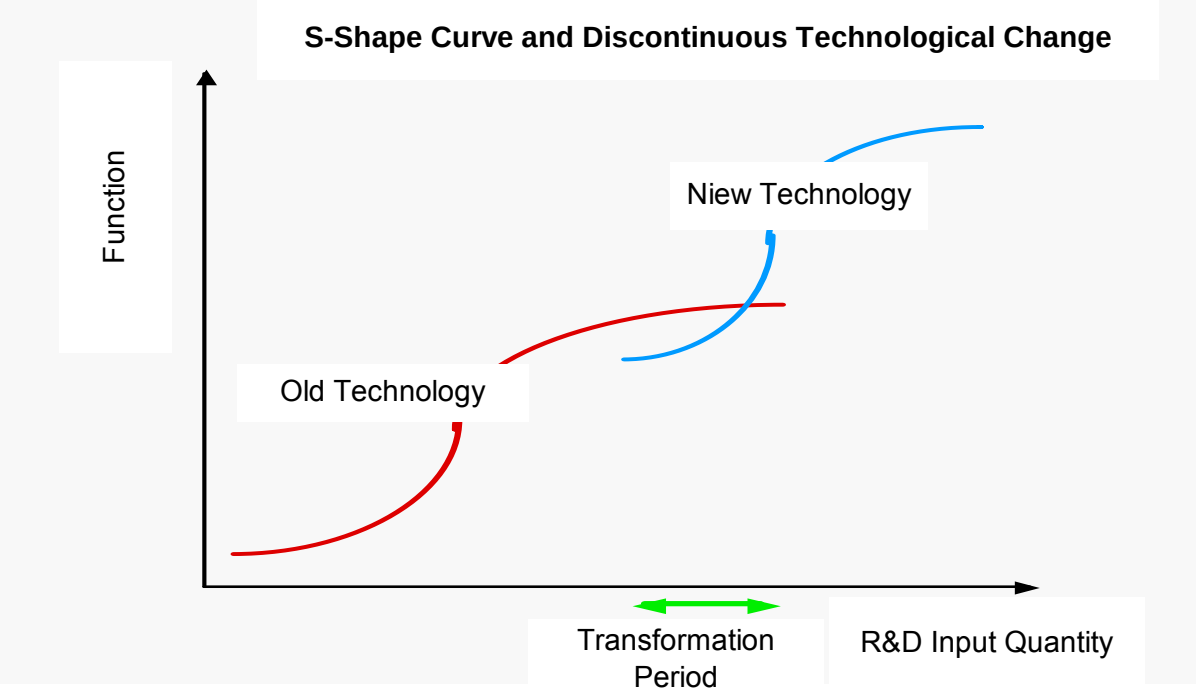
Due to copyright.

2.2 De-Maturity and Re-Maturity Process



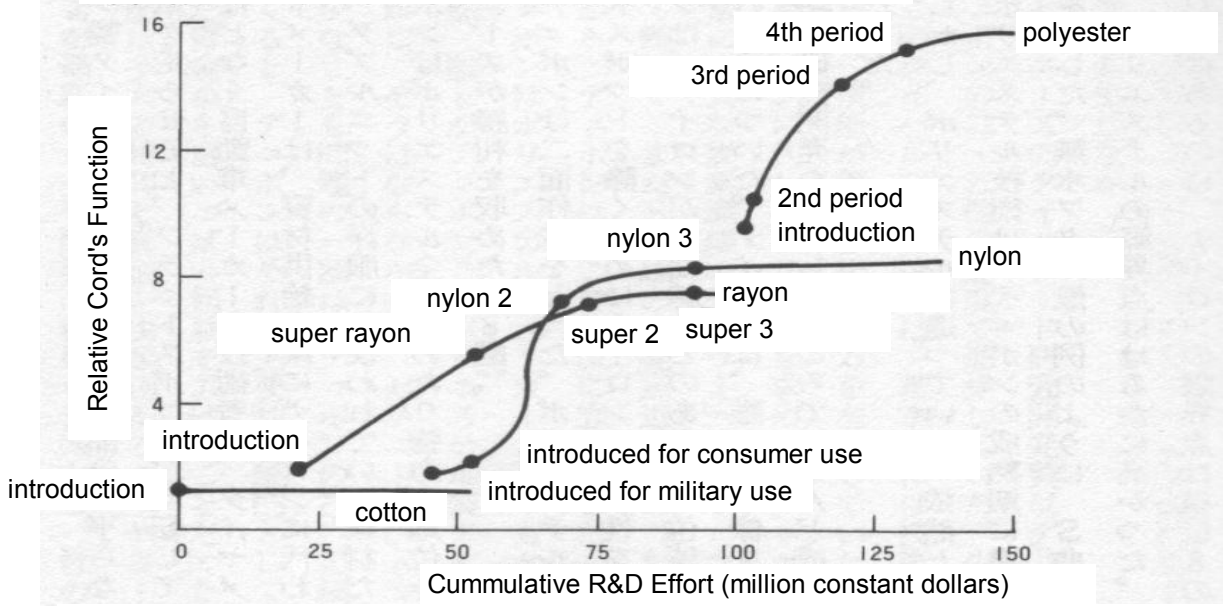
Origin: Shintaku, Junjiro, *Competitive Strategies of Japanese Companies*, p.6



◆Incoherent S-Shape Curve of Tire Cord

Foster, R. (1987), *Innovation*, TBS Britannica, p.117

Diagram 8 From Cotton to Rayon, Nylon and to Polyester



Failed to comprehend an S-shape curve of the nylon technology, Dupont could hardly obtain from $750,000 it invested in the final stage of R&D. On the other hand, Celanese put in a smaller capital in polyester which was staged at the beginning of its S-shape curve, and gained much greater fruits.

2.3 Emergence of New Technology and Its Diffusion

◆Limits of functional advancement and cost reduction

-Both an S-shape curve of functional improvement and a U-shape curve of cost lowering reach their limits in due course.

-Then, neither an investment for product improvement nor one for cost reduction brings about an effect to be commensurate with such efforts.

-It is possible that these limits are conquered by developing/introducing totally new technologies on products or processes, thereby ensuring an epoch-making functional advancement and cost reduction. This is the possibility of De-maturity.

◆Emergence of new technology

-A new product technology in its infancy may contribute to a revolutionary improvement of certain product function, but, more often than not, it is inferior to traditional technologies in the area of other product functions ant its cost is way beyond that of traditional technologies.

-Because of this, in an early phase, the demand for a product based on a new technology is limited only to a minor market segment.

◆Diffusion of new technology: Re-maturity

-As certain technology gets improved to a level mostly surpassing the traditional one in the areas of product function and cost, a market segment to demand the new-technology-based product increases, and over time, majority of market segments become the market of the new technology.

Examples: Mechanical wrist watch → Quartz watch; Japanese-character typewriter → Word processed

-Some of new technologies have little room for improvement, which are demanded only by a portion of market segments, or are destined to disappear from the whole market due to the emergence of other new technologies.

Example: Tuning folk watch

2.4 Various Examples of De-Maturity

Utterback, J.M. (1998), *Mastering the Dynamics of Innovation,* Yuhikaku Publishing Co.

◆Product/process: Discontinuous format

-Vacuum bulb → Transistor

-Airplane engine: Piston → Turbojet

-Calculator: Electrically-powered mechanical → Electronic desktop calculator

-Steam locomotive → Diesel locomotive

◆Process－Product: Discontinuous format

-Glass manufacturing: Grinding process → Pilkington float glass

-Natural gem → Synthetic jewelry

◆Product－Discontinuous format

-Transistor → IC
-Airplane engine: Water cooling → Air-cooling turbojet → Turbo fan
-Mechanical typewriter → Electric typewriter
-Tire cord: Rayon → Nylon

◆Process－Discontinuous format
-Open-hearth furnace → BOF (pure-oxygen top-blown converter)
-Casting → Continuous casting

2.5 Competitiveness of Japanese Companies after the War

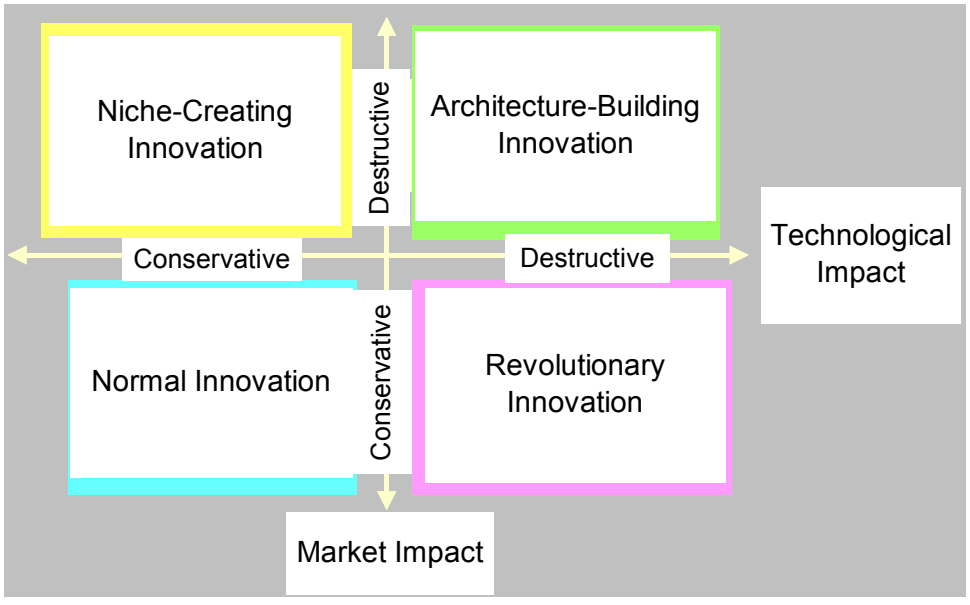
◆Companies participated in industries that were on their way to a maturation, and imported basic technologies from the U.S. which these companies improved.

◆In certain industries, some firms gained an overwhelming advantage over American companies by developing entirely new technologies nonexistent in the U.S. (discontinuous product innovation, process innovation).

-Cf. Iron steel: Pure-oxygen top-blown converter (BOF)
Watch: Quartz
Automobile: ?

3 Evolutional Power of Innovation

Abernathy, W., Clark, K. and Kantrow, A., *Industrial Renaissance* , (1983) TBS Britannica



◆Architecture-Building Innovation
-The introduction of an entirely new technology or production system destroys the existing technology/system, and creates a commitment to the totally new market/customers. In short, it

builds a new industry and structure.

Ford Model T: Artisanal skill → Mass production by moving assembly line

Providing a basic transportation device with farmers, common people

◆Normal Innovation

-This format of innovation, without any new discovery/invention, produces/sells what already exists at a cheaper price and/or with a better quality: Upgrading or improvement. In fact, this type possesses an accumulated effect that makes a firm's competitiveness leap forward most significantly, and provides the creative destruction and restructuring of the existing industry's regularity.

Example: Long succession of day-to-day improvements in job sites in Japanese corporations

◆Niche-Creating Innovation

-To develop a connection with new market/customers while incorporating the existing technology/ production system

-This type creates a new niche in the market place. In terms of product life cycle, it's positioned in the stage where a matured industry develops a new market niche.

-To create a new market by refining the existing technology/production system

Sony's Walkman, Honda's RoadPal

Casio's Casio Mini

Ford's Mustang

-To further strengthen the sales organization

Takeda Chemical Industry's Plussy: Rice stores as its sales channel

Honda's small motorbikes: Bicycle stores added as its sales channel

◆Revolutionary Innovation

-The format, while utterly outdating the existing technology/production system, further intensifies a tie-in with the existing market/customers. With this evolution, the industry faces a new domain, and the company owns a definitive competitive advantage. Often, it also rejuvenates that industry, or, as it transits to Architecture-Building Innovation, creates a new industry.

GM's automatic transmission:

- Introduced in the 1940s, it perfectly pushed the manual shift into a minority.

Japanese steel makers' LD converter, continuous-casting facilities

Seiko's quartz watch, CD

Transistor: It was a substitute item of vacuum bulbs in the early stages, but triggered such new industries as semiconductor and computer afterward.

4 Failures of Leader Corporations

◆An accumulation of excellent adaptations to environments in the past and of resources (technology, sales and brand) constitutes an obstacle to the new change as well as the reason

for the foregone success at the same time.

-Productivity Dilemma

-Productivity and innovation

-Efficiency and flexibility

◆Failure in acknowledging changes

◆Deficiency in adaptability

◆Technological capacity: Discontinuity of technology

◆ Organizational inertia: Information-processing mechanism of an organization (structure, awareness map, culture)

◆Customer's pressure

◆Innovator's dilemma

-Christensen*, The Innovator's Dilemma*, 1998

-While a legitimate and competent decision-making by management is important to success of a leading company, that simultaneously constitutes a reason for the leader to lose its position.

4.1 Changes in Value Network

◆Value Network

Christensen & Rosenbloom (1995)

-Specific product, in certain level, is treated as a complicated architecture system, but in a higher level, is captured as a component that comprises a system, namely a nesting structure.

-This nesting structure is sometimes borne by a single integrated company (AT&T, IBM), or is a combined relationship of demand and supply among plural firms that are divided by individual specialization. This transaction system is called "Value Network".

-Even within the same category, product architecture, i.e., value network, is different.

-With different value networks, the ranking of importance among a variety of performance attributes becomes different.

-Examples: As for discs in mainframes; Capacity → Speed → Decay durability

As for portable computers; Obdurability →Electric power consumption → Size

To Xerox, having established a network dealing with institutional customers, the order of importance is: Speed → Resolution → Cost. The firm has lost a new opportunity as downsizing and ease of use were not very important.

◆Adaptation to Value Network

Christensen, *The Innovator's Dilemma*, 1998

- "The more a firm accumulates experience in certain network, the more this firm is likely to acquire capacity, structure and culture that fit its position by accommodating itself to demands peculiar to its network. An organizational consensus differs between an existing network and a new one regarding such matters as production quantity, product development cycle, identifying customers and their needs."

- "The longer the firm stays in a given position, and more successful it is, the more this

kind of effect is likely to happen." p.242

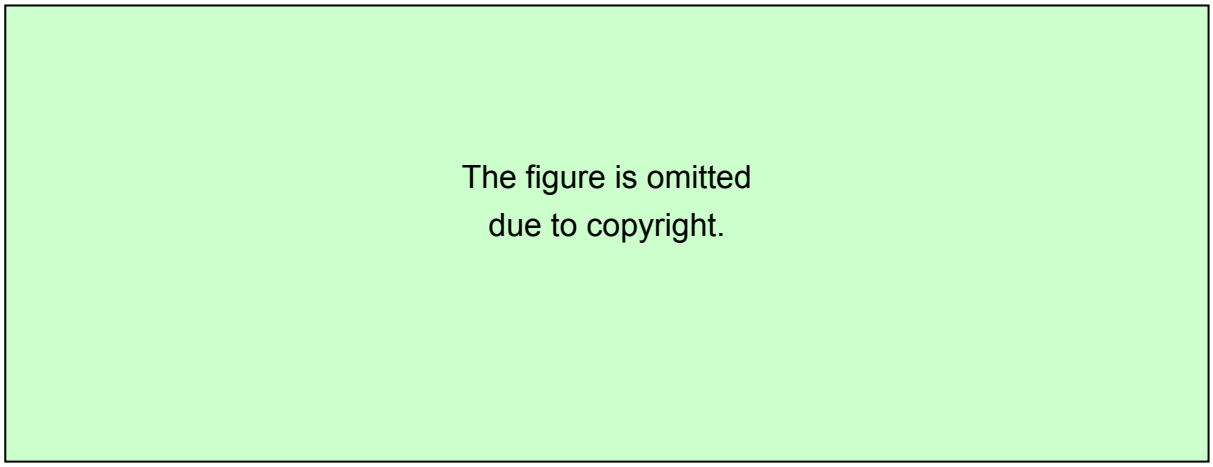
4.2 Switches in Leading Corporations: Hard Disk Industry

◆17 firms pulled out in 1976, and 14 thereafter by '89; during this interim 124 firms entered and 100 left.

◆While the modular innovation was led by existing firms, the architecture innovation was initiated by new entrants.

◆Changes from 14 inches to 8, 5.25, 3.5, and to 2.5 were architecture innovations in the sense that, through the miniaturization of the entirety, each part got downsized, number of parts decreased, and the combination among parts altered. Keeping pace with such changes, newly- entered firms grew dominant.

◆Existing firms did not introduce any new-generation product, or introduced laggardly if any. Although the product quality of existing firms' was equal to that of new entrants, the formers were eventually defeated.



Christensen, C. (1997), *The Innovator's Dilemma*, HBS Press, p.16

4.3 Framework of Failure

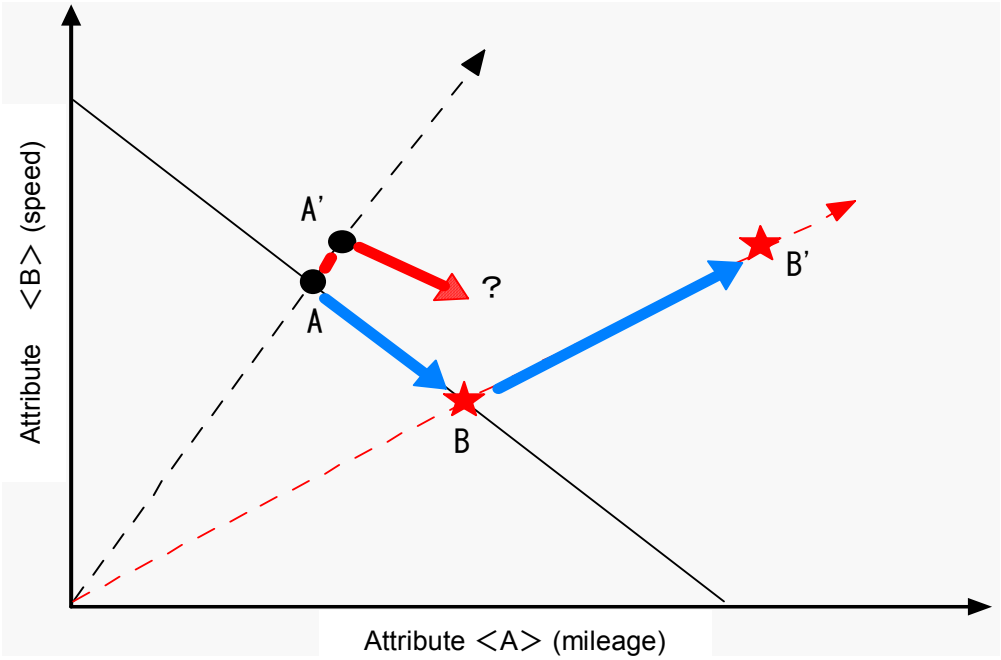
4.3.1 Sustaining Technologies－Disruptive Technologies

◆Sustaining Technologies: Technology to improve the functions of an existing product in accordance with the functional criteria which the mainstream customers of the mainstream market have evaluated up to then

◆Disruptive Technologies: Technology which, at least for a shot term, makes the product function inferior to the existing product in the mainstream market. But that function possesses other characteristic which deserves an appraisal of customers in peripheral markets (mostly new customers), and provides markets with a value assumption which is different from the one that used to be applied earlier. Products based on disruptive technologies are, typically, inexpensive, simple, and easy to use, e.g., personal computers, small motorbikes.

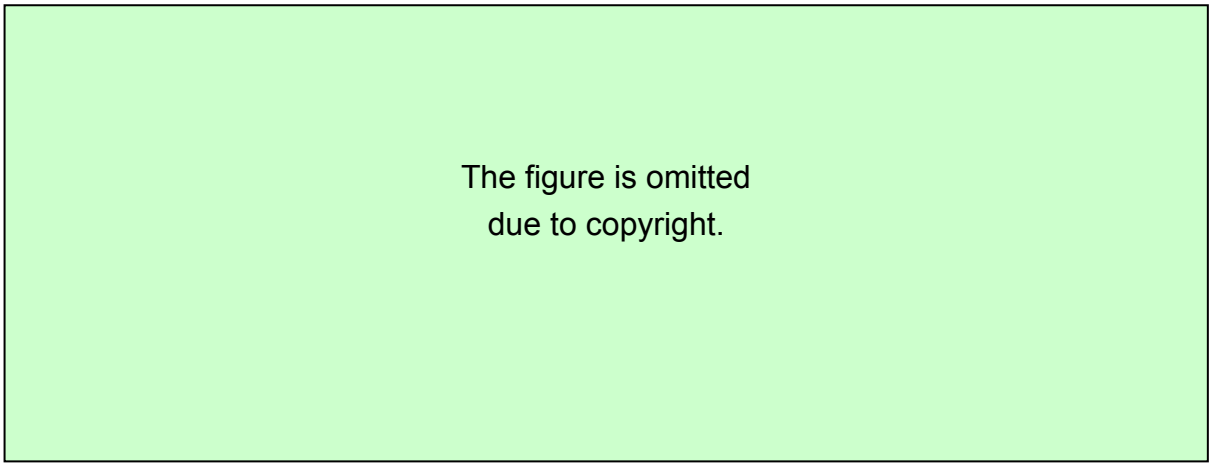
The figure is omitted
due to copyright.

Christensen, C. (1997), *The Innovator's Dilemma*, HBS Press, p.39



4.3.2 Trajectory of Market Needs vs. Trajectory of Technological Upgrading

◆Technology can progress faster than a market demand. Suppliers may "overshoot" the market. Disruptive technology which does not currently satisfy function that users demand may be able to functionally possess an enough competitive edge in the same market in future.



Christensen, C. (1997), *The Innovator's Dilemma*, HBS Press, p.XVI

4.3.3 Customers and Financial Structure of Successful Companies

◆Because disruptive products are simple and inexpensive, their margins are low in general. Disruptive technologies are commercialized in an emerging or unimportant market in the beginning. Those customers who bring the most benefits to the leader do not want products based on disruptive technologies, nor can they use them at first.

4.4 Conquest of Obstacles

1) Restoration of the division of labor
2) Autonomous organization and disruption of resources
3) Reexamination of quality-appraisal standard

1) Restoration of the division of labor

◆Watch makers of Switzerland

-High-level structure of the division of labor where each firm specializes in specific parts/ product fields. Each individual firm is engaged in the production of certain parts or the final assembling.

→Merits of specialization, obstacles to changeover

-To transform an industrial structure, for integration and concentration

SSIH

Advantage in design area; Swatch

-Same to be applied to a firm's inside: Re-organization, transfer of resources

◆Intel: From the separation of works to the integration

- Vice president Eimerl, "Intel's cutting-edge MPU cannot show its true ability unless peripheral chips and DRAM advance their performance as high as MPU. It's just like a car cannot run fast with an enhancement of its engine's capacity alone."

-Enlarging the business coverage over to peripheral chip sets and mother boards, etc.

- Subsidizing software makers

- Architectural reform: Dual independent path
-Speed limit of bus (66 megahertz)
-Separation of system bus from cash bus

2) Autonomous organization and disruption of resources

◆Companies depend on customers and investors for resources.

→For the interest of disruptive technologies, to set up a new independent business and let this autonomous organization take charge

◆Small markets do not solve the growth needs of large companies.

→Unless one participates promptly, a success probability is low: Fast-mover advantage
-IBM-PC

◆Markets that do not exist cannot be analyzed → Planning not for a market research or for an implementation, but a Discovery-Based Planning

3) Reexamination of quality-appraisal standard

◆Not to quote the quality evaluation standards of existing products and major businesses

◆Large companys' failure in the electric desktop calculator: Excessive quality check

◆Toshiba's DynaBook: "This mustn't be approved as our product."

◆Digital camera: Casio's QV10 (1995) at 250,000 pixels

-For VCR-camera firms, the evaluation standard of picture quality lies in the television standard, which used to be CCD's quality standard. Freeze-frame picture could tolerate lax standards versus CCD, for which Casio set the precedent.

◆Hitachi's liquid-crystal TV: It was Seiko Epson that commercialized a small-size liquid-crystal color TV with the active matrix LCD in the first place (1984). In Hitachi, there were "quite a few engineers who had worked on the appraisal of screen image for many years within the company. And the fact that these engineers made a judgment that the quality of LCD TV had not reached the enough level for the market introduction" was one of the reasons why this product could not be commercialized. **.....** Numakami (1999), pp.355-356.

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