Will Digital Appliances Save Japan?

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Japan's information technology (IT) industry, which had been weak since the bursting of the IT bubble, has suddenly returned to life. Digital appliances products such as mobile phones and DVD (digital versatile disc) devices are propelling this movement. In particular, sales figures for DVD recorders, digital cameras, and LCD televisions have each grown by 40% or more on a year-on-year basis. Sales of all electronic devices have increased by 14.9%, to a level higher than that during the era of the IT bubble (according to figures from the Japan Electronics and Information Technology Industries Association [JEITA]).

Although in the personal-computer industry Intel and Microsoft have overwhelming control of the market, home electronics are a specialty of Japanese firms. For this reason, the argument is often made in the media that, should Japan's public and private sectors cooperate to create a global standard originating from Japan, Japan could take the lead in such an era of "ubiquitous computing". But would things really go so smoothly?

<Semiconductors are the key to digital appliances>

A characteristic of digital appliances is that the internals of such devices are made up of semiconductors. For this reason, the value of semiconductors shipped from Japanese manufacturers in 2003 has increased by 22.5% up on the previous year, a rate of growth far exceeding the worldwide average of 14.8% (according to figures from World Semiconductor Trade Statistics Inc. [WSTS]). A breakdown of these figures shows that the relative importance of DRAM chips (used for memory in personal computers), in which Japan once boasted an overwhelming market share, has fallen, while shipments of system LSI chips incorporating software for digital home electronics have increased.

Since its birth in the 1960s, integrated circuit (IC) technology has experienced rapid technological innovation. According to Moore's Law, the number of transistors per square inch on an integrated circuit should double over 18 months. Empirical research shows that the cost per volume of calculations has decreased to 1/100 millionth of what it was 40 years ago[*1], a figure largely consistent with Moore's Law. This is evidence of a level of technological innovation for which there is no historical precedent. The performance of the semiconductors in today's mobile phones is equivalent to that of the mainframe computers of years past.

As it is an economic principle to reduce the use of expensive (scarce) resources and rely heavily on inexpensive resources, explosive technological innovations such as those in the semiconductor industry will have a major impact on the structure of the industry. As the performance of semiconductors improves, the relative cost of the use of digital technology decreases rapidly. This leads to information that had conventionally been processed using analog (manual) means to be processed by converting it to digital signals.

For example, while traditional cameras record images on a silver halide film that is then processed physically through developing and printing, a digital camera processes an image by converting it to digital signals. Although it seems like a waste to use complex calculations to digitally process an analog image which is ultimately printed as an analog photograph, the very inexpensive semiconductors relied upon in this process can reduce costs, such as those for development, thus justifying what once seemed wasteful. What's more, as the price of a semiconductor decreases by 75% over three years, digital-camera images, which were once no match for analog photographs, can now exceed analog photographs in terms of quality.

Moving images require a particularly large volume of calculations. Yet, image compression devices once found only in television studios are today included in DVD recorders costing only tens of thousands of yen. In addition, broadband connections (another result of semiconductor technology) enable the transmission of such images into homes. DVD technology does not require the precision control technologies that are a specialty of Japanese firms. This is due to the fact that an incorrect signal can be corrected electronically. General-purpose technology such as the semiconductor replaces delicate craftsmanship with digital signals and reduces the functions of a wide range of home electronics devices to differences merely in terms of application software.*2 For example, Sony's DVD recorder – the PSX – is nothing more than an application that enables a hard disk, a game console, and networking technology to function on the same hardware.

Although in the past home-electronics manufacturers frequently ordered semiconductors from other firms, as the semiconductor is the core of a digital appliances, many home-electronics manufacturers now produce their own semiconductors in-house. Creating smaller and more energy-efficient devices by incorporating a large number of functions into a single semiconductor chip is Japan's specialty. The strong teamwork achieved through Japanese-style cooperation works well when hardware and software are combined into a single high-performance unit that exceeds their respective roles. Although American manufacturers have dominated personal-computer platforms, in the home-electronics field the combination of hardware and software into a single device can be planned from the beginning, enabling Japan to take the lead: this is the strategy mapped out by Japanese home-electronics manufacturers.

<The computerization of home electronics>

However, when we turn to the internals of actual system LSI chips, the discussion is not so simple. For example, in the past, each manufacturer of mobile telephones incorporated its own semiconductors into its products, but today many manufacturers share common browser (such as those for i-mode). What’s more, third-generation (3G) mobile telephones use the same operating system (OS) worldwide, and manufacturers are also working to standardize applications for such phones. This is because software is comprised of millions of individual steps and it is difficult for each firm to design all of its own software. In other words, while the external appearance of a mobile telephone is made unique by each manufacturer, the internal logical design of each phone is modularized and consists of a combination of general-purpose parts.

This same phenomenon has been occurring in the computer industry for years. Originally, there were many different types of computers, and they were not compatible with each other. However, as software grew in complexity, a horizontal division of labor was required between hardware and software. The common points of computer technology became standardized in the computer's OS. The OS that is becoming the standard for 3G mobile telephones, Linux, is a clone of Unix, originally designed for minicomputers. As the IBM-PC that debuted in the 1980s incorporated an OS and a CPU that IBM purchased from other companies, compatible machines could be built easily. As a result, these compatible clones far overtook the official IBM-PC in terms of market share.

In the memory industry as well, although in the early 1980s the physical planning of circuits was a specialized technique and the manufacturing process required a large amount of manual labor, since the end of the 1980s circuit planning has become standardized, manufacturing processes have become automated, and technology has shifted due to the development of semiconductor manufacturing equipment, which has lead Japanese manufacturers to lose their predominant market share. At the same time, South Korean manufacturers have used semiconductor manufacturing equipment to mass-produce low-cost DRAM chips with no need for investment in plants and equipment, and semiconductor manufacturing foundries that do not design but specialize in producing semiconductors under contract to other firms have arisen in Taiwan and elsewhere. These low-cost, high-volume producers have overtaken Japanese manufacturers.

Changes such as these are not limited to the PC and semiconductor industries. The shaded area in the Figure indicates the area between the upper and lower levels of performance demanded by the marketplace. In the early stages of a integrated *sustaining technology*, as the performance of devices does not fully satisfy the requirements of the market, it is necessary to increase the degree of completion of the system as a whole, resulting in an advantage for vertically integrated firms (Zone A). However, as a technology matures, its performance exceeds that required by the market (Zone B), leading to the appearance of modularized *disruptive technology* that can perform the same functions at lower costs, which in turn results in a reduction in costs through the horizontal division of labor (Zone C). This cycle is repeated with each generation of products, as has been demonstrated in the hard-disk industry*[3].

(Figure: Sustaining and disruptive technologies)

Current digital appliances can be considered to be in Zone A of the Figure, as integration proceeds along with the development of single chips for the control of such devices. This trend will lead the degree of completeness of such semiconductors to increase until the devices exceed the upper limit of the demands of the market (Zone B). As semiconductor technology matures, manufacturers should begin to mass-produce the same types of chips at low prices, leading to the start of price competition in Zone C.

In the future, as mobile phones are used by incorporating applications downloaded from the Internet, the performance of such general-use terminals should continue to increase, leading them to approach the performance levels of computers. For this reason, the industrial structure of the digital-appliance industry should be considered to be more along the lines of the PC industry than the traditional home-electronics industry. This is due to the fact that such devices are closer to single-function home computers than digitalized home appliances.

In fact, large computer manufacturers such as Dell, Hewlett-Packard and Gateway have begun selling LCD televisions manufactured by companies in China and Taiwan. As LCD screens are standardized the world over and have become commodities, manufacturers of "clone appliances" have arisen. Such clone manufacturers do not need to make investments in plants and equipment, but instead purchase low-cost parts and assemble them. What's more, this change has occurred even faster in the LCD screen industry than in the PC industry. Although 20 years were required from the appearance of the $3000 IBM-PC until the price of a PC fell to below $1000, the price of a DVD recorder fell from $1000 to $300 in only two years.

<Toward diverse competition between architectures, rather than public-private cooperation>

As symbolized by the term “silicon cycle,” the semiconductor industry is a cyclical one. As commoditization of the digital home-electronics industry cannot be avoided, it is likely that the current boom in Japan’s home-electronics industry will not continue for very long. In responding to such circumstances, it is not necessarily a wise policy to turn to the “intellectual-property strategy,” in which technologies are fenced in by patents and copyrights. The current superior positions of companies such as Intel and Microsoft were the result of a skillful strategy of first implementing open standards, which then became de facto standards, leading these firms to achieve monopolistic positions in markets that gradually shifted toward integrated technology.

The worldwide spread of new technologies, such as the Internet and open-source software, results from platform competition for architectural superiority rather than competition for the advantages of core technologies. In this competition, open technology is a necessary condition for becoming a market leader. For this reason, what Japan’s manufacturers must consider are, not such meaningless nationalistic concepts as a “Japanese global standard,” but strategies to increase profitability through the open release of information on a global scale.

Although this is not a simple task, merely being content with local standards is not a way to survive in the IT industry, in which price competition is severe. Although in the mobile-phone industry the Japanese PDC standard has managed to survive due to the industry’s failure to agree upon a single standard, 76.9% of the mobile phones shipped worldwide in 2002 conformed to the European GSM standard, while PDC’s share was only 1.5% (according to statistics from EMC). For this reason, no matter how good the products of Japanese manufacturers become, they cannot overtake Finland’s Nokia. In the telecommunications world as well, although domestic standards had been strong in the past, the Internet has consolidated the worldwide market, leading to circumstances in which Japanese local standards are unlikely to survive.

At the same time, in the DRAM market, in which Japanese manufacturers at their peak accounted for 80% or more of the worldwide market, Japan's market share has fallen to 7%. Today, only Elpida Memory, Inc., in which NEC and Hitachi have invested, manufactures DRAM chips in Japan. However, Elpida's President Yukio Sakamoto, a veteran of foreign-owned firms who assumed his current post in 2002, has led the company to a rapid rebound in performance. A characteristic of this rebound has been its focus on products for use in digital appliances and the abandonment of its focus on producing chips in-house, so that today the firm outsources production to countries such as Taiwan and China, where necessary, in what might be called the company's American management style.

Just as Japanese-style management was not all-powerful, the current situation should not be taken as evidence that American-style management is always superior. As shown in the figure above, the optimal business type changes according to the phase of technological progress, and business types also vary by industry. Separating these types of management by country into "Japanese-style" and "American-style" categories is pointless.

As is the case with the semiconductor and computer industries, national borders no longer exist in the home-electronics market. Although the diverse uses of home appliances implies that not all such technology will be replaced by modules, at least in the case of IT-related appliances, the vast superiority in cost terms of the global production of disruptive technology is likely to lead to specialized domestic products becoming mere niche products. In industries such as digital broadcasting, in which Japanese government leadership has led to the implementation of fixed Japanese standards, Japan seems to be forcing itself into a niche market.

As seen throughout the history of the semiconductor industry, the weakness of Japanese firms stems from the fact that, because Japanese manufacturers tend to be vertically-integrated “general electronics manufacturers”, they can dominate in terms of volume but their position becomes fragile when products commoditize and price competition becomes fierce. In particular, with the horizontal division of labor characteristic of the industrial structure since the 1990s, companies producing specialized modules have dominated. As Japanese manufacturers have been unable to shed their integrated uniform structures, they have been routed by overseas firms. What Japan needs today is not public-private cooperation but a wide range of small and large firms taking part in global competition using diverse architectures. Procuring a wide range of resources from overseas and abandoning the focus on producing such resources in-house should result in an increase in Japan’s presence in Asia.

*1 W.D. Nordhaus, “The Progress of Computing,” Cowles Foundation Discussion Paper, 2002.

*2 Nobuo Ikeda, “Semiconductors as General-Use Technology,” RIETI Discussion Paper 03-J-018, 2003.

*3 C.M. Christensen, M. Verlinden, and G. Westerman, “Disruption, Disintegration and the Dissipation of Differentiability,” Industrial and Corporate Change, 2002, 5:955-993.

1/ Performance

2/ Zone A

3/ Zone B

4/ Sustaining technology

5/ Market requirements

6/ Zone C

7/ Disruptive technology

8/ Time