Competitive Strategy of Global Firms and Industrial Clusters[1]

Case Study on the Hard Disk Drive (HDD) Industry

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1. Introduction

This report discusses the location strategies of multinational firms and the industrial policies of the countries that are the recipients of their investment. For firms engaged in international business, the timing of foreign investment, selection of locations, and maintenance and expansion of their local operations are all important strategic matters.

Then what foreign investment strategies have been used by firms that have succeeded in strengthening their competitive advantage? What are the unique aspects of the policies taken by recipient countries? This report will focus upon the *strategic nature of investment* for global firms and the *strategic nature of investment-attracting policy* for the recipient countries.

Because the determinant factors of foreign investment have been a core theme for studies on multinational firms, there is already a large literature upon the topic. However, much of it consists of studies that identify and classify the location factors based on economic theories and empirical studies using cross-section or pooled data. While these studies indicate the general framework of multinational firms' location selection, it is difficult to derive from them the strategic implications related to individual firms' foreign investment.

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[1] This report is an expansion and revision of the content of Chapter 5 of the following book for the purpose of presentation at the GRIPS/MMRC Joint Symposium: Amano Tomofumi, *Higashi Ajia No Kokusai Bungyō To Nihon Kigyō: Aratana Kigyō Seichō He No Tenbō (East Asian Linkage and Japanese Firms: A New Perspective of Corporate Growth)*, Yuhikaku.

Foreign investment in a growth region is an important strategic matter for firms. Industry-specific conditions must be taken into account to appropriately examine its strategic nature. However, to this end, the focus should be placed on how firms recognized the industrial environment and what approaches they took; in other words, we must focus on firm-specific recognition of the environment, decision-making, and implementation, rather than on the general determinant factors of investment.

This report takes the hard disk drive (HDD) industry and looks at how major Japanese and U.S. firms have made investments in Asia. Over the past 20 years, the HDD industry experienced dramatic changes in technology and market conditions. For HDD manufacturers, investment in Asia during this period was a critical issue for their survival. How did they perceive this challenge and what strategies did they take? This point is closely related to the first focus: *strategic nature of investment*.

The second focus, *strategic nature of investment-attracting policy*, will rather become clear by looking at the investment history of surviving firms. These firms have concentrated their large-scale investment in specific areas. In these areas where a large number of firms have gathered, collaborative relationships can be observed between local governments, local universities, local firms, and global suppliers. Such agglomerations have served to attract investment to these areas in a sustainable manner.

These areas are called *industrial clusters*. In a global industry like the HDD industry, the greatest concern for the recipient country is the risk of the client firms leaving the country to invest in another country due to subsequent wage increase or rivalry against newly developed countries. The challenge for the recipient country is to consolidate investment, and one means to achieve this could be to increase the attractiveness of the area as an *industrial cluster*.

In the process of East Asia's economic development, investment from other countries gathered in a number of areas and industrial clusters were formed in these major areas. This enabled the recipient countries to provide abundant and diverse resources to the multinational firms located inside these areas. There was also intense competition among the recipient countries for attracting investment. The point is how these countries strategically differentiated their policies from the others in forming attractive industrial clusters.

2. Competitive Strategy of Global Firms and Industrial Clusters

This section explains the three basic viewpoints applied to the case study. They are *(1) global location strategy and clustering; (2) integration of global production networks; and (3) consolidation of foreign investment in recipient countries.*

Global Location Strategy and Clustering

During the past several decades, in which economic globalization has made remarkable progress, firms have actively expanded the geographical base of their operations through direct investment or strategic partnerships. *Competition in Global Industries* (Porter, 1986) is a representative study and an early attempt at systematizing international business expansion.

Porter analyzes firms' global strategies by focusing on two concepts: *allocation* and *coordination. Allocation* refers to the internationally distributed allocation of the value chain, while *coordination* means the coordination among the distributed bases. He defines a global strategy as "a strategy to achieve a global competitive advantage through concentrated allocation or coordination of distributed activities, or both" (Porter, 1986, p.35) and states that "in order to understand the competitive advantage of a global strategy or the cause of globalization of a firm, one must know the conditions for achieving cost reduction or differentiation through globally concentrating the activities and/or coordinating the distributed activities" (*ibid*., p.36). He indicates that such conditions are: (1) proximity to markets; (2) economies of scale and experience effect; (3) effective consolidation and coordination of activities; and (4) comparative advantage of each country.

This framework presents the basic idea of a global strategy. In order for a firm to achieve a global competitive advantage, both two factors are essential: the expansion of activities and building of operational foundations at the overseas locations by seizing the internationally spread opportunities for achieving advantages and growth; and the integration of networks of the internationally spread activities under a unified philosophy and business strategy.

In addition to this, the approach of committing to local industrial clusters is vital for the foreign subsidiaries. In an industrial cluster, many firms and institutions are located together, forming multi-dimensional networks to create the characteristics of the area. Inside clusters, markets of diverse human resources and intermediate goods are also formed. Thus firms can secure the diversity, quality and quantity of their managerial resources. Moreover, as technical domains are specialized through division of labor, knowledge accumulates more effectively and operation costs are reduced through the economy of scale. These benefits are collectively called *agglomeration economies*.

David McKendrick, Richard Doner and Stephan Haggard (McKendrick, Doner, & Haggard, 2000) analyzed the agglomeration economies in the HDD industry. They refer to areas such as Silicon Valley and the Japanese archipelago as *technology clusters*; they refer to areas like the Southeast Asian region, mainly Singapore, Thailand and Malaysia, as *operation clusters*.

The agglomeration economies that firms can enjoy in a t*echnology cluster* include (1) early recognition of new technology and market opportunities; (2) creation of new technology, products and services through many start-ups and technology spillovers; (3) prompt problem-solving and product development; (4) access to venture capital; (5) human resource pools that are specialized and differentiated for each technical field; and (6) prompt imitation of product innovations.

In an *operation cluster* firms can enjoy (1) low transportation costs; (2) shorter transportation times between the respective stages of the value chain; (3) economies of scale in production; (4) quick production launch; (5) skillful human resource pools that are specialized for each process or function; (6) prompt imitation of innovation related to assembly, production and physical distribution; (7) monitoring of the quality of suppliers; and (8) low inventory costs.

One of the purposes of a global strategy is to establish the firm's own base within the local industrial cluster, in other words, to take part in creating such agglomeration economies and fully enjoying the benefits they produce. In studies on international business, the need for *localization* is often discussed. A firm that expands overseas but does not localize its overseas base cannot fully enjoy the benefits of globalization. The same applies in the context of an indus-

trial cluster. Spreading the value chain itself is insufficient for achieving essential advantage. The key is how deeply a firm can get involved in the industrial cluster, and how well it can find and develop resources there. The advantages to be gained in a cluster are sometimes highly firm-specific and relation-specific, unlike the initially available advantages like low wage level and land resources; these specific advantages become the firm's core competitive advantage.

Integration of Global Production Networks

As business opportunities spread worldwide and a firm's scope of operations broadens, the firm's business management becomes more complicated. One of the important conditions for a multinational firm to smoothly carry out its global operations is to know how to integrate its decentralized and complicated management into a single direction. The purpose of *integration of global production networks* is to ensure that the activities that have achieved a global spread through foreign investment are not conducted in a disorganized way, but are implemented in an integrated manner under a common vision and business strategy.

A firm that has effectively integrated its specialized functions with an eye on the changes in environmental conditions could turn the benefits into a competitive advantage in the market through the division of labor. Furthermore, it could enjoy large *integration benefits* by creating synergy between its bases. On the other hand, a firm that is lacking integral ability could lose its operation efficiency through international division of labor. In globalization, the logic of integration is in fact more important than the logic of division and spread.

In order for a firm to integrate its operations beyond national borders, the strategic abilities, leadership, and coordinating ability of the firm's headquarters are essential. It is the duty of the headquarters, or the top management, to instill its business philosophy and business strategy in overseas growth markets and to make the firm's resources complement each other. The management requirements for integrating global production networks are (1) presentation of vision and strategy; (2) leadership of top management and the management team; (3) integration of organizational structure; and (4) sharing of organizational culture.

The first requirement is *presentation of the vision and strategy* because in order to integrate businesses beyond national borders, vision and strategies need to be clearly indicated as the purpose of integration. It is ideal to have overseas employees and partners understand and share basic principles and strategy, including the firm's purpose of doing business and the desired future direction, beyond cultural barriers.

However, merely indicating the vision and strategy is not enough; the leadership of the top management and the management team and integration of the organizational structure are also important. The top management and the management team at the headquarters should launch concrete initiatives to put the vision and strategy into practice within the local operation bases. Also, they should indicate the vision's importance to the local management team and employees.

Furthermore, the firm needs to identify the way of sharing the responsibilities and communication between the headquarters and the local bases to implement its vision and strategy in an organized manner. At the first stage, the headquarters needs to take the initiative in overall matters. However, as the subsidiaries become localized, their responsibilities increase and the communication becomes two-way and multi-tiered. Finally these division and communication systems will be optimized so that the firm can fully enjoy the merits of integration.

The last requirement is *sharing of the organizational culture*. Internationalization of business can be regarded as an act of sharing the firm-specific organizational culture among group companies while respecting the *differences in culture* in each country. A firm's organizational culture is expected to gradually permeate the overseas operation bases through its operation. This culture becomes the code of conduct for the members of the organization. In other words, it becomes the corporate identity. A firm having a reasonable code of conduct is likely to be capable of integrating its international business activities smoothly.

Industrial Clusters and Consolidation of Foreign Investment

The country on the receiving end of investment is interested in effectively attracting multinational firms with the above-mentioned behavioral prin-

ciples. In this case, the point of concern is the issue of *mobility of investment*, namely that a firm that has been attracted under initial conditions such as low wage levels and ideal land conditions could move to another country in light of wage differences and investment opportunities in newly developing countries.

In order to have a multinational firm continuously invest in the initially chosen area, the recipient country needs to take the lead in developing competitive advantages that do not rely only on wage level and land resources. The key to achieving this is forming *industrial clusters*.

As discussed earlier, *industrial clusters* involve various *agglomeration economies*. The recipient country must promote regional development with these agglomeration economies in mind. For example, development of expressway systems and port improvements are indispensable for achieving low transportation costs and shorter transportation times. It is also necessary to simplify customs procedure. In regards to forming pools of intellectual human resources and promoting innovations, it is important to develop human resources through collaboration between industry, academia, and government. Another possible measure would be to implement special taxation that meets the industrial needs.

The regional development of an industrial cluster involves both planned factors and emergent factors. Establishment of development zones, development of public infrastructure, and revision of the tax system are planned factors. These are important, but may easily be copied by others. More important factors are emergent ones such as industry-specific networks and a pool of qualified human resources, which are accumulated through the industrial development of the recipient country. Both planned and emergent factors are critical to provide located firms incentives to secure their investments, which contributes to the consolidation of investments for the economic growth of recipient countries.

3. Structural Changes in the HDD Industry

The above-mentioned three concepts provide the analysis framework for studying the HDD industry case. From this section onward, the report will look at this industry. This section focuses on the structural changes in the industry since the 1980s, with particular emphasis on the competition between Japan-

ese and U.S. firms over investment in Asia.

Changes in the Product Architecture and Industrial Structure

Product architecture in the HDD industry was led for a long time by IBM. The firm has a long history in the data storage business, starting with tapes, moving on to floppy disks in 1970, and establishing the standard for the "Winchester" HDD in 1973. In 1989, it developed the magnetic head technology that applied the principle of magneto-resistance (MR) to the recording head, allowing recording of 1 gigabyte per square inch. Furthermore, in 1996, it succeeded in developing the giant magneto-resistive (GMR) head. In this way, IBM has constantly led the development of cutting-edge technology in this field.

Dramatic changes occurred to the industrial structure from the second half of the 1970s through the 1980s. After the HDD industry took off with the establishment of the standard for the Winchester HDD, U.S. computer manufacturers outsourced HDD production to external firms, and U.S. and Japanese firms with a high level of technology entered and formed the industry. As the computer platform changed from mainframes to minicomputers, office computers, workstations and personal computers, the HDD interfaces evolved to enable the use of HDDs as modules. The demand structure shifted from large general-purpose machines to small computers, and there was a transition from centralized processing using mainframes to distributed processing using small computers.

In the mainframe era of the 1970s, a computer and an HDD were connected via IBM-IF, and the physical address of the HDD was controlled by the host computer. Later, with the rise of minicomputers, office computers, and workstations, the interface between the computer and the HDD evolved into the storage module drive (SMD) and subsequently into the Shugart Associates System Interface (SASI) in the second half of the 1970s.[2] With the introduction of the SASI, the host computer came to control the HDD not through physical addressing, but through logical block addressing. Until this point, development

[2] Shugart Technology was a leading HDD manufacturer and was the predecessor of the present Seagate Technology.

of HDDs required close coordination with the computers due to the need for such addressing.

However, when the personal computer (PC) market began to take off at the end of the 1970s, things began to change. Apple Computer, the pioneer of the PC market, had not revealed its basic input/output system (BIOS) for its Apple-1. However, after IBM revealed the BIOS source code for its IBM-PC XT, the design of controllers and HDDs became more open.

In the middle of the 1980s, the small computer system interface (SCSI) was introduced as the interface connecting the computer to the HDD in the PC field. As a result, the HDD came to be connected to an external expansion bus via a controller board, and it became possible to support various HDDs using the BIOS parameter table. With this, the modularization of the HDD made rapid progress. After that, in the PC field, standardization of external interfaces made headway with the introduction of intelligent drive electronics (IDE), achieving the complete modularization of the HDD by moving the hard disk controller that had been mounted on the PC motherboard to within the drive. The IDE specification was later certified by the American National Standards Institute (ANSI), and is being standardized as the AT attachment (ATA).[3]

Because the external interfaces became standardized and it became sufficient to comply with the rules of a specified interface, drive manufacturers no longer had to adjust their HDD specifications according to the computer in the design phase. They could now make the internal design of their HDDs as they liked, which expanded the possibilities for technological innovations and cost reductions. These changes were so dramatic that they completely changed the competition rules of the industry; they served as the background to the subsequent entry of many firms into the industry and their fierce competition in development and cost.

[3] BIOS is the basic program that controls a computer's input and output. SCSI is an interface connecting the computer with peripheral equipment. It was developed based on the SASI to make it more versatile. IDE is the interface standard jointly developed by Compaq Computers Corporation and Western Digital Corporation. It has achieved wide distribution as the standard interface due to its mechanical simplicity.

Figure 1. (A) Changes in HDD Shipment Value by Inch

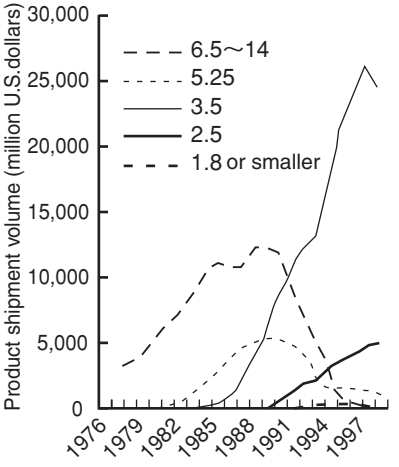
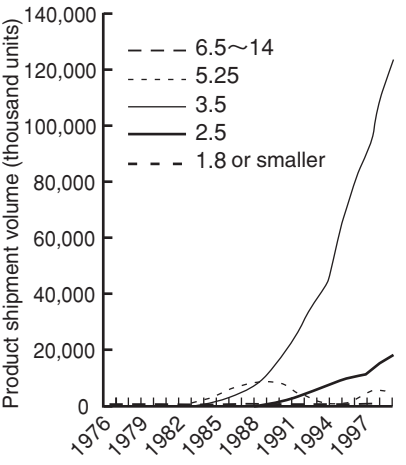


Figure 1. (B) Changes in HDD Shipment Volume by Inch



Source: Created based on McKendrick, Donner and Haggard [2000], p. 27.

Miniaturization of HDDs and Changes in Competitive Conditions

During this course, HDDs also became more compact. Figure 1 shows the changes in the world's total HDD shipment value and shipment volume by inch. The type of HDD that contributed to the growth of the industry in the second half of the 1970s when the industry had just started was the 6.5- to 14-inch drive for mainframes. The HDD industry had originally been monopolized by IBM. However, because new computer manufacturers emerged in the first half of the 1970s and procured their HDDs from external suppliers, the original equipment manufacturer (OEM) market for HDDs grew.

HDDs were first miniaturized from the 14-inch drive for mainframes to the 8-inch and 6.5-inch drives targeting minicomputers and office computers. By the first half of the 1980s, the 5.25-inch drive for desktop PCs was gaining popularity (Figure 1 (A)). This market was cultivated by such emerging firms as Seagate Technology, MiniScribe, and Computer Memories.

After that, the small HDD for PCs was further miniaturized from 5.25 inches to 3.5 inches, and the 3.5-inch drive achieved full-fledged diffusion in the 1990s. In this process, the emerging manufacturers of the 5.25-inch drive took bold growth strategies in entering the competition arena of the 3.5-inch

drive. Conner Peripherals was hived off from the leading 5.25-inch HDD manufacturer, Seagate. Within a few years, Seagate, Quantum, Maxtor, and Western Digital entered the market.

The important turning point was when HDD size shifted from 5.25 inches to 3.5 inches. Comparison between the shipment value and the shipment volume of HDDs in Figure 1 shows this fact. The changes in the HDD shipment value by inch in Figure 1 (A) suggest that the industry followed the miniaturization trend in a sequence from 14 inches to 6.5 inches, 5.25 inches, 3.5 inches, and 2.5 inches.

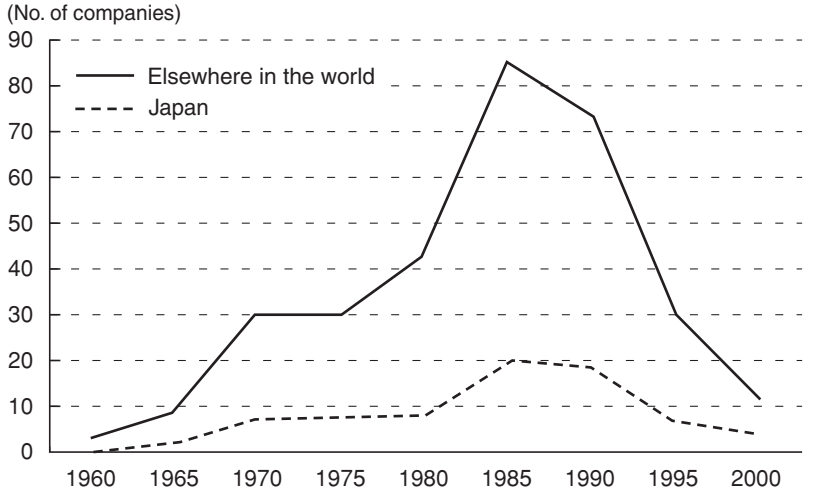
The changes in HDD shipment volume by inch in Figure 1 (B) indicate an essential difference between the miniaturization up to 5.25 inches and that from 3.5 inches onward. The miniaturization of the HDD up to 5.25 inches, though it brought changes to the market segment structure, did not change the basic structure of the industry; the shipment volume remainined at a low level.

In the process of miniaturization from 3.5 inches onward, the HDD manufacturers faced demand for product volume exceeding that for the 5.25-inch drive. The modularization trend created an incentive for increasing the production volume and accelerating innovation, and firms could secure profits only if they could manufacture HDDs of higher performance at lower costs. Instead of adopting a flexible development framework to adapt to market changes, firms had to take bold growth strategies by focusing on growing market segments such as that of the 3.5-inch drive.

Figure 2 shows the changes in the number of firms in the HDD industry. The figure clearly indicates the changes in the industrial structure caused by the expansion of the 3.5-inch drive market. The number of firms peaked in 1985 with 105 players in the industry. This was the time when the 3.5-inch drive market was launched in the United States. A large number of firms attempted to enter this market segment at the time, seeking potential business opportunities.

After the peak, however, many firms withdrew from the HDD industry, and the number of firms remaining in the industry rapidly declined. Only 15 firms remained in the industry in 2000, which means 90 firms, or about 86% in proportion to the number of firms in the industry in 1985, withdrew from the industry over 15 years. This rapid decline indicates that unusually fierce compe-

Figure 2. Changes in the Number of Companies in the HDD Industry



Source: Created based on data from the International Disk Drive Equipment and Materials Association (IDEM), *Trend* FOCUS, and an interview survey of firms.

tition characterized the small HDD market segment.

Market Performance as of 2000

To look more closely at the intensification of competition in the small HDD market throughout the 1990s, the performance of the market is identified based on the shipment volumes of HDD manufacturers and major component manufacturers as of 2000 (FY1999) as well as the changes in the sales and operating margins of major firms (see Table 1).

The small HDD market is divided into 3.5-inch ATA (drives for PCs; sold at around 10,000 yen), 3.5-inch SCSI (drives for servers; sold at around 30,000 yen), and 2.5-inch or smaller HDD (drives for mobile computers). The 3.5-inch ATA accounts for the largest volume, commanding a 73.6% share of the 184 million-unit HDD market. Meanwhile, the 3.5-inch SCSI commands a share of 11.0% and the 2.5-inch HDD a share of 15.4%.

As mentioned earlier, the SCSI and the ATA are only different in terms of the interface; they share the same magnetic heads and media for the 3.5-inch drives. As for price, the SCSI for servers is about three times more expensive than the ATA for PCs. With regard to the media used, the 3.5-inch

Table 1. Volume of HDD Shipped Worldwide (2000)

(thousand units)

	2.5-inch or smaller	3.5-inch ATA	3.5-inch SCSI	Total
Seagate (U.S.A.)		30,100	8,900	39,000
Quantum (U.S.A.)		26,800	2,500	29,300
Maxtor (U.S.A.)		25,400		25,400
IBM (U.S.A.)	11,100	8,300	5,100	24,500
Fujitsu (Japan)	5,300	14,500	3,200	23,000
Western Digital (U.S.A.)		18,200		18,200
Samsung (South Korea)		10,100		10,100
Toshiba (Japan)	7,200			7,200
Hitachi (Japan)	4,700		600	5,300
Others		2,000		2,000
Total	28,300	135,400	20,300	184,000

Notes: 1. The "2.5-inch or smaller drives" are all ATA. The "ATA" is for PCs and the "SCSI" is for servers.
2. Maxtor acquired Quantum's HDD business in April 2001.
3. Hitachi acquired IBM's HDD business in December 2002.

Source: "'01 HDD Market Survey: Current Status and Prospects of HDD-based Digital Home Electric Appliances" (June 2001) Japan Economic Center.

drives use aluminum and the 2.5-inch drives use glass.

By type of drive, U.S. HDD manufacturers achieve overwhelming production volumes in the 3.5-inch ATA segment. In particular, the top HDD manufacturer, Seagate, which boasts a tremendous production volume in this segment, also secures a 44% share in the high-priced 3.5-inch SCSI for servers. The firm's strategy is to secure its share of the high-end market while pursuing a high production volume in the ATA segment in order to attain a high production scale of its in-house manufacturing components.

The firms that made both HDDs for PCs and those for servers, similar to Seagate, included Quantum, IBM, and Fujitsu in 2000. They competed in developing cutting-edge component-level technology. They tended to self-manufacture some of the core components, including the head and media.

Other firms, such as Maxtor, Western Digital, and South Korea's Samsung, do not have the capacity for in-house development of core components, partly owing to their later entry into the industry compared to Seagate and IBM. Therefore, they specialize in the 3.5-inch ATA for PCs.

IBM and Japanese firms including Fujitsu, Hitachi, and Toshiba have also placed emphasis on 2.5-inch and smaller HDDs for mobile computers. This market segment is expected to grow in the future. Hitachi's 2002 announcement

that it would acquire IBM's HDD business was a strategy to gain dominance in the market of HDDs for mobile computers. Hitachi and Toshiba specialize in HDDs for mobile computers.

In addition to the drives, the market conditions of the key HDD components at the time should be studied. Table 2 shows the major manufacturers and the shipment volumes of the key components mounted on HDDs.

The supply markets of the major HDD components are dominated by Japanese firms. Such HDD manufacturers as Seagate, IBM, Fujitsu, and Hitachi

Table 2. Shipment Volume of the Key HDD Components (2000)

(A) Media (hard disk [HD]) (thousand units)

	Aluminum	Glass
Komag (U.S.A.)	46,500	
Fuji Electric (Japan)	39,400	1,800
Showa Denko (Japan)	34,800	8,900
IBM (U.S.A.)	53,900	
Mitsubishi Chemical (Japan)	34,200	700
Seagate (U.S.A.)	34,900	
Fujitsu (Japan)	12,800	
Nippon Sheet Glass (Japan)		11,100
Hoya (Japan)		25,600
Others	12,700	
Total	269,200	48,100

(B) Magnetic heads (thousand units)

IBM (U.S.A.)	102,800
Alps Electric (Japan)	101,600
Seagate (U.S.A.)	118,200
TDK (Japan)	154,300
Hitachi (Japan)	19,000
Fujitsu (Japan)	50,200
Read-Rite (U.S.A.)	66,100
Others	
Total	612,200

(C) Spindle motors (thousand units)

Nidec (Japan)	113,100
Matsushita-Kotobuki Electronics Industries (Japan)	31,500
Minebea (Japan)	31,100
Victor Firm of Japan (Japan)	11,900
Sankyo Seiki Manufacturing	8,100
Others	2,400
Total	198,100

Note: Samsung withdrew from the spindle motor market in 1999.
Source: "01 HDD Market Survey: Current Status and Prospects of HDD-based Digital Home Electric Appliances" (June 2001) Japan Economic Center.

manufacture magnetic heads and media (hard disks [HD]) in house, but even these firms procure any volume that cannot be covered by their own production capacity from these outside suppliers. In addition, because self-manufacturing of components requires development of cutting-edge technology and global production capacities, many HDD manufacturers do not self-manufacture the components. Therefore, the market for supply of the key components is enormous.

By type of component, the supply of magnetic heads is dominated by Alps Electric and TDK. As for media, there was intense competition among Japanese firms in the aluminum media market for 3.5-inch HDDs as of 2000. However, because the absolute number of media required for HDDs for PCs decreased with the improvements in the recording density, the media became oversupplied from around 2000. After that, the industry's structure changed with the withdrawal of Komag and the acquisition of Showa Denko by Mitsubishi Chemical, leading to a state of oligopoly. The supply of glass media for HDDs is dominated by Hoya and Nippon Sheet Glass. In the spindle motor market, Nidec boasts an overwhelming share.

It could be said that U.S. HDD manufacturers are more competitive in small HDDs, centering on 3.5-inch drives, and Japanese firms differentiate themselves by focusing on the 2.5-inch and smaller HDD market for mobile computers. On the other hand, Japanese firms are found to be more competitive in the key component markets. Why is there such an inconsistency in focus between the U.S. and Japanese firms when they are both part of the HDD industry?

4. Shift Towards Asia

Competition Strategies in Growth Markets

How did the structure of U.S. HDD manufacturers taking the offensive in the 3.5-inch HDD market and Japanese firms gaining an advantage in the key component market come about amidst the rapid expansion of the HDD industry? To answer this question, we must look at the growth strategies of major firms during this period.

Figure 3. (A) Sales of U.S. Manufacturers

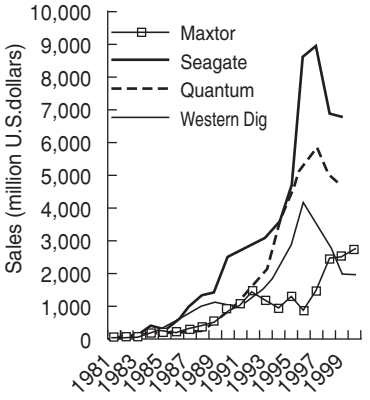
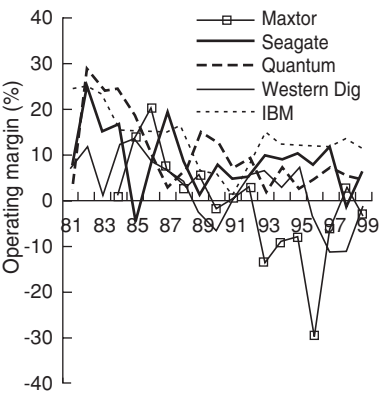


Figure 3. (B) Operating Margins of U.S. Manufacturers



Notes: 1. Financial data is on a consolidated basis.
2. Operating margins are EBIT margins.
Source: Created based on financial data from the Development Bank of Japan.

Figure 3 shows the changes in the sales and operating margins of U.S. HDD-specialized manufacturers. Due to the limitation in acquiring long-term data, earnings before interest and taxes (EBIT) were used for the operating margins instead of sales profits. The EBIT are the values close to operating profits, which are obtained by adding the interests paid to the ordinary income and subtracting the interest income from that total.

As Figure 3 (A) shows, U.S. HDD manufacturers dramatically increased their sales during this period, growing robustly with focus on the OEM market in 3.5-inch HDDs for PCs. In particular, Seagate continuously kept its top position in the industry. Its sales doubled in 1996 due to its acquisition of Conner Peripherals. Seagate has been followed by the second largest manufacturer, Quantum.

Compared to these two firms, Maxtor and Western Digital, which are latecomers that only deal in drive assembly, began to show a decline or a slowdown in growth in the second half of the 1990s. The reasons are said to be that they failed to integrate their global operations and that they were late in placing their new products on the market because they found quality problems at the mass production stage due to not manufacturing the key components by them-

selves.

In this industry, the scale of operation has a large influence on profitability. Figure 3 (B) suggests that the industry leaders, Seagate and Quantum, have maintained a certain level of profitability over a long term. The firm secured high profitability by growing. Meanwhile, the operating margins of Maxtor and Western Digital fell into the red in the second half of the 1990s and have stayed in the red since then. Because they could not expand their scale of operation smoothly and because they were not market leaders, they had no choice but to give in to PC manufacturers' pressure to lower the prices and thus failed to make profits.

The situation was not promising for Japanese HDD manufacturers either during this period. In the case of general electric appliance manufacturers, the profits and losses for individual divisions cannot be identified from the published financial reports. However, according to some interviews, it seems to have been difficult for them to make notable achievements in terms of profit, because the scale of commercial production was small for 3.5-inch HDDs, and the market for 2.5-inch or smaller HDDs was limited to laptop PCs with the proportion of domestic production also being high.

Figure 4. (A) Sales of Major Component Manufacturers

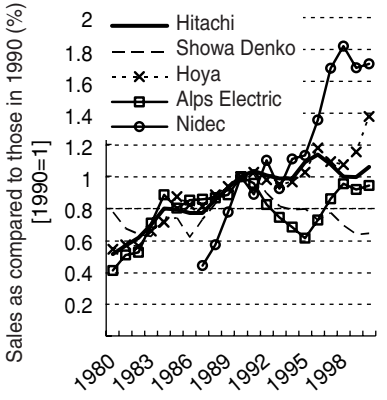
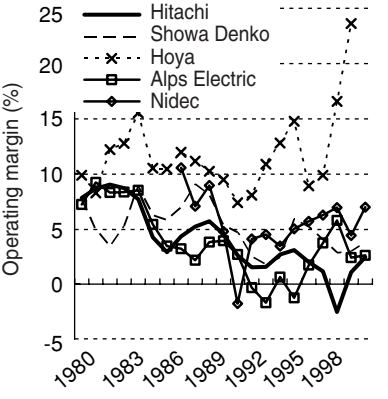


Figure 4. (B) Operating Margins of Major Component Manufacturers



Notes: 1. Financial data are on a non-consolidated basis.
2. Data for Hitachi is shown for reference.
Source: Created based on financial data of the Development Bank of Japan.

In the meantime, how did the business performance of component manufacturers change? Looking at the financial data of major firms in Figure 4, in the media market, Showa Denko has seen stagnation in both sales growth and operating margins, but Hoya has achieved an outstanding growth rate and profitability. The fact that Hoya has established a monopolistic position in the glass media for the 2.5-inch HDD has also contributed to its high profitability.

Among the manufacturers of magnetic heads and motors, Nidec boasts a monopolistic share in spindle motors, achieving notable sales growth. Its operating margin has remained within the region of 7% as well. In the case of Alps Electric, the firm had conventionally focused on magnetic heads and electronic components for home electric appliances. Nevertheless, it formulated a business restructuring plan in 1993 and shifted the production of electronic components for consumer products to China; it also restructured its domestic operations with focus on heads for HDDs. These efforts began to show results in 1996, and the firm's sales and operating margin have been recovering.

As a matter of course, these data are based not on individual operations, but on the overall operations of firms, so various factors are involved in their changes. As each firm defines its divisions differently, it is impossible to extract and compare information on the HDD-related segments alone. However, at least for the firms mentioned here, manufacturing of HDD components is a very large-scale operation and a business that contributes greatly to the firms' sales and operating margins.

Be they manufacturers of HDDs or HDD components, firms that assumed the market would expand, took active measures in anticipation of such growth, and built an operational framework that could withstand rapid business expansion succeeded in increasing their market control and profitability; even taking into account the restriction of data, this can be said about firms' strategies amid the rapid expansion of the 3.5-inch HDD market. Many of the Japanese component manufacturers that succeeded to grow and increased their competitiveness during this period established close relationships with leading U.S. HDD manufacturers. Firms that fell behind in achieving growth faced a decline in profits, both in the areas of HDD and their components.

U.S. HDD Manufacturers' Shift to Asia

Foreign investment in Asia played an important role in expanding operations in the growth phase that started in the 1980s. This is an aspect in which notable differences are observed between firms that achieved remarkable growth and those that became stagnant. The first point is the timing of the investment.

Table 3 shows the timing of HDD manufacturers' investment in Asia. The industrial leader, Seagate, was also the first firm to invest in Asia. Seagate was a venture firm founded in 1979 by an IBM engineer, Alan Shugart. Since Shugart himself was the person who promoted the standardization of the interface of 3.5-inch HHD, he thought it was only a matter of time until the HDD would

Table 3. Timing of HDD Manufacturers' Investment in East Asia

Year	Company	Place of investment
1983	Seagate Technology	Singapore
	Ampex	Hong Kong
	Computer Memories	Singapore
	Tandon	Singapore
	Tandon	India
1984	Seagate Technology	Thailand
	IBM	Japan
	Maxtor	Singapore
	Miniscribe	Singapore
	Quantum (OEM to MKEI*2)	Japan
1985	Microscience International	Singapore
1986	Micropolis	Singapore
	Tandon	South Korea
1987	Connor Peripherals	Singapore
	Control Data	Singapore
	Cybernex	Singapore
	Microscience International	Taiwan
	Priam	Taiwan
	Seagate Technology	Thailand
1988	Unisys	Singapore
	Western Digital	Singapore
1989	IBM (Saha-Union)	Thailand
	Seagate Technology	Malaysia
	Kalok	Philippines
	SyQuest	Singapore
	NEC	Philippines
1990	Connor Peripherals	Malaysia
	Microscience International	China
1991	Fujitsu*1	Thailand
	PrairieTek	Singapore
	Xebec	Philippines
1992	Integral Peripherals	Singapore
	Ministor	Singapore
1993	Connor Peripherals	China
1994	DEC	Malaysia
	Hewlett-Packard	Malaysia
	Quantum	Malaysia
	Western Digital	Malaysia
	MKEI (Quantum OEM)	Singapore
1995	IBM	Singapore
	Hitachi	Philippines
	Toshiba	Philippines
	Fujitsu	Philippines
1996	IIBM	Thailand
	Seagate Technology	Thailand
	Fujitsu	Vietnam
1998	MKEI (Quantum OEM)	Indonesia
2002	Western Digital	Thailand
	Hitachi*3	Thailand

Notes: *1.Fujitsu launched Fujitsu (Thailand) Co., Ltd. (FTC) in 1988, but shifted its HDD production to FTC in 1991.
*2. MEKI: Matsushita-Kotobuki Electronics Industries.
*3. Hitachi acquired IBM's HDD division.
Source: Created based on McKendrick, Donner and Haggard (2000) at p. 99 and data from interviews.

become adaptable to a wide variety of applications. Therefore, he established a production base in Singapore in 1983 and in Thailand the following year, driving forward the mass production of the HDD, already with a full understanding of how the modularization would affect the industry.

Seagate frequently conducted M&A in its growth process. It acquired Grenex (a thin-film media manufacturer) in 1985 and Aeon (an aluminum substrate manufacturer) in 1986. Furthermore, it purchased HDD software manufacturers in the 1990s and acquired Conner Peripherals, which had originally hived off from Seagate, in 1996. By procuring funds from the stock market and acquiring external resources through M&As, Seagate came to posses the largest HDD production capacity in the industry. Much of the production capacity it established through this process is located in Southeast Asia.

The next firms to invest in East Asia were Tandon and Maxtor. Tandon advanced into countries such as Singapore, India, and South Korea in the first half of the 1980s. However, this expansion ended in failure and the firm was acquired by Western Digital in 1988. Conversely, Western Digital managed to invest in Singapore through the acquisition of Tandon. Firms including Maxtor, Conner Peripherals, and Miniscribe also invested in Asia in and around the mid-1980s.

In the beginning, the race for foreign investment was started by U.S. venture firms. At that time, many of them chose Singapore as the place for investment. Since the OEM market (non-captive market) for the 3.5-inch HDD for desktop PCs was developing, backed by the rapid expansion of the PC market, U.S. venture firms daringly attempted to invest in Asia in order to establish a competitive advantage in the OEM market.

From the end of the 1980s, the place for investment by U.S. firms spread from Singapore to Thailand and Malaysia. Seagate invested in Thailand in 1987, in Malaysia in 1989, and once again in Thailand in 1996. Western Digital expanded into Malaysia in 1994, and Quantum also invested in Malaysia in the same year.

IBM's case is interesting. The firm had engaged in developing and manufacturing all types of HDD, from drives for servers to 2.5-inch or smaller drives for mobile computers. It had also conducted in-house development of key components, including magnetic heads and media. IBM America outsourced the development and manufacturing of 3.5-inch and 2.5-inch HDDs for PCs to IBM

Japan in 1984. IBM Japan initially developed and manufactured HDDs in Fujisawa, Japan. However, due to the competitors' shift to Southeast Asia and the impact of yen appreciation, they started to outsource the manufacturing of HDDs to Saha-Union Public Firm in Thailand in 1989. Moreover, IBM America shifted its operations related to HDDs for servers from San Jose in the United States to Singapore in 1995, and established a wholly owned manufacturing base in the Prachinburi Province, Thailand, in 1996.

Quantum also expanded its operations by using contract manufacturing. The firm was founded in 1980 and had expanded its business mainly through the 5.25-inch HDD. Quantum listed its stock in 1982 and came to command a 25% share in the HDD market. However, in order to further expand its production capacity, it entered into a partnership with Matsushita-Kotobuki Electronics Industries in 1984, regarding contract production of the 3.5-inch HDD. Matsushita-Kotobuki was first manufacturing the HDD at its base in Ipponmatsu, Ehime Prefecture, Japan but in order to evade the impact of yen appreciation, the firm launched overseas production of HDD in Singapore in 1994.

Concentrated Investment and Geographic Advantage

U.S. manufacturers invested in Southeast Asia, centering on Singapore and gradually spreading to Malaysia and Thailand. Eventually, a mass production framework in Asia became a requisite condition for securing large-scale transactions in the 3.5-inch HDD market. As indicated in Figure 2, the number of firms entering the industry declined and the number of firms withdrawing from the industry increased rapidly after this period. The overseas mass production capacity began to function as an entry barrier for surviving in the industry.

HDD manufacturers that achieved foreign investment consistently began to increase their overseas production ratios at this time. According to a study by McKendrick, Donner and Haggard (2000), which examined the changes in the overseas production ratio with regard to the HDD industry, the overseas production ratio of U.S. firms, which had only been 4% in 1983, increased to 67% by 1990. These firms had conducted a major shift to overseas production in the second half of the 1980s.

In contrast, the overseas production ratio of Japanese HDD manufacturers was only 2% in 1990 and 54% in 1995; they only began to make full-

fledged expansion into Asia from the mid-1990s. The main reason for the foreign investment was to deal with the second yen appreciation in the mid-1990s. Despite having a competing operational domain, Japanese HDD manufacturers were more than a decade late in engaging in foreign investment. It is doubtful that Japanese firms that made foreign investments with an eye on the exchange rate fluctuations were able to act based on a consistent global strategy.

As an example of concentrated foreign investment in Southeast Asia, the investment process of Seagate will be studied below in detail. Seagate's expansion into Asia began in Singapore in 1983, later spreading to Thailand and Malaysia. Seagate had 12,000 workers in Singapore and 16,700 workers in Thailand and Malaysia compared with 11,000 workers in the United States in 1990, and the number of workers in Asia increased to 15,000 in Singapore and 57,000 in Thailand and Malaysia against 9,000 workers in the United States in 1999. The firm now has 4,000 workers in China.

Seagate's employee makeup in Asia by region points to some interesting facts. One is that the firm has regarded Singapore as the central base in Asia for a long time. In terms of labor cost, it would have been wiser for the firm to downsize its base in Singapore and expand its bases in Thailand, Malaysia, and China. However, it did not do that. Seagate positioned Singapore as a base for supplying engineers and supervisors, which complements the U.S. headquarters, and as the core base for the industrial cluster in Southeast Asia. Therefore, the number of Seagate employees in Singapore never decreased throughout the 1990s.

Among the Southeast Asian countries, Singapore has substantial preferential measures for foreign firms, including tax incentives. For example, in Thailand, the Board of Investment (BOI) gives approvals for inward investment by foreign firms, and by dividing the land area into three zones from Zone 1 to Zone 3, it provides a tax allowance of 40% to 50% for firms investing in Zone 2 and Zone 3, which are far from Bangkok. Malaysia provides a tax allowance for re-investment and a tax allowance of a little over 10% for collaboration with universities and public research institutions. The Thai government usually takes about three to six months to approve an investment project.

Compared to neighboring countries such as Thailand and Malaysia, the support policy of Singapore had distinctive characteristics. First of all, its

taxation system was highly preferable for foreign firms conducting sophisticated operations, including an R&D allowance (23.1%), an equipment purchase allowance (61.5%), an allowance for collaboration with universities or public research institutions (61.5%), a depreciation allowance (53.8%), a human resources development allowance (46.2%), and an allowance for technical assistance to small and medium-sized enterprises (SMEs) (69.2%). At the same time, the time required for gaining an approval for an investment project was three months in 80% of all cases, which was extremely short compared to other countries. This point was very important for making large-scale investment with a short payback period in the IT industry, which has short lifecycles. The Singaporean government was thoroughly aware of the needs of the U.S. IT industry.

A more important point was that Singapore provided, in addition to the above-mentioned general incentives applicable to all industries, industry-specific incentives for the HDD industry. Singapore provided substantial preferred measures in association with a wide range of activities in the HDD industry, including (1) development of engineers and operators, (2) diffusion and development of technology, and (3) development of local vendors.

The organization that played the central role was the Magnetic Technology Centre (MTC; renamed as the Data Storage Institute [DSI] in 1996). The MTC was established within the National University of Singapore at the government's initiative in 1984. Since then, it has promoted basic research related to data storage and joint projects between industry and academia, and has produced a large number of engineers for the HDD-related industry. It also provided support measures for SMEs, provided them with basic knowledge and techniques for quality control and production management, and engaged in operator training.[4]

U.S. HDD manufacturers sought assistance from the Singaporean government and the government made active efforts to support Singapore's HDD industry. As a result, many firms related to the HDD industry established "advanced mass production bases" equipped with a technology development capacity and a mass production capacity in Singapore. Under a favorable envi-

[4] According to an interview by the author with the Data Storage Institute (DSI) (2004, February).

ronment, Seagate developed engineers, supervisors, and operators in Singapore, appointed them as core personnel, and spread a low-cost operation framework throughout Southeast Asia. When launching production bases in Malaysia and Thailand, the operational experience in Singapore and the human resources it had developed there played a key role. The concentrated human resources development at the core base and prompt transfer of knowledge to the neighboring mass production bases enabled Seagate to conduct what can be called a *vertical launch* of HDD mass production.

Furthermore, the firm developed local suppliers and encouraged global suppliers to establish their bases close to Seagate's bases. The firm provided technical guidance to local suppliers to raise their technical level. Seagate also appointed local workers as personnel in charge of procurement and repeatedly applied unique ideas in product design in order to be able to manufacture HDDs using local components. For global suppliers, the firm increased the incentive for establishing their bases nearby by increasing the production ratio in Southeast Asia and securing production volume. Since component cost accounts for a large share of the HDD production cost, such local supplier networks are likely to have contributed greatly to increasing the firm's cost competitiveness.

Seagate's efforts have been copied by other U.S. HDD manufacturers, and have sparked successive waves of investment. Underlying the rapid increase in the overseas production ratio in the second half of the 1980s were such efforts by the aforementioned pioneering firm, with subsequent firms immediately following its example.

Hesitant Japanese General Electric Appliance Manufacturers[5]

The U.S. HDD manufacturers' investment in Asia can be understood as part of the competition to acquire production resources on a global scale amidst the rapid expansion of the 3.5-inch HDD market. However, Japanese electric appliance manufacturers were not quick to respond to this trend. The reason was closely related to their conventional business circumstances.

The HDD sections of Japanese electric appliance manufacturers were usually established within the in-house computer divisions as sections provid-

[5] For the efforts made by Japanese general electric appliance manufacturers, see Amano (1999).

ing storage devices. From the end of the 1970s through the first half of the 1980s, they supplied storage devices to U.S. office computer manufacturers as OEM suppliers and expanded their operations. Since the HDDs for office computers had close technical relevance to computers, Japanese electric appliance manufacturers provided technical support and engaged in joint development with U.S. computer manufacturers; they gained tremendous trust from leading client firms, including IBM. The HDD business earned the biggest profits for computer manufacturers at the time, and some firms gained nearly 70% of their overall profits from the HDD business.

One example of this success is Fujitsu. The firm jointly developed an 8-inch HDD with Memorex Products in 1979, and independently developed a 48-MB HDD in 1981. It also succeeded in developing a 10.5-inch drive and supplied the product to the United States. Until the mid-1980s, the OEM business of HDDs for U.S. office computer manufacturers was one of the core businesses of the firm. Although the HDD business required cutting-edge technology, the unit prices for products were extremely high. Fujitsu exerted efforts to develop HDD-related technology in-house and in affiliated firms, and won orders from U.S. clients.

However, such success produced the opposite result in the world of small HDDs. In the second half of the 1980s when U.S. HDD manufacturers achieved rapid growth, Japanese electric appliance manufacturers faced a very severe situation. The market for medium and large-size HDDs was eroded by that for small HDDs, and shipment values for the HDD operations of Japanese electric appliance manufacturers, which had relied on medium and large-size HDDs, dropped sharply. Moreover, yen appreciation spurred a decline in profits. In order to break through this situation, Japanese electric appliance manufacturers finally began to review their operational structure in the early 1990s, but the process did not progress smoothly.

In the case of Fujitsu, which fared relatively well among the Japanese firms, the firm launched Fujitsu (Thailand) Co., Ltd. (FTC) in 1988 and attempted to shift its 3.5-inch HDD operation to FTC in 1991. However, the operation did not succeed, and Fujitsu withdrew from global production. It invested in Thailand once again in 1994, but full-fledged mass production only started in the second half of the 1990s, nearly ten years later than that of U.S. firms.

NEC Corporation was more passive. The firm had produced HDDs mainly for its PC98 series computers and computers for its internal systems divisions, as well as for the captive market in which products were sold through its distributors and exclusive dealers. NEC expanded into the Philippines in 1989, but all products were sold to Japan and the components were supplied from Japan; only the labor-intensive processes were outsourced to the local Japanese subcontracting firms, and the finished products were imported into Japan.

Overseas production was adjusted in line with exchange rate fluctuations, so the overseas production ratio changed wildly. The firm lacked the attitude to commit itself to establishing a mass production framework in Asia. As a result, costs became high and the firm had no choice but to withdraw from the in-house manufacturing of HDDs in 1998, and from the entire HDD production business in 2001.

Toshiba and Hitachi, at first, intentionally avoided full-scale entry into the 3.5-inch HDD market and specialized in the 2.5-inch HDD for laptop PCs. The two firms invested in the Philippines in 1995 and gradually increased their overseas production ratios. However, the market of the 2.5-inch and smaller HDDs for mobile computers was smaller in absolute scale compared to that for the 3.5-inch HDD, and had little growth potential.[6] Because they could not allocate a substantial amount of management resources to their HDD operations, the firms purposefully avoided entering into full-fledged competition with U.S. firms.

Compared to U.S. HDD manufacturers, Japanese firms were later to expand overseas, and their commitment to overseas production was irresolute. Their main investment location was the Philippines, which was far from Singapore and Thailand. By looking at their mode of investment, it is doubtful that they promoted foreign investment with a view to forming local industrial clus-

[6] In 1994, the world's total demand for HDDs was 62.58 million units, of which 900,000 units were for 2.5-inch and smaller HDDs, accounting for 14% of the total. In 2000, the world's total demand was 184.02 million units, of which 28.3 million units were for 2.5-inch and smaller HDDs, accounting for 15% of the total. The proportion increased little, but the production volume of the 2.5-inch HDD nearly tripled during these six years. The market is expected to grow further in the future.

ters and strategically expanding the scale of operations as the U.S. firms did. They seem to have regarded the shift of production to overseas bases a temporary measure to deal with the relative personnel costs that soared in Japan due to yen appreciation. Such differences between Japanese and U.S. firms manifested as differences in their competitive advantages in the HDD market in the 1990s when the 3.5-inch drive became the standard.

Rapidly Growing Japanese Component Manufacturers

In contrast to the struggling general electric appliance manufacturers, Japanese component manufacturers gradually gained strength in the 1990s. These firms paid attention to the growth of U.S. firms from an early stage and established business connections with them. Since U.S. firms started increasing their production in Asia the Japanese component manufacturers have attempted to establish their production bases near the U.S. firms' bases.

Japanese component manufacturers started investing overseas relatively earlier than Japanese general electric appliance manufacturers. They promoted overseas production in pace with the trend of U.S. HDD manufacturers rather than that of the Japanese HDD manufacturers.

The first Japanese firm to begin the trend of investment in Southeast Asia was the top spindle motor manufacturer, Nidec. It is a venture firm, founded by Shigenobu Nagamori, which was hived off from TEAC Corporation in 1973. At the time, Japanese general electric appliance manufacturers tended to produce motors in-house or at their affiliated firms, so it was relatively difficult to expand the motor business within Japan. Therefore, the firm conducted active sales and marketing activities in the United States.

At that time, U.S. HDD manufacturers were switching from self-manufacturing the spindle motors to procuring the motors from outside. Thus, Nidec was able to start a deal with Seagate in 1983. HDD manufactures including Seagate concentrated their development resources in the development of the drives and magnetic heads in order to catch up with the rapid market expansion of the 3.5-inch HDD. Nidec acquired orders for motors from most HDD manufacturers, weaving its way through this niche.

Table 4. Major Component Manufacturers' Operational Expansion Into East Asia And Its Timing

(A) Media manufacturers

	Overseas bases (operation; year of foundation)	Domestic bases (operation)	Remarks
Showa Denko	Malaysia (aluminum substrates; 1997)	Ichihara Plant (aluminum/glass media)	Showa Denko and Showa Aluminum merged in March 2001. It acquired the HD operation of Mitsubishi Chemical in 2002.
Mitsubishi Chemical	Singapore (aluminum/glass media; 1996)	Mizushima / Naoetsu Plants (aluminum/glass media)	
Komag (U.S.A.)	Malaysia (aluminum media; 1993, 1996)	San Jose in California (only development)	Asahi Komag, founded in 1987, was dissolved in March 2001. Komag closed all plants in the United States and shifted the operation to Malaysia.
Fuji Electric	Malaysia (aluminum/glass media; 1996)	Matsumoto / Yamanashi Plants (aluminum / glass media)	
Nippon Sheet Glass	Philippines (glass blank sheets, substrates, media; 1997), Malaysia (same as above; 1999)	Yokkaichi Plant (blank sheets, substrates, media)	The base in Malaysia is ADP (joint venture between Kobe Steel and Nippon Sheet Glass). It transferred its Philippine base to Hoya in 2004.
Hoya	Thailand (substrates; 1990), Singapore (media; 1995)	Akishima Plant (blank sheets)	Hoya received Nippon Sheet Glass'substrate base in the Philippines by transfer in 2004.

Notes: 1. Blank sheets are aluminum sheets punched out in a doughnut shape or glass sheets processed into a doughnut shape.
2. Substrates are blank sheets polished on the surface and cleaned. Media are substrates to which a magnetic film has been sputtered.

(B) Magnetic head manufacturers

	Overseas bases (operation; year of foundation)	Domestic bases (operation)	Remarks
TDK	Dongguan Plant in China (back-end process; 1994), Philippines (back-end process; 1996)	Chikumagawa Plant (development, front-end process)	TDK is the top supplier of magnetic heads for HDD.
Alps Electric	Wuxi Plant in China (back-end process; 1995)	Nagaoka Plant (development, front-end process), Furukawa Plant (back-end process)	
Read-Rite	Thailand (back-end process; 1991, 1995)	Milpitas Plant in California (development, front-end process)	Read-Rite established Read-Rite SMI with the capital participation of Sumitomo Metal Industries in 1991, but it was dissolved in 2001. The firm has continued its magnetic head operation in Thailand and undertakes processing work from HGA.

(C) Spindle motor manufacturers

	Overseas bases (operation; year of foundation)	Domestic bases (operation)	Remarks
Nidec	Thailand (motor component processing and assembly; 1990)	Kyoto / Nagano Plants (development, processing, assembly)	Nidec invested in Thailand in 1990, and has established and expanded its plants in nearby locations including Bangkadi and Rojana.
Matsushita-Kotobuki Electronics Industries	Indonesia (motor component processing and assembly; 1998)	Ipponmatsu Plant (development, processing, assembly)	
Minebea	Thailand (motor component processing and assembly; 1990)	Karuizawa Plant (development, processing, assembly)	

Source: Created based on data from interviews with firms, "Market Survey on HDD" for the relevant years, Japan Economic Center and "Electronic Manufacturers' Investment in East Asia," Electronic Economic Research Center, 1995.

In the case of Nidec, U.S. HDD manufacturers had been major clients from the beginning, so the firm had seen the need to establish its production framework in Southeast Asia from the mid-1980s. Nidec established a branch office in Singapore in 1984 to gather information while engaging in sales and marketing activities, and achieved investment in Thailand in 1990. The direct cause for the investment was a request from Seagate, which had already started manufacturing in Thailand, and from IBM-affiliated Saha-Union.

Later, while U.S. HDD manufacturers expanded their mass production at their overseas operation bases, Nidec established and expanded its plants in Thailand. After Nidec advanced into Thailand, Fujitsu, IBM (Prachinburi), and Western Digital also advanced into Thailand and nearby Malaysia, so it became even more advantageous to establish operation bases in this area. Nidec mentioned the following points as the reasons for choosing Thailand: (1) clients are concentrated in the area; (2) supply chains are developed, and about 70% of the components can be procured within Thailand; (3) there is access to the BOI's tax exemption measures and the preferential treatment for the HDD industry; and (4) they believe that people in Thailand are diligent and friendly.

Currently, Nidec controls the Ayutthaya, Bangkadi, Rojana, and Nidec Hi-tech Motor (NHMT) (acquired from Seagate) plants in Thailand, with about 9,000 workers. The firm has a separate production line for each client.

Nidec deals with most of the HDD manufacturers, including GSM, Maxtor, Western Digital, Hitachi Global Storage Technologies, and Fujitsu.

While Nidec conducted one of the most daring foreign investment campaigns of Japanese HDD-related component manufacturers, manufacturers of other types of components also shifted their operations overseas one after the other in the mid-1990s. In the area of hard disk media processing, U.S.-based Komag (1993 and 1996: Malaysia), Mitsubishi Chemical (1996: Singapore), Fuji Electric (1996: Malaysia), and Hoya (1995: Singapore) established their plants close to HDD manufacturers' bases. Their overseas expansion was also influenced by the local production activities of U.S. HDD manufacturers that were their major clients. Therefore, investment locations came to be concentrated in Singapore and Malaysia.[7]

5. Establishing Bases within Industrial Clusters and Creating Competitive Advantages

Growing Competitive Pressure and Establishment of Bases within Industrial Clusters

The HDD industry's shift to Asia cannot be discussed only from the viewpoint of the timing of the establishment of overseas production bases. In this industry, the significance of establishing production bases within industrial clusters in Asia gradually increased through the 1990s. This is closely related to the changes in competitive pressure within the industry. From the 1980s to the 1990s, the competitive pressure in the industry changed and HDD manufacturers' establishment of production bases in Southeast Asia came to take on a different meaning in terms of competition.

In the first half of the 1980s when U.S. HDD manufacturers began to consider the establishment of bases in the Southeast Asian region, particularly Singapore, the only roles of Southeast Asia were to accept matured products and manufacture low added value at a low cost by providing low-cost labor and investment incentives.

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[7] Based on "Market Survey on HDD" for the relevant years (Japan Economic Center) and "Electronic Manufacturers' Investment in East Asia," (Electronic Economic Research Center, 1995).

Table 5. Changes in the Competitive Pressure in the HDD Industry and Comparative Advantages of Each Country

			Comparative advantages of each country		
	Competitive pressure	Role of Southeast Asia in the HDD industry	Singapore	Thailand	Malaysia
1980-1985	Cost	New products were produced in the United States and the matured products were shifted to Southeast Asia.	Labor cost, general incentives, infrastructure, supervisors and engineers	Labor cost, general incentives, proximity to Singapore	—
1986-1992	Cost, Time to Market	Development of new products was launched in the United States, and when the processes became stable, mass production was conducted in Singapore. When the products matured, they were shifted from Singapore to Thailand or Malaysia.	Weak industrial cluster effects (human resources, industrial linkage), industry-specific incentives, general incentives	Supervisors and engineers, labor cost, proximity to Singapore	Supervisors and engineers, labor cost, proximity to Singapore
1993-2000	Cost, Time to Market, Time to Volume, Yield Improvement	The pilot run is conducted in the United States, and the production is directly launched in Southeast Asia.	Strong industrial cluster effects (specialized human resources, industrial linkage, technology spillover), strong industry-specific incentives, general incentives, proximity to Thailand and Malaysia	General incentives, weak industrial cluster effects, proximity to Singapore and Malaysia, labor cost	General incentives, weak industrial cluster effects, proximity to Singapore and Thailand, labor cost

Note: General incentives are general preferential measures for foreign investment and industry-specific incentives are preferential measures for investment which are specific to the HDD industry.
Source: McKendrick, Donner & Haggard (2000), p. 60.

The situation began to change in the second half of the 1980s. U.S. firms launched new products in the United States, commencing mass production in Singapore when the processes became stable, and shifting the production to Thailand or Malaysia when the products matured. Meanwhile, the product life cycles became shorter in the market, generating the need to shorten the time required for placing a new product on the market (Time to Market). Singapore played the key role in shortening the Time to Market.

After the mid-1990s, firms faced the need to expeditiously place new stable-quality products at low prices from the start. Therefore, while conducting a pilot run in the home country, the firms came to directly launch mass production in Southeast Asia. Today, they even conduct pilot runs in Southeast Asia.

By 1996, firms no longer simply sought low-cost labor from the investment locations. They were now required to shorten the development period in the United States, and to solve the quality problems involved in the process, from the pilot run to the launch at their local bases in Southeast Asia, so as to smoothly place the products on the market. In order to withstand such competitive pressure, the firms needed to promote localization in Southeast Asia and effectively exploit the various effects of industrial clusters.

The firms that responded actively to this issue were the U.S. HDD manufacturers and the Japanese component manufacturers. U.S. HDD manufacturers made concentrated investments in Southeast Asia from an early stage and actively involved themselves in the formation of local industrial clusters. They invited key component suppliers to these locations in order to enjoy stronger cluster effects. As their local production increased in scale, it became more beneficial for component manufacturers to move into these locations, so Japanese component manufacturers advanced into these areas.

Nidec in the earlier example was also quick at shifting its operations to Southeast Asia. Currently, the firm not only conducts the daily operations related to mass production, but also conducts product launches and pilot runs at its production bases in Thailand. They say they will transfer more of their back-end product development operations to Thailand in the future. It can be said that the firm has steadily reinforced its ties with industrial clusters under the increasing competitive pressure.

In contrast to these successful strategies, many Japanese general electric appliance manufacturers that were late in expanding overseas invested in the Philippines, far from the major industrial cluster areas. This can either be construed as having prioritized low wages to industrial cluster effects or having intentionally avoided the industrial cluster areas where U.S. manufacturers had a firm foothold.

Significance of Establishing Bases in Industrial Clusters in Terms of Operations

What, then, is the significance of establishing production bases in such mass production clusters in regards to the HDD industry? First of all, there are two significant points in regards to operations.

The first point is the ability to deal with daily production fluctuations and quality problems. Since most HDDs are currently destined for the PC OEM market, there are considerable production fluctuations on a daily basis. Information regarding market trends is relayed through the chain of production, to the component manufacturers by way of information systems. Thus, HDD manufacturers and component manufacturers must change their production volumes every day. Such daily adjustments of production volumes and response to quality troubles need to be conducted locally.

The second, more important point is the ability to improve yield upon launching a new model. Even if the key HDD components are of good quality when shipped from the component manufacturers, this does not guarantee a high quality final product. The quality of the finished product can only be confirmed after combining the components in the HDD manufacturer's final assembly process. In particular, when launching a new model, how quickly the manufacturer can correct the *compatibility problems* between the components and improve yield greatly affect the profits of the HDD manufacturer and the component manufacturers.

A case of a media manufacturer is highlighted below as a textbook example of this point.[8] This media manufacturer conducts business with its client firms in the following manner. When an HDD manufacturer commences initial development, the firm always has the homeland development team participate in the client firm's development to acquire information on the product's specifications and process attributes. Then the firm conducts the initial process development in the homeland, gradually shifting the operations to Singapore. The homeland staff and local staff carry out the pilot run at the overseas loca-

[8] Based on an interview with Hoya's subsidiary in Singapore (2004, February).

tion in cooperation with each other. During the same period, the client firm also shifts its pilot run and process development operations to Southeast Asia and works on launching the production. The two firms actively exchange information during this course.

The reason for conducting the pilot run at the overseas location is that, even if the trial products created in the product and process development phases comply perfectly with the intended design, when they are moved to the mass production phase, the percentage of good-quality products can be low due to the peculiarities of the actual facilities and the process characteristics. Also, even if a component manufacturer delivers good-quality components that meet the specified specifications, *defects* could occur when they are assembled into a product in the HDD manufacturer's final stage of production, due to a bad combination or incompatibility of components. In particular, problems frequently occur with respect to the interface between the head and the media.

The parameter adjustment in the media manufacturer's production process is important in solving this yield problem. Therefore, the media manufacturer in this case example has a separate production line for each client, conducts lot control, carries out 100 percent inspection in the pilot run phase, and informs the HDD manufacturer of the results. If the HDD manufacturer requests correction of a product's attributes, the firm makes adjustments by changing the parameters in the production process.

Due to the need for frequent adjustments in the mass production phase and early achievement of economies of scale, it is highly beneficial for component manufactures to locate their operations close to the HDD manufacturers' bases.

Access to Human Resources and Technology Spillovers

It is also possible to discuss the significance of establishing production bases within industrial clusters from the viewpoint of access to human resources and technology spillovers. This refers to the direct or indirect use of the labor market formed within a cluster.

In the case of mass production-type products such as the HDD, the manufacturers often face the need to establish a new plant or suddenly expand its production capacity. In such a case, it would be too late to start training

human resources with the know-how to launch such operations. The key to determining the production location would be the ability to promptly hire people who already have the necessary skills at that location. This point is evident in IBM's case.

Since its contract production to Saha-Union in Thailand in 1991, IBM has expanded its production in Southeast Asia. It established a wholly owned production subsidiary in Prachinburi in 1997. As of 2003, Saha-Union produced over 12 million units of product and the Prachinburi Plant produced over 28 million units. About 7,000 employees are working in the two locations combined.

When IBM established its Prachinburi Plant, it conducted personnel exchanges with Saha-Union, which had a long production experience. The firm had the staff hired at the Prachinburi Plant receive training in Saha-Union, and had engineers from Saha-Union dispatched to the Prachinburi Plant. In this case as well, the yield upon the initial production launch was very low at about 50%, and the firm was required to promptly solve the quality problems and smoothly inaugurate the production. Thus, the above-mentioned personnel exchanges were indispensable for launching production in the new plant.

Later, in the second half of the 1990s, IBM expanded the Prachinburi Plant and hired people at the mid-career level. It is notable that two-thirds of the engineers hired at this time had been working for nearby competitors, such as Seagate or Fujitsu, and the remaining one-third were people who had moved from semiconductor-related firms. Sometimes, such people coming from other firms brought their subordinates with them.

A similar situation occurred in Singapore. IBM established a production base for HDDs for servers in Singapore in 1994. The person who supervised the launch of this production base was an engineer who had over 20 years of experience with IBM's competitors, including Seagate. He took his subordinates with him when he joined IBM. A person who was assisting him stated as follows.

> When he started business in 1994, many senior staff members gathered under him. All of us had worked with him for ten years or more. I had the experience of working with him for another firm for ten years. We had accumulated work experience, sometimes in the same firm, and sometimes in different firms. However, when he was going to establish IBM Singapore, we all came back to him. So we already knew each other and had experiences at the time of establishment. This is why we could launch the business so quickly.[9]

This statement expresses the essence of the white-collar labor market in Southeast Asia very well. U.S. HDD manufacturers and Japanese component manufacturers that expanded their operations to Asia in a decisive manner launched production quickly by actively hiring people who had accumulated experience with other firms.

In recent years, many firms have also acquired such human resources through M&A. Western Digital acquired Fujitsu's plant in 2002 to expand production of the 3.5-inch HDD. The main reason for the acquisition was to acquire a large amount of experienced human resources along with the manufacturing equipment.

In an industrial cluster, information moves around through movement of labor, close business relationships between firms, and frequently held seminars. Best practices concerning production or distribution operations often come to be shared within an industrial cluster through various routes. By establishing a production base in a cluster and taking root there, a firm is able to increase its sensitivity to such information and effectively incorporate it into the firm's operations.

Many of the Japanese general electric appliance manufacturers that invested in areas far away from ASEAN's major industrial clusters could not enjoy such benefits at the initial phase of their production launch. The slow speed of the mass production launch of Japanese electric appliance manufacturers is attributable in part to limited access to experienced human resources at the locale. Due to this lack, the firms had to dispatch many engineers from Japan, so they took a long time to develop a local framework for solving problems independently and are likely to have failed to reduce the overhead costs in

[9] Based on an interview with IBM Singapore (1998, December).

proportion to the increase in the production scale.

6. Closing Remarks

The competition between firms in the HDD industry from the 1980s through the 1990s indicates how Japanese and U.S. firms competed fiercely based on the premise of accelerated innovations in line with the modularization of HDDs and a trend toward global competition. With additional involvement Asia, investment competition took place to gain dominance in this region, which is rich with management resources.

U.S. HDD manufacturers and Japanese component manufacturers that managed to achieve high business growth through investing in East Asia formed full-fledged industrial clusters in ASEAN countries including Thailand and Malaysia, centered around Singapore. Their expansion into Asia and their use of industrial clusters were backed by long-term principles, and they gradually involved the entire region. In that sense, these firms were strategic.

Japanese HDD manufacturers, in contrast, expanded into Asia passively to deal with yen appreciation and competitive pressures from U.S. firms. Applying no long-term principles, they did not maintain a consistent strategy. Their investment in Asia in the initial stage was not so different from their conventional outsourcing and reduction of processing costs within Japan, highlighting the difference with the competitors that pursued full production scale and speed. However, by the end of 1990, they also began to expand the scale of operation though M&A and are making efforts to form full-fledged industrial clusters in the Philippines and China, following the example of U.S. HDD manufacturers.

In the HDD industry, the expected functions of industrial clusters became more advanced with the increase in competitive pressures, so firms have made efforts to enhance the functions of industrial clusters and develop human resources. The countries on the receiving end of investment also developed industrial policies for making the industrial clusters more sophisticated. The efforts of the Singaporean government are notable in this respect. Since the mid-1980s, Singapore has rolled out investment-attracting policies that reflected the intentions of the investors, targeting specific industries, including the HDD industry.

The shorter time for approving investment projects and tax incentives focusing on capital investment and R&D, which the government presented, sufficiently met the needs of the HDD industry for short payout periods and intensive development of production technology at the locale. The initiatives targeting the HDD industry, including development of engineers and operators, technical/management support for local vendors, and support for R&D and commercialization of magnetic recording technology at the National University of Singapore, formed strong incentives for the investors in the industry to sophisticate the functions of the local area. U.S. firms and some Japanese component manufacturers used these support measures to actively localize part of their technology development and operational management function, so as to pursue scale and speed as well as improve the quality of local management. Additionally, the engineers and supervisors that had been trained at the local bases became indispensable when the firms expanded their business into other ASEAN countries or China.

The case study of the HDD industry reveals that U.S. firms and some Japanese component manufacturers were able to achieve competitive advantages in this industry because they quickly selected their business practices in line with technology and market changes, and committed themselves to pursuing potential in Asia in order to achieve an advantage in that business area. They did not merely aim to establish buffer locations to take advantage of low wage levels, but aimed to enhance their global competitive advantage through building global production networks with bases in Asia among their core bases. The local governments approved of such large schemes, and industrial clusters were formed to serve both parties' interests.

Finally, if multinational firms aim to strategically advance the functions of investment locations, and local governments develop support measures that match the needs of the industry, their strategies will bring extremely significant benefits to the country on the receiving end of the investment. While the establishment of large-scale bases will naturally have the effect of creating employment, particularly important factors are advancing the functions of the local bases and improving the quality of local human resources through the creation of diverse educational opportunities within the industrial cluster.

To maintain competitive advantages, firms need to clearly indicate their goals for advancing the functions and developing human resources at the bases of their global production network, and they need to take advantage of the external effects of industrial clusters. The countries on the receiving end of investment also need to cooperate with firms to produce employment opportunities for the workers and to foster the development of potential leaders within their ranks. When the firms' global strategies and the countries' industrial and human resources development policies intersect in this strategic way, business provides fruitful opportunities for developing high-quality human resources in the recipient countries.

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