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# **Architecture-based Advantage of Firms and Nations: New Global Alliance between Japan and Catch-up Countries**

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**Abstract:** Competitive advantage of Japanese firms and of catch-up countries' firms has been discussed through the case study on optical storage products. The dynamic change of product architecture from integral to modular mode has brought out the latent potential of catch-up countries. The more modular the architecture is, the larger the market shares of catch-up countries' firms and the smaller the market share of Japanese firms are. The analysis shows that the competitive advantage/disadvantage of the catch-up countries' firms depends not on the direct labor cost but on the overhead cost, in which the patent royalty accounts for the most portions. Based on the contrastive position in the product architecture and in the patent royalty, authors propose that Japan and the catch-up countries promote the architecture-based global alliance for symbiotic co-prosperity, in which the power of integral architecture and of modular architecture are combined into one joint venture company.

**Keywords:** competitive advantage, comparative advantage, product architecture, technology diffusion, catch-up country, Chinese firm, global alliance, patent royalty, intellectual property, optical storage, CD, DVD.

## **1. Introduction**

The aim of this paper is to analyze empirically the competitive advantage of Japanese firms and of catch-up countries' firms, and to propose a new global alliance model between Japan and the catch-up countries. The product architecture theory first appeared in US and Japan as a powerful tool to analyze the competitive advantage of firms and has even been applied to the comparative advantage of nations. US firms have been successful in the modular architecture products such as computers and digital networks, while Japanese firms have been successful in the integral architecture products such as automobiles, key parts/components, and key materials. According to the industry analysis by Fujimoto and Shintaku (2005), Chinese firms have been and will continue to be very competitive in the modular products.

The dynamic change of product architecture from integral to modular mode has been accelerated by the innovation of micro-processor and microcode technology, and this dynamic change has brought out the latent power of catch-up countries. However, they faced the following three problems: (1) heavy legal claims for patent royalty from advanced countries, (2) many products were less value-added products which are made of costly key parts imported from advanced countries, and (3) labor cost is not a key factor of the competitive advantage. These are typical trade conflicts between catch-up countries and developed countries which we can see many examples in our history, and will always come

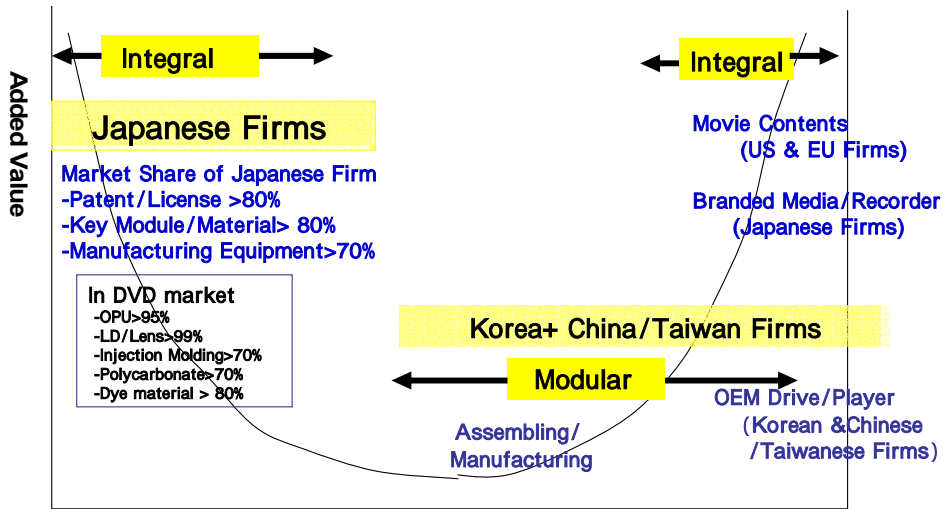
to the surface as a firm in a catch-up country becomes conspicuous by competitive products in the market.

In this paper, the authors introduce first the architecture-based analysis of optical storage products and then take the Chinese DVD player as an example to compare empirically the competitive advantage of Japanese firms and the catch-up countries' firms. Based on comparative analysis, the authors propose a new type of global alliance for symbiotic co-prosperity model between Japan and the catch-up countries.

## **2. What is Product Architecture**

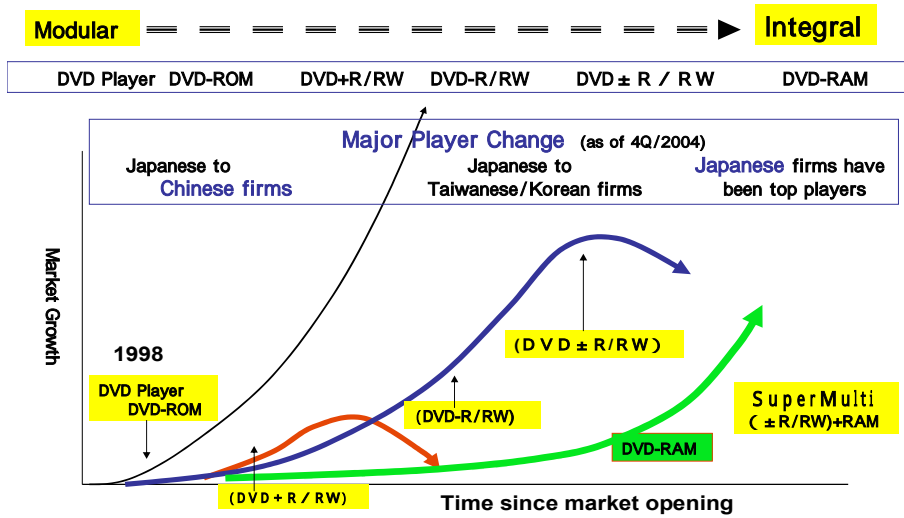
Product architecture is a basic design concept for the product and can be classified into two basic types: modular architecture and integral architecture. A distinctive feature of the modular architecture includes "open design rule", "open standard", "low barriers to entry", and "less interdependency among components". The typical examples of modular products are bicycle, PC, packaged software, cellular phone, Dynamic-RAM, CD-ROM, VCD, and DVD player. A distinctive feature of the integral architecture includes "closed design rule", "closed or de-fact standard", "high barriers to entry", and "strong interdependency among components", which are represented by passenger car, backup tape drive, DVD-RAM, CPU, optical pickup, magnetic head, printer head and so on. From the management aspect, it can also be defined that the modular architecture is a very powerful design concept to make a profit by

Figure 1. Smile-curve Analysis of Product Position



Source: Interview with the industry, 2004.

Figure 2. Architecture-based Position of DVD Drive



cost reduction and volume production in a global environment, while the integral architecture concept will create a high gross margin because the philosophy of the design is to restrict many of the technologies, the intellectual properties, and

know-how within the product.

Figure 1 shows a “smile curve” analysis of the DVD industry: Japanese firms have been very competitive in the domain of key materials, key parts, and branded products, while Chinese/Taiwanese

firms are very strong in low-cost assemble/manufacturing and non-branded OEM and/or ODM products. Among various kinds of DVD drives, Chinese firms have very large market share in DVD video player because it is a typical modular product, while Japanese firms have large market share in the DVD-RAM and the super-multi DVD drive as is shown in Figure 2 because it is a comparatively integral product. According to the authors' analysis on the DVD industry, it has been concluded that the more modular the architecture is, the larger the market share of Chinese/Taiwanese firms is and the smaller the market share of Japanese firms is.

### **3. Modular Architecture Drives Market Growth and New Entrants from Catch-up Countries**

The product architecture of CD and DVD drive was initially integral mode when they first appeared in the market, and then changed to modular mode in a process of market development and volume production (Ogawa, 2005). Engineers should have integral technological knowledge such as focusing and tracking of optical pickup and reading/writing a variety of media in order to develop the new concept of the products. These integral technologies are based on long term R&D investment and collaboration among experienced engineers.

According to our investigation, the innovation of micro-processor (MPU) and micro-code technology has radically changed the architecture

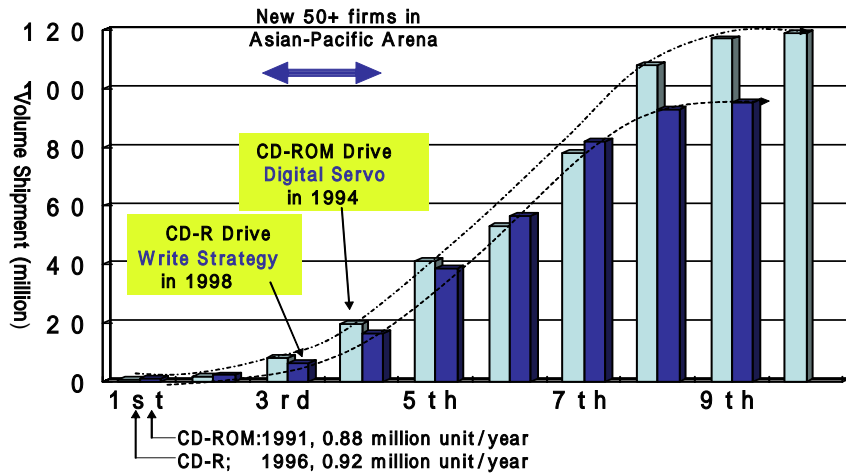
from the integral to the modular mode. The digital-servo technology of CD-ROM drive and the write strategy of CD-R drive are typical examples of such innovation. The chipset of the digital servo and the software package of the write strategy have been available in the Asian-Pacific market since 1994 and 1998 respectively. These two technologies have played critical roles for the modularization and provided new business opportunity for catch-up firms, such as Samsung and LG in Korea, and BenQ and Lite-On in Taiwan in the mid-1990s. They could go into the CD-ROM/CD-R drive business because they can buy the modularized key components like software package and/or LSI chipset that contain the sophisticated integral technologies inside.

Because the modularization of the drive technology reduced interdependency between key technologies/key parts and most of them became available in the market, even catch-up firms who did not have deep background of optical storage technology, could manufacture CD-ROM/CD-R drives in the mid-1990s. This is one of the major reasons why Korean and Chinese/Taiwanese firms have quickly become top players in the world-wide CD and DVD market in a few years. It is said that more than 50 firms in Taiwan, Hong Kong, and Korea had entered into CD-ROM business since 1994 and had developed a huge market in the PC environment as is shown in Figure 3.

The radical effect of modularization in the PC industry of US in the 1980s, has also been observed in the CD and DVD industry of Asian-Pacific arena

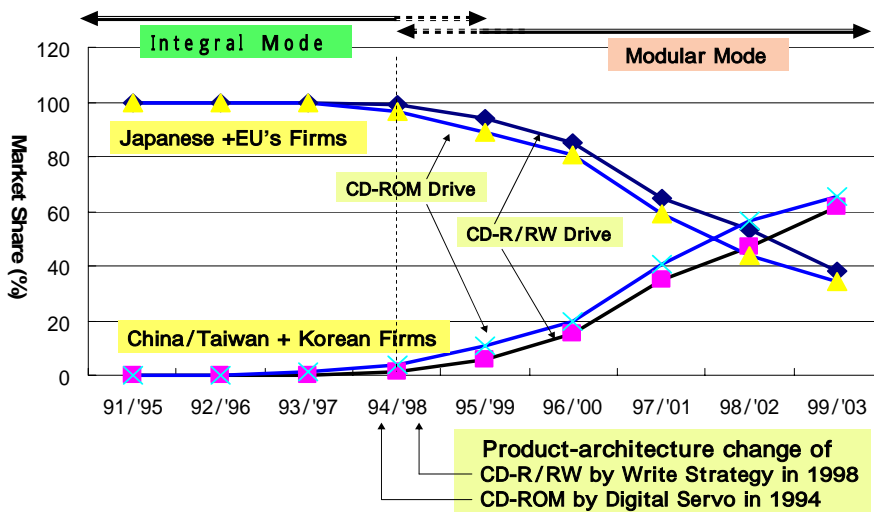
### Architecture-based Advantage of Firms and Nations

**Figure 3.** Market Expansion after Product-architecture Change in Computer Market Environment



Sources: TSR (2004) and authors' interview with Giga-Stream Inc. and optical storage industry, 2004.

**Figure 4.** Effect of Product-architecture Change on Market Share by Country



Source: Authors' interview with Giga-Stream and optical storage industry, 2004.

in the mid-1990s. The change of product architecture to the modular mode has brought out the latent power of the catch-up countries. The modular architecture was very powerful to popularize the CD and DVD product not only in US/EU/Japan but also in BRICs' (Brazil, Russia, India, and China)

countries and has grown into a world-wide market up to over 800 million units of CD and DVD drive per year and 30 billion pieces of CD and DVD media per year in 2004. We have observed almost the same phenomenon in the PC industry of the 1980s and the 1990s.

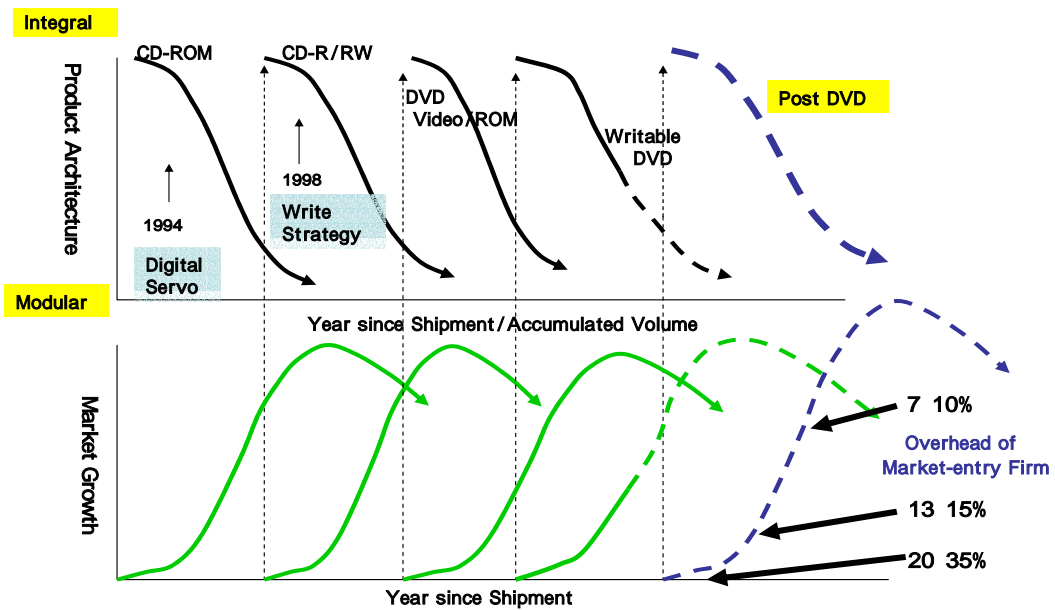
The architecture change from the integral to the modular mode has accelerated the technology diffusion from front-runner countries to catch-up countries. Figure 4 shows the sudden drop of market share of Japanese and European firms. While keeping the product architecture at the integral mode, or until the time when the digital servo chipset and write strategy software became available in the Asian-Pacific market, the share of CD-ROM and CD-R drive by the Japanese and European firms have exceeded 90%. But the market share suddenly dropped after the architecture changed into modular mode as is shown in Figure 4. It is interesting to mention that this relation between front runner firms and catch-up firms is the same with the relation between IBM and clone PC manufacturers such as

Compaq and Dell in the late-1980s.

The transition of the market share in CD-ROM is almost the same with CD-R/RW. The similar trend has also been observed in DVD player, DVD-ROM drive, and writable DVD drive. The trend will be the same with HD DVD drive of post DVD. This is the power of the product architecture change which has accelerated Japanese and European firms to withdraw from the market in most optical storage products in the past 20 years. The relation between market growth and dynamic change of the architecture is schematically summarized in Figure 5.

According to the authors' investigation and analysis, the number of Japanese scientists/engineers who have contributed to the world authorized major international symposium on optical memory called

Figure 5. Dynamic Change of Product Architecture and Contribution to Market Growth





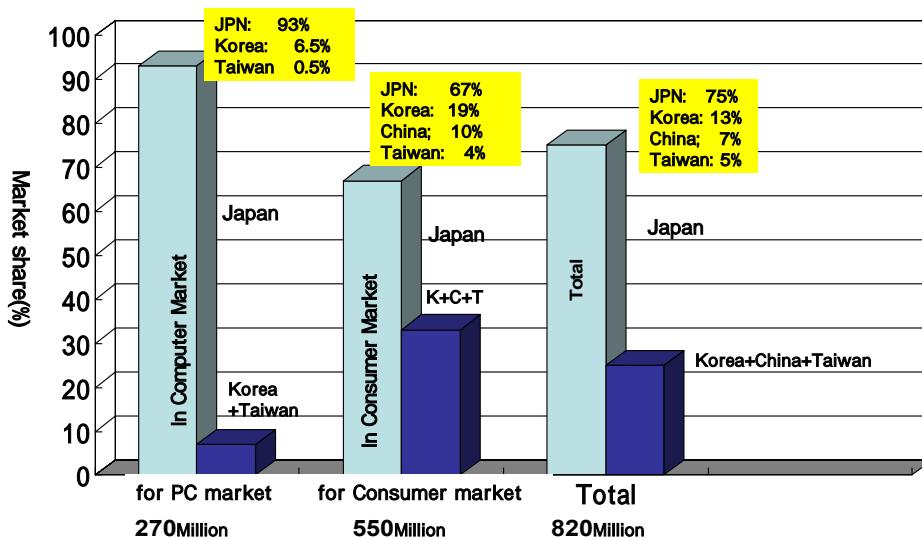
### **Architecture-based Advantage of Firms and Nations**

ISOM, has been about ten times larger than that of Korean and Taiwanese. But the market share of actual products of Japanese firms in the PC market environment has decreased to 22-23%, while the market share of Korean and Taiwanese firms together has rapidly increased up to 77-78% since 1994. The authors believe that it is very important for Japanese firms to understand the reason why many of the Japanese firms who have developed almost all of the technologies, the products, the international standard, the new applications, and even most of the patents, have been forced to withdraw from the market when the architecture changes into the modular mode.

### **4. Sustainability of Competitive Advantage in Integral Architecture**

The optical pickup (OPU) is a core component of the CD and DVD drive. The role of OPU is similar to Intel CPU's in PCs. The product architecture of OPU first appeared as integral mode, and remains the same integral mode even today. The integral architecture has also enabled Japanese OPU manufacturers to maintain over 70% market share as is shown in Figure 6. The same trend has also been observed in many key parts/materials and manufacturing equipments in DVD products (See Figure 1). Even among the DVD drive families, Japanese firms have a very large market share in the slim type DVD drive and the super-multi DVD drive, because these are comparatively integral products (See Figure 2). It can be concluded that the more

**Figure 6.** Market Share of Optical Pick-up by Country (year 2004)



Sources: TSR (2004) and interviews with Nomura Research Institute Ltd. (NRI) and OPU suppliers.

**Table 1.** Share of Japanese Firms in Optical Storage Industry in 2003

	Drive*	Optical Pickup
CD-ROM	5.25%(54.49%)	92.50%
CD-RW	5.64%(40.53%)	94.00%
DVD-ROM	10.27%(78.13%)	98.20%
DVD-W	67.60%(87.17%)	82.80%

Note\*: The numbers in parentheses include share of joint venture companies between Japanese firms and Korean and Taiwanese firms.  
Sources: TSR (2004) and field survey by authors.

integral, the larger the market share of Japanese firms, and the smaller the market share of Chinese/Taiwanese firms (See Table 1).

### 5. Architecture-based Global Alliance in Asian-Pacific Arena

Figure 7 summarizes the product architecture position of Asian countries in the optical storage industry. It should be emphasized that Japanese firms which are positioned in the domain of integral architecture products and components cannot exist in the market without modular products of Chinese/Taiwanese and Korean firms. On the other hand, most of the modular products cannot be manufactured nor shipped to the market without the integral components from Japanese firms. In other words, many firms of the optical storage industry in Asian-Pacific arena have been and will continue to be in symbiotic business relationship.

Each country has a unique and strong position in their product architecture. Their position will not change quickly because it originates in the business culture and the characteristics of each nation. Based on their different unique advantages in the product architecture, Hitachi of Japan and LG Electronics of Korea have started a new joint venture company called HLDS in 2000 (Ogawa, 2003; Yoshimoto, Shintaku & Ogawa, 2005). Hitachi takes charge of the integral technology and products, while LG is responsible for the modular technology and products. In other words, the power of the integral architecture and the power of the modular architecture have been combined into one company (See Figure 8). Since 2003, only three years after the company started, HLDS has been number one CD/DVD drive manufacturer in the world and has grown into a very profitable company.

Figure 7. Position of China/Taiwan, Korea and Japan in Product Architecture of CD/DVD Families

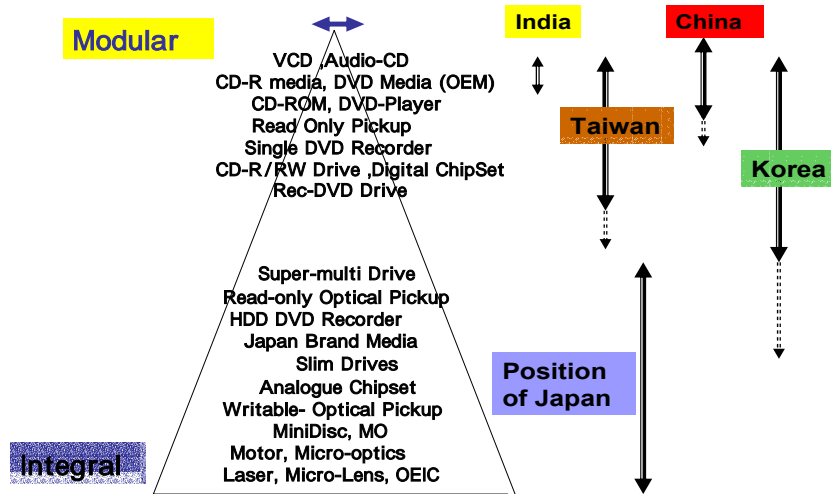
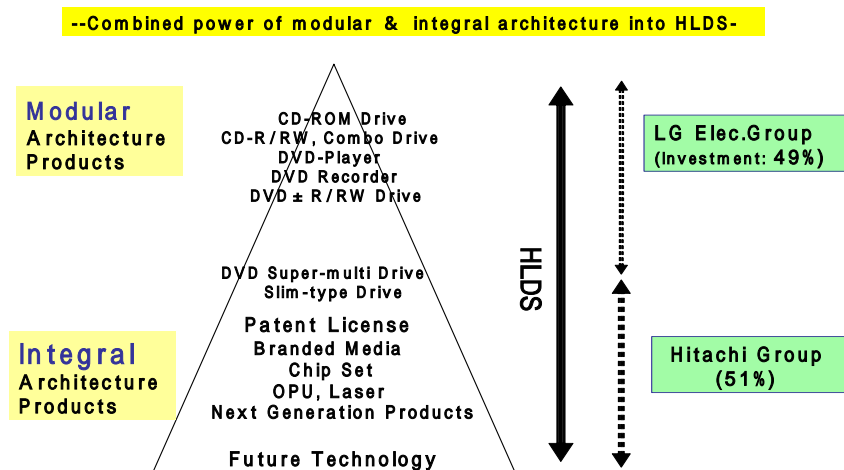


Figure 8. Hitachi-LG: Global Vertical Integration Model



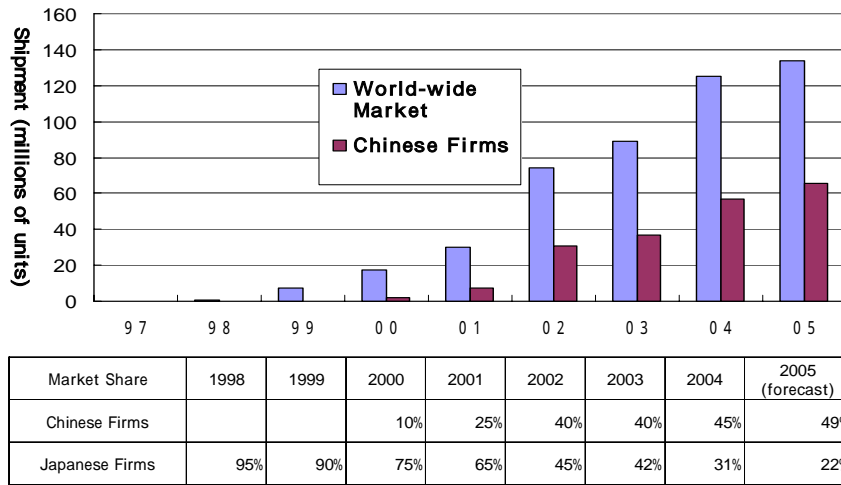
## 6. Competitive Advantage and Vulnerability of Chinese Firms

Figure 9 shows the market growth and the rapid progress of Chinese firms in the world-wide DVD player market. The market growth has been strongly dependant on the sales price (See Note 1). In other words, the higher price products with better

performance have been restricted to the niche market domain. Japanese firms have first developed most of the products and were the top players while the product architecture was the integral mode. It was a profitable business but the market size was very small, because the sales price was very high.

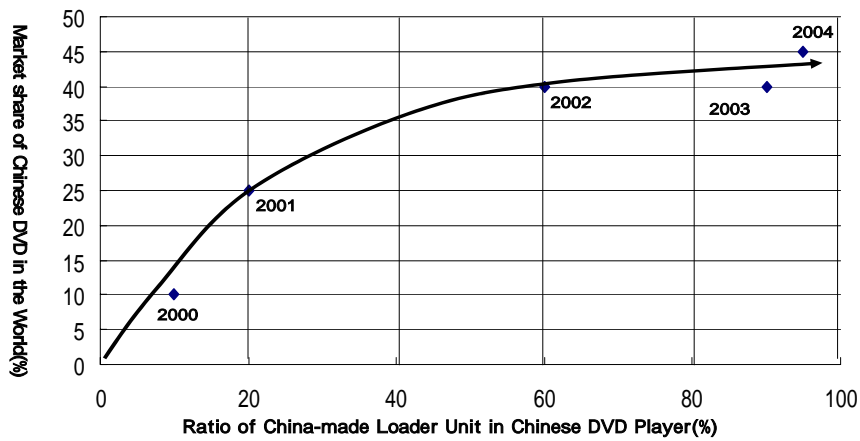
The integral mode of the DVD player has

Figure 9. Rapid Progress of Chinese Firms in DVD Player Market



Note: Chinese firms defined here includes joint venture companies between Chinese and Taiwanese firms.  
 Sources: TSR (2004) and authors' interview with Giga-Stream and optical storage industry, 2005.

Figure 10. Contribution of China-made Loader to Rapid Progress of Chinese DVD Player



Source: TSR (2004).

gradually changed into the modular mode in the process of market development (see Figure 5). The modular mode has provided new business opportunity for the catch-up firms like Chinese firms to join the new market, because the change into the

modular mode has accelerated technology diffusion from front-runner firms to the catch-up firms. In the case of Chinese DVD player for example, many Chinese firms have been able to start assembling the loader unit (see Note 2), since the product

### ***Architecture-based Advantage of Firms and Nations***

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architecture has been further modularized by combining the chipset of Taiwan and the optical pickup of Japan into simple solution-kit which Taiwanese firms and Japanese firms have jointly provided. Figure 10 shows an emblematic potential brought out by the product architecture change, in which the China-made loader unit has greatly contributed to the rapid progress of Chinese DVD player since the key parts have been further modularized into the solution-kit (See Note 3).

According to authors' investigations and interviews to the DVD industry people, Chinese firms have not joined the DVD standardization activity nor contributed to the technology development. However, as has been observed in Taiwanese and Korean optical storage industry since 1994, it did not always require deep technical backgrounds for the Chinese firms to startup business of the modularized DVD product. As the modular mode advances, price of the product radically drops, because the barriers to entry become very low and many catch-up firms can easily enter into the business. The modular mode inevitably brings excessive price competition. This is one of the major reasons why the top player has gradually been replaced by catch-up firms such as Korean firms and then by Chinese firms. This is the power of the modular architecture.

The replacement of the top player shown in Figure 4 and Figure 9 originates in the difference of the total business overhead cost. In the case of DVD player for example, competitive advantage of the

Chinese firms originates in very small overhead which is estimated to be 5-7% smaller than Korean firms (see Note 4) and 10-20% smaller than traditional Japanese firms. With the lower retail price and then the smaller gross margins, almost all of the Japanese firms and even Korean firms will not be able to compete in the DVD player market. This is the reason why Japanese firms have been forced to withdraw from the market, and Chinese firms have been pushed into top player in the market. As can be expected from Figure 9, the Chinese firms shall soon take more than 50% of the world-wide market share. It is projected by the industry people that Chinese firms will take 80% of the share in the DVD player market by year 2010 if the overhead is kept small as it is.

What is the vulnerability of Chinese firms? Chinese DVD industry, as a typical example of the catch-up country-industry, has faced the following three problems:

- 1) heavy legal claim for patent royalty from front running countries,
- 2) most of the value-added key parts and modules have been and will continue to be imported from front running countries, and
- 3) labor cost is not and will not be a key factor of comparative advantage and/or competitive advantage of China/Chinese firms.

It will become very difficult for Chinese firms to run the DVD business by paying all of the royalty which have been claimed from front runner countries,

because the percentage of the relative amount of the royalty will become unreasonably higher and higher as the retail price of the DVD player becomes lower and lower. It is a noteworthy fact that, in a case of a major DVD manufacturer in Taiwan, the ratio of the royalty was estimated to be over 50% of the total overhead in year 2004 (Note 5) and have become almost impossible to continue the business if they would keep paying all of the claimed royalty.

It has been said that Chinese/Taiwanese firms should establish their patent claims to rank with the front running countries, as it would be indispensable to invest in bringing up talented people in the long run, but it would invariably increase the overhead of the firm. On the other hand, if Chinese/Taiwanese firms would continue to pay the license fees, it also would certainly increase the total overhead of business operations. The Chinese/Taiwanese firms need to solve this dilemma. As it has always been very difficult for the firm in the modular product business environment of any country to make affordable investments in key parts development on long-term business strategy, it has been and will be very difficult for the Chinese/Taiwanese firms to get out of the modularity trap. This is because modular products such as VCD and DVD player have been in excessive price competition and is very difficult to make profit. Even if the firms could afford to develop the key parts by themselves, it would also definitely increase the overhead and would lose competitiveness. Above all, if the Chinese/Taiwanese firms do not acquire the integral

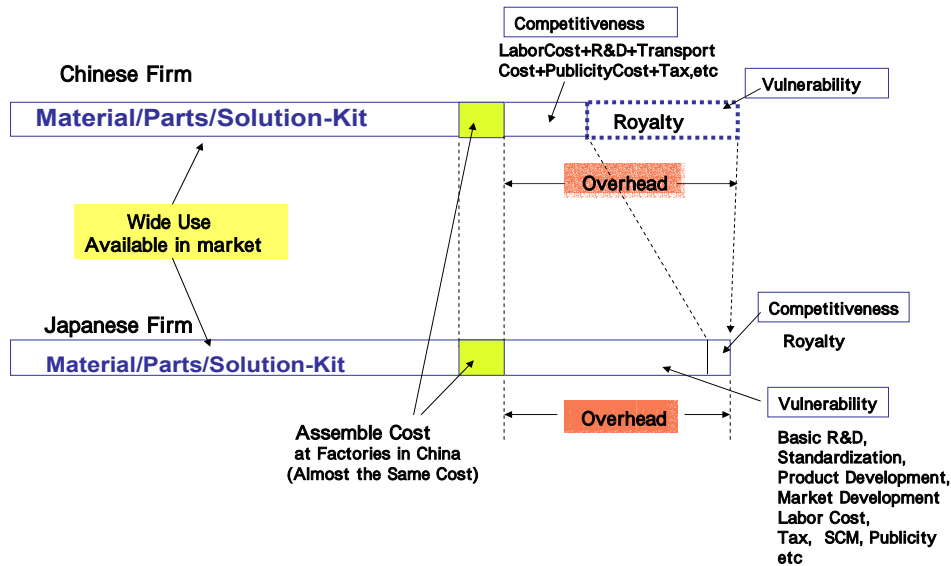
technology of the key parts, the late coming catch-up countries would take over their market position by means of much smaller overhead.

As the cost of total business operation is only a factor to win the business of the modular products in the given market, the role of the overhead rises up out of the depth of business operation. This is because most of the modular products are built from almost the same key parts and/or solution-kits which are in wide use in the market and because not only Chinese/Taiwanese firms but also Japanese firms and Korean firms manufacture the product at factories in China. This means that the manufacturing/assemble direct costs turn out to be the same for all firms of any country.

The overhead defined here includes the patent royalty fee, long term investment for basic R&D, key parts development, product development, market development, international standardization, manufacturing factory/equipment, SCM, tax, and so on. As is schematically shown in Figure 11, among the overhead in the DVD business, patent royalty accounts for the most significant portion of the product competitiveness for the catch-up countries' firms (see Note 6), because the royalty of the DVD is much higher than that of CD's.

A Japanese firm called Funai Electric, a typical catch-up type firm in Japan, has started DVD player and recorder business and has quickly joined the top runner group in the world-wide DVD market. Funai's products are manufactured at factories in China and directly shipped to the US market. Its

Figure 11. Product-cost and Overhead Comparison of DVD Drive between Chinese Firm and Japanese Firm



overhead is much smaller than Korean firms and even smaller than major Taiwanese DVD manufacturers. Funai is the toughest competitor to Chinese firms (See Note 7).

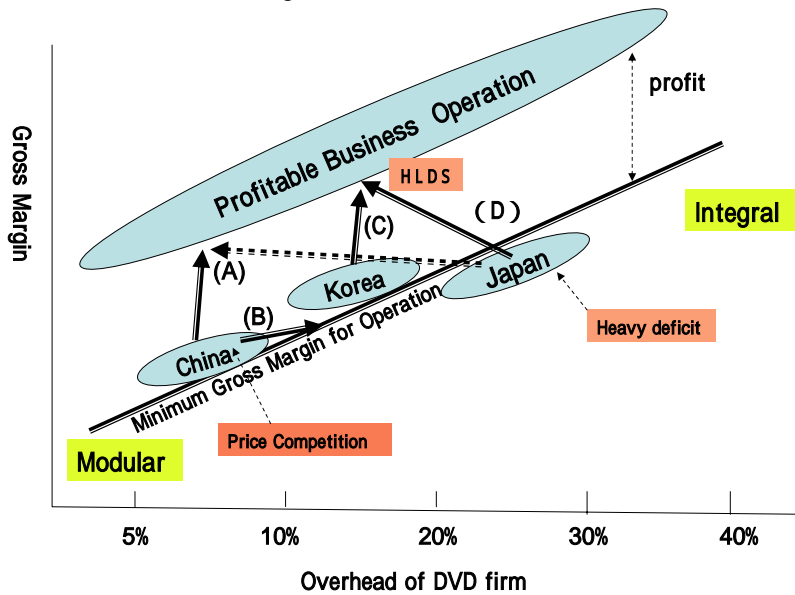
The competitive advantage and the vulnerability of the Chinese firms described above are the typical international trade conflict between catch-up countries and developed countries which we can see many examples in our history, such as between India and England in the late 1600s and the early 1700s (Kawakatsu, 1991 and Note 8), Germany/France and England in the mid-1800s, USA and Europe in the early 1900s, and Japan and USA in the 1970s and 1980s (Shintaku, 1994). These conflicts will always come to the surface as firms of catch-up countries become conspicuous by competitive products in the worldwide market and/or

as the products of front running counties are forced to be banished from the market.

## 7. Proposal of New Global Alliance between Japan and Catch-up Countries

As has been described above, the product architecture has been gradually changed from the integral to the modular mode and the modular mode has provided new business opportunity for the catch-up firms to join the market. The catch-up countries' firms has been and could be very competitive in the modular product if the overhead would be kept very small as it has been, while Japanese firms have been and will be competitive in the integral product because it restricts many of the technologies, integral properties, and know-how

Figure 12. Overhead-position of China/Taiwan, Korea, Japan and Direction of Profitable Business Operation



within the products.

Understanding (1) the difference of the product architecture position (see Figure 7), (2) that the patent royalty claimed from Japanese firms accounts for the most significant portion of the overhead for the catch-up countries' firms (see Figure 11), (3) that most of the Japanese firms have been and would be forced to withdraw from the market saddling with heavy deficits (see Figure 4 and Figure 12), and (4) that each nation has its own strong point, authors propose that Japan and the catch-up countries promote the architecture-based global alliance for symbiotic co-prosperity. As has been mentioned in Section 5 of this paper, we can see a successful example of the alliance between LG of Korea and Hitachi of Japan, in which the power of integral architecture and of modular architecture are

combined into one joint venture company called HLDS. Funai Electric, the typical catch-up type firm in Japan, had started a joint venture company called Digitek with Mitsubishi Electric in 1999 before Funai started DVD player and recorder businesses.

It is very important for the industry of the catch-up countries to understand the reason why the percentage of Hitachi's investment to HLDS is 51%, and why Mitsubishi's investment to Digitek is 51%. The 51% from Hitachi means that HLDS is consolidated subsidiary company of Hitachi and thus all the patent royalty issues are automatically handled by Hitachi. It is said that the actual royalty fee of the DVD business has been significantly decreased because Hitachi has established patent claim to rank with other patent holders, and moreover Hitachi has many cross-licensed partner



### ***Architecture-based Advantage of Firms and Nations***

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firms in the world.

Most of the optical storage products were first developed by Japanese firms who have competitive advantages in the integral product. However the position of the top player has been quickly replaced by catch-up firms in the process of market development and/or volume production. A very serious problem for the Japanese firms is that the period of profitable business operation has become shorter year by year, because speed of the architecture change from the integral to the modular mode has become faster and faster. In these digital business environments where product architecture shift occurs rapidly, Japanese firms need to find business partners who have strong competitiveness in the modular products, while catch-up countries' firms need to build up closer cooperation with a partner who has strong competitiveness in the integral products and has many essential intellectual properties of the product. Without moving on to a global alliance, the catch-up countries' firms could not continue the business even in the modular products under the WTO environment.

We must emphasize that positive technology transfer does not mean technology leakage. From a position of Japanese firms, the global joint venture company shown in Figure 8 means that it has changed the business direction of Japanese firms alongside arrow (D) in Figure 12. Since 2003, only three years after the joint venture company has started, HLDS has turned into one of the most profitable subsidiary companies of Hitachi group. It

has been said that without moving on to the alliance, Hitachi would have been forced to withdraw from the optical storage industry. The joint venture company between Mitsubishi Electric and Funai Electric also shows similar success story that Funai is exceptionally a profitable firm among the DVD suppliers in Japan because Mitsubishi Electric is the majority (51%) among the investors and is one of the major license holders in the DVD Forum.

According to our investigation, similar relation of symbiotic co-prosperity has been observed in the business relation between JVC and Lite-On (2002), Philips and BenQ (2003), and Toshiba and Samsung (2004) aiming at the same success story. From a stand position of the firms of the late coming catch-up countries like China, to start the global joint venture company with Japanese firms will change the business direction of the firms along arrow (A) in Figure 12. Without moving on to the architecture-based global joint venture company, most of the catch-up countries' firms would go in the direction of arrow (B), in the same way as many of traditional Japanese, US, and European companies have experienced. If they would pay all of the claimed royalty, the overhead cost of almost all the firms of the catch-up countries would become very large and will push the business direction alongside arrow (B) in Figure 12 (see Note 9). On the other hand, without moving on to the architecture-based global joint venture company, many of the Japanese firms except for the firms like Funai (see Note 10) would be forced to withdraw from the market

saddling with heavy deflects.

The concept of the symbiotic global joint venture company in the digital business environment of the Asian-Pacific arena is inevitably required as the dynamic change of the product architecture to modular mode occurs and as the total business overhead, in which the royalty accounts for the most important portion, becomes the key factor of the competitive advantages. The authors propose that both Japan and the catch-up countries promote this new type of architecture-based global alliance. These alliances will definitely contribute not only to prevent Japanese firms from withdrawing from the market but also to produce the cash-flow for the Japanese firms to develop new integral technologies. Furthermore, the alliance will contribute not only to the economic growth of each country but also to solve trade conflicts between Japan and the catch-up countries.

**Note 1**

*PCST Report* (2005) by Giga-Stream referring the American CEA report which analyses the DVD player and the DVD recorder market in USA.

**Note 2**

Loader unit defined here includes optical pickup, disk rotation motor, traverse mechanics, and loader mechanics.

**Note 3**

Chinese firms cannot join the writable DVD market so far, because technology of the chipset and optical pickup is much more advanced than

those of the read only DVD player, and because Taiwanese chipset suppliers cannot provide even a single chipset nor further modularized solution-kit to Chinese firms. Japanese chipset suppliers have learned much about the business strategy in the modular product business environments in the past 15 years.

**Note 4**

The overhead of Chinese firms noted here does not include the royalty which has been claimed from front runner countries. The percentage is estimated by the authors based on the interview with the industry analysts and to direct interview with major DVD manufactures of Japan, Taiwan, and Korea.

**Note 5**

The percentage noted here is estimated based on the authors' interview to the analysts who have been deeply involved in Taiwanese optical storage industry.

**Note 6**

More than 80% of the essential patents in DVD are covered by Japanese firms (DVD Forum <http://www.dvdforum.org/forum.shtml>), but not many licensors have opened the royalty fee. According to industry analysts, total sum of the royalty claimed against Chinese firms is estimated to be well over 10 dollars per a DVD player even though the retail price of the player in US market has dropped to 30-50 dollars in 3Q/2005, while royalty claimed against Japanese firms is estimated to be 2-4 dollars because the firms are

major license holders in the DVD forum. Furthermore, the street price of Japanese brand DVD player is 50-80 dollars, which is 50% higher than that of Chinese brand products.

**Note 7**

On top of the low overhead, Japanese firms like Funai Electric has a high potential to reduce the manufacturing cost of the DVD player, that is, much lower than that of Chinese firms, because Funai has powerful vertical integration manufacturing system based on technologies and sophisticated production system FPS (Funai Production System) like Toyota's, which Chinese firms do not possess. By taking many of the added-values inside of the vertical integration, Funai can reduce the cost in each process of the manufacturing system at the factories in China, nonetheless.

**Note 8**

The fur textile industry of England was forced to withdraw from the market by the mass export of calico (cotton) from India in the late 1600s and the early 1700s. But the withdrawal had created the technology-enabled industry revolution in England, where they manufactured copied calico by newly invented spinning machine (Kawakatsu, 1991).

**Note 9**

According to the DVD industry people, the number for the DVD players formally reported by Chinese firms to the licensors is much smaller than the actual shipment. Bad firms have driven

out good firms in China.

**Note 10**

If Japanese industry policy could encourage and bring up powerful manufacturing firms such as Funai Electric, Orion Electric, Nidec, Minebea, Mitsumi Electric, Teac, and so on, the integral type Japanese firms would choose these Japanese manufacturing firms as partners for architecture-based alliance. In such an alliance, Japan could control the technology diffusion more strategically than today even while the product architecture changes to the modular mode. And if the Japanese firms could strictly control the patent royalty, the architecture-based alliance among the Japanese firms would take over the world-wide DVD market. According to DVD industry people, Japanese firms have gradually become profitable even from the low price DVD player business in US market, nonetheless, where the royalty is attached a great importance to the DVD business. The authors believe that not only the innovation of the vertical manufacturing integration but also strategic control of the patent royalty which have been created through the long term R&D investment, will be the fount/source of the comparative/competitive advantage of Japan/Japanese firms. The authors will report in another paper the new direction of Japanese manufacturing management system of the modular product by combining the importance of the vertical integration and of the strategic control of the patent royalty.

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