Software as a Tool of Competitive Advantage: A U.S.-Japan Comparison

U.S. software firms are widely believed to have a competitive advantage over their Japanese counterparts in most horizontal application software. Does the same hold true for vertical application software? How do U.S. and Japanese firms compare in the use of software to enhance product design, production and delivery?

Through a research project seeking to assess the strategic implications of competitive interaction between Japanese and U.S. software firms, Center Research Associate William Rapp found that U.S.-Japan software competition is best understood by distinguishing between competition in the software industry and the use of software for competitive purposes in other industries. While Japanese firms lag behind in many markets for packaged software, they are ahead in certain uses, particularly in those industries where software is a strategic production input rather than an independent output.

On April 11, 1996, the Center on Japanese Economy and Business, with support from the Alfred P. Sloan Foundation, hosted a one-day conference to report and evaluate these results, and to set parameters for further comparative research on industry use of software as a strategic input for competitive advantage. Bringing together specialists in software, semiconductors, computer hardware, automobiles, steel, consumer electronics, and financial services, the conference explored cutting-edge approaches to enhancing competitive advantage through the use of software.

Excerpts of the speakers' presentations are presented below, along with highlights of the audience discussion, which comprised a significant and informative portion of each session.

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The Software Industry and the Use of Software in Enhancing Competitive Advantage

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Large Users' Adoption of Information Technology

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Discussion

In reviewing the factors leading to a U.S. competitive advantage in the computer software industry, it is important to note that software products may be divided into at least three broad categories: software produced by users for internal application, including so-called embedded software; custom software produced for sale by developers or service firms; and standard software, including both shrink-wrapped software and standard operating systems. In terms of output or market share, reliable measures of performance are available only for the third category of standard software.

Concerning the consumption of these different types of software across the United States, Japan and Western Europe, an important distinction is the very substantial share of domestic consumption in the United States accounted for by standard software, estimated in the 70 to 75 percent range. In Japan, consumption of standard software is estimated to be 25 to 35 percent, or less than half of that in the United States, and in Western Europe, it accounts for an estimated 50 percent. Market share data indicate that whereas U.S. firms have a very substantial competitive advantage in packaged software, this advantage is much less pronounced in applications. This reflects the increasing significance of differences in user requirements across industries and national borders as well as the importance of close interaction between users and suppliers in the applications area.

Four important turning points have marked the evolution of the U.S. software industry, and to a large extent the global software industry over the past 45 years.
First, the development of a large installed base of mainframes in the United States in the 1960s created the beginnings of a market for standardized software that could operate across individual mainframe installations. Second, the unbundling of hardware and software in the late 1960s, which occurred first in the United States and later, to a lesser extent in Western Europe and Japan, led to the separation of pricing and marketing of an independent and substantial software industry. Third, the rise of the desktop computer in the early 1980s, in which again the U.S. market was the leader, led to a system for which software was provided almost entirely by independent vendors. Many of these vendors were new firms with very little experience and very little history as software suppliers in the mainframe or minicomputer segments of the market. The fourth and final turning point is the rise of networking, both networking among firms and organizations through the Internet and networking within firms through decentralized computer installations. Throughout each of these phases of the industry’s evolution, the United States has played a consistently important role as market leader.

Key Factors Leading to a U.S. Competitive Advantage in the Computer Software Industry

The competitive advantage that the United States has derived in traded software reflects in the first instance the creation and maintenance of an open, highly competitive market for hardware, which contrasts with the much more protected markets for hardware in Western Europe and Japan during this period.

Second, the liberalization of telecommunications in the United States has supported innovation in services and created opportunities for entry by new firms for marketing new products and applications.

A third factor that has been very important in driving competitive advantage and influencing the structure of the software industry in the United States has been the very rapid entry of new firms into the industry, complemented in many cases by entry of new firms into hardware.

A fourth factor of importance has been the development of a large pool of skilled personnel in software engineering and computer science at American universities. The interaction between American universities and particularly the software side of the computer industry has been extremely important, and has no analog yet in the software industries of Western Europe or Japan. One of the interesting factors to consider is how this interface between universities and industry may change in the United States in the future as universities become more heavily involved in formal licensing and attempt to reap revenues from software developed by their faculty and researchers.

A fifth factor important to the U.S. competitive performance in this industry has been the weak environment of intellectual property protection, creating spillovers captured primarily in the United States rather than across national boundaries. Again, as we look forward in this industry, one of the interesting issues will be the role of formal intellectual property protection and its implications for competition in the industry.

Government policy is another factor important in understanding differences in performance of domestic software industries. To some extent, Japanese and Western European government policies toward their domestic hardware industries have mitigated against possibilities for growth of their domestic software industries. Moreover, the record in both Japan and Western Europe of federal government programs targeted to civilian applications in the software industry has been relatively unsuccessful. This contrasts with a very different federal policy in the United States which provides substantial funds for defense-related research and basic research at universities, without targeting specific civilian applications.

WILLIAM RAPP

Recent Trends in the Japanese Software Industry

Over the last three or four years, the Japanese software market has shifted from an essentially producer-driven market to a user-driven market. What is driving the large firms is their own competitive evolution as businesses. In other words, Toyota’s evolution as an automobile company is to a large degree determining its demand for software and competitive systems. In addition, the development of the Japanese software industry has led to a highly fragmented market with numerous proprietary systems. Given these two trends, an interesting question is how to manage the current technological shift toward open systems, downsizing and other factors.

Approximately 85 percent of the Japanese software market is for customized software, or some two to three times what we find in the United States or Europe. This customization phenomenon continues down to PCs, about 30 percent of the market for PC software is customized. The standard argument is that this is merely historical legacy since large companies are essentially locked into whatever system they had installed initially. Of course, major computer companies want to continue this lock-in
effect, particularly with respect to their mainframe sales since the mainframe market is growing slowly. Clearly, there is a great incentive for them to maintain these proprietary systems at the same time that they are trying to introduce new technologies and more open systems.

At the time this study was conducted, the highest growth was in the workstation area, not the PC area. Again, this reflects the fact that large firms are the biggest customers for software in Japan. Mainframe sales continue to go slowly, consisting primarily of customized software. Moving down to minis and workstations, packaged sales begin to grow.

But in order to incorporate them into the mainframe system, a lot of customization is still required. This is due in part to Japan's three-tier system in which the mainframe is used as a network server, forcing large Japanese firms to adapt even packaged software to their mainframe systems.

The Japanese Software Industry and the Historical Evolution of Major Japanese Companies

Developments in the Japanese software industry are closely tied to the historical evolution of Japan's major companies, most of which have achieved their competitive advantage through sophisticated processing systems rather than through new products. Software systems have incorporated these process technologies and are now an important part of the constant improvement process. Our study reveals that developing customized software can cost roughly 20 to 30 times the value of an import package and that these high prices have led to semi-customization, which is only five or six times the import value. In the case of Toyota, for example, the company could save approximately $3,500 per car, or over $150 million per year, simply by moving from a customized to a packaged software solution. This substantial savings notwithstanding, Toyota prefers the customized solution which enables their operation to drive the software rather than the software system to drive their operation.

We also discovered that Toyota protects its proprietary technology and operating systems by not going on-line with its suppliers, its customers, or its U.S. subsidiaries. Data is transferred, but the company is not on-line. Toyota believes if it switched to an undedlined system through which everyone could access this information, it would lose whatever competitive advantage it otherwise might have.

The Future of the Software Industry

In sum, our study points to a number of conclusions concerning the Japanese software industry. First, a strong interest in customization will continue, leading to what I call a hub-and-spoke strategy of foreign software development in which software companies will adapt or semi-customize their software to fit each of the different operating systems. To the extent that they are successful, these companies will capture a large share of the Japanese market. Again, maintenance and further development of customized systems will operate as barriers to entry, since the use of such systems will increase the cost of localization and customization to foreign software developers. Clearly, Japanese companies using this software will have to make up for these inefficiencies by improving the efficiency of their overall business. High cost Japanese software will have to be integrated into and improve the volume manufacturing process if these users are to remain competitive. In short, companies will adapt software products developed abroad to local use, and large clients will customize and integrate these products into their proprietary systems for competitive purposes. Hardware producers will support this because it is a way for them to perpetuate the lock-in effect.
The Response of Large Users to Innovation and Technical Change in the Computer Hardware & Software Industries

Commercial computer systems development is an area of business life that is characterized by constant renewal of innovation and technical change in computer hardware, software and networking which permits and enables—but does not compel—complementary change in the using organization. Computer hardware and software are enabling technologies; they are blank slates for the user. Buyers of computer software are also authors of computer software: they get to develop it as a system.

In 1994, or about two years into the excitement of using network software for achieving improvements in management, only a few users actually used new computer hardware and software applications to change their business processes. But in each case the experience was fantastically successful. In health care, for example, on-line eligibility verification through a binary network application enables an admitting clerk or nurse at a hospital to tell a patient whether or not the treatment to be received will be covered under that patient’s insurance plan. This practice has improved by 30 percent the returns to insurance companies by reducing their accounts receivable costs. Most new applications, however, appeared in the area of simple automation processes where companies improved their return on investment by using computers, rather than people, to handle menial tasks such as billing. Company experiences in Europe reveal a similar duality.

Opportunities for Useful Commercial Applications of Hardware and Software

The most common way of filling this commercialization gap is for technical personnel to lay down the hardware/software networking infrastructure within the organization and to have internal business customers learn by using and experimenting with the new applications. A second way of filling the gap is essentially through imitation. There are a wide variety of institutions within industries and across firms to facilitate this process. These include user organizations, such as those created by IBM, to encourage sharing of ideas within industries, and in cases where certain applications may provide a strategic or competitive advantage, a systems integration mechanism can be used through which the business content of a computer system can be replicated. Computer vendors have recently entered this fray by embedding the basics of business logic in their computer products and selling these as packaged software rather than customizing and localizing at every site. In fact, systems integration has become part of the commercialization strategy of most computer vendors and tool companies.

How does this picture vary across sectors and across continents? Where do you find the top-down, high-risk, high-return, big-push approach, and where do you find more simple automation and learning by using? Generally speaking, external competitive changes are the primary driver of the big-push model. The many innovative financial applications in the health care sector are evidence of this, as too are the fancy new competitive billing systems of telephone companies, and the big-push applications initiated by Walmart in the increasingly competitive consumer products industry. The big-push approach is also more common in cases where the use as well as the computing is technical, although such applications are of much less value. Much the same can be said of the newly competitive industries in Europe, although regional integration also has a great deal to do with the specific industries affected.

Clearly, if the development of users’ commercial computer systems can be explained by factors such as top-down pushing and organizational resistance, very large differences are more likely to appear among Western and Japanese organizations than among American and European organizations.

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According to the Japan Users Association’s latest survey of medium-sized companies in Japan, Japanese users are behind in the use of packaged software. This is because mainframe computer companies supply some 50 percent of business applications, especially universal applications such as accounting and payroll which do not need to be customized. Middleware and development tools are also supplied by mainframers.

There is also a closely supportive environment between hardware vendors and their customers in Japan. For example, last year when we had the earthquake in Kobe, all of the mainframe computer companies supported their customers. Of course, customers must pay for hardware maintenance contracts, but when their applications need to be revised they do not pay a charge. System engineers of the mainframe vendors must facilitate these application changes free of charge, although vendors certainly receive a large amount of purchase orders from users through this support system.

Nevertheless, along with the growth of PC’s in Japan has come the increased popularity of packaged software in
1995, shipments of PCs in Japan reached about five million, almost double the shipments of the previous year. In addition, Japan’s long and deep recession has forced Japanese users to think more about the cost effectiveness of their operations, and in particular the efficacy of using packaged software. Some companies do not allow customization of their packages, even though customers want to customize them. At present, there is an increasing interest among software vendors and users for object-oriented technologies, whereby parts of application packages are developed as components and then these components are combined in a customized package.

**DISCUSSION**

**Q:** Although it is certainly true that Japanese academic institutions have not been very successful in doing research in computer science, I have been unable to find any significant impact on the U.S. software industry by computer science departments in American universities, other than the possible transfer of students. In fact, I believe computer science departments have not been nearly as effective as industrial innovators, and the role of computer scientists who are not generally programmess has been relatively minor in the software industry.

**Mowery:** Not knowing what data you have looked at, I think the training role of universities is no less than their innovative role. Second, much of the innovation in this industry rests on innovations made at universities. I think roughly a quarter of the advances in software which have been made are university-based.

**Q:** Has any kind of price index been developed for software systems?

**Bresnahan:** Yes, there are lots of them, all very specific. In the United States software gets cheaper every year.

**Rapp:** However, in Japan increases in the cost of software are more likely because of the cost of customisation, general wage increases, and so on. This makes semi-customisation increasingly attractive.

**Q:** Is there some economic reason why companies in Japan find it worthwhile to customise despite the high cost?

**Rapp:** Since Japanese firms typically take a total-cost approach, they are willing to pay more for software in order to have a more efficient overall system. The U.S. approach, on the other hand, tends to be more compartmentalised. In a recent report by the International Trade Commission on the software industry, for example, Kodak is reported to expect a 25 percent cost reduction in its information system. Nothing is said, however, about the costs to Kodak of no longer controlling its information system or being able to take advantage of the benefits which might accrue to its manufacturing and operating systems. The flip side of this is a company like Walmart that views control of its information system as fundamental to maintaining its competitive advantage.

**Q:** What about licensing as a strategic option for managing users in both the United States and Japan?

**Bresnahan:** Licensing and dozens of other relationships between vendors and buyers are in a transitional state now because of the competition between two models of commercialization. First, there is the mainstream model of tight relations between a lead vendor and a user model which is still very important in Japan but rapidly waning in the United States. The second PC model is of very loose, market-like relationships between buyers and sellers. A number of vendors are trying to craft a new relationship which retains the appropriate parts of these two inherited models, so pricing, licensing, and even the use of a field sales force—all of the things which mediate between buyers and sellers—will be different in the future.

**Mowery:** Another recent development is university licensing for software developed by faculty. This trend is growing rapidly at large research universities such as Berkeley, Stanford and Columbia, and certainly has implications for commercialization.
Vertically Integrated Embedded Software: Automobiles and Smart Highways

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Robert Burmeister  President, Saratoga Technologies
Smart Highways: Implications for Automobile Production

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Discussant

Software as a Competitive Tool

One example of how software is becoming a tool of competition in the automobile industry is in making existing data available to improve cost estimates of designs. Rather than guess at what the cost of a design will be, for example, software is being used to bring together data from suppliers, customers, and development functions, thereby cutting a lot of uncertainty out of the process. As it turns out, one of the key pieces of data for making a cost estimate more accurate is what color cars to produce. Instead of having thousands of workers in an automotive web guessing at what color cars to make, software can be used to determine what color a customer wants at any given point in time. Similarly, designers use software to access the statistical process control data in the factory to determine if design modifications can be handled by the manufacturing system. This can save tens of thousands of dollars in retooling costs.
There are three types of data which make the automotive industrial web competitive. At the bottom there are the deep, dense databases of resident expertise, large amounts of information that has to be stored precisely and is usually not understandable across the functions of a corporation. At the top there is the information that has to be passed down through the 22,000 workers in the industrial web, for example the statistical process control data. In the middle there are the negotiations between functional experts and generalists which take the deep, dense functional data and translate it back up to generalists. I assert Toyota does this better perhaps than anyone else in the world, and they have done it without a lot of computer-aided systems. Toyota software is made to order, but it is not customized. It is standard software designed to protect Toyota’s deep, dense databases so that information is conveyed in a very controlled fashion.

A social software network which will redefine how automobile companies compete is now also developing. For example, Chrysler has created a web page for the anti-lock braking system, which allows people who have a problem with their car to talk to other people. Clearly, engineering and marketing departments of other automobile companies will not be able to ignore this.

To reiterate my main point, today large organizations have all kinds of software. Some use it poorly, some use it well. We also have a new class of software that will redefine competition, and this will be reinforced by the structure of the automobile. Now almost everything in a car has some form of electronic base, which is redefining the way a car is designed. Because cars are now electronically defined, they can interact better with the production system, the market system and this infrastructure.

ROBERT BURMEISTER

When talking about smart highway systems, we need to consider traffic route advisories, electronic navigation systems, including the vehicle information and communication system (VICS), electronic toll collection, and highway condition monitoring. In Japan, the number of traffic accidents and fatalities has decreased despite the growth of vehicles in use partly because of increased automation in traffic control systems. The amount of new construction of highways is not very high in Japan (or in the United States), even though there are more and more people driving cars. Since we want to move these people around efficiently and safely, this is an ideal area for information systems.

The Vehicle Information and Communication System

The VICS system, which was first implemented in 1990, will be officially introduced in Japan in mid-April 1996. It is a joint project of the Ministry of Construction, which is interested in the infrastructure, and the National Police Agency, which is responsible for traffic. This is a unified system which will be extended throughout the country.

The system tracks accidents, analyzes them in a central location, and then distributes the results to vehicles on the road. The role of the VICS Center, which started operations last year, is to collect and process information. The Center has responsibility as a central organization for the control of intellectual property rights, but this is an open system and they want as many people as possible to participate. Built on an installed base of one million navigational systems in automobiles, the VICS system uses radio waves, infrared beacons, and an FM multiplex system to track vehicles. In addition, the bi-directional beacon transceivers allow wireless data communication between a car and the Center through traffic control centers which integrate data from many locations. There is a multi-mode display which allows the
driver to view a map, or get accident/road information, or even watch television. Tokyo also has smart parking garages so that drivers know ahead of time which parking garage will have space. It is a powerful information system right in the dashboard.

Implications of VICS

One of the most important aspects of VICS is that it inspires collaboration with competition, something at which Japan excels. In terms of building the system, auto companies are working with electronics companies to install VICS hardware in an open system and with a common set of exchangeable software. At the same time, each car designer has integrated a different version of VICS with its own value-added features. This contrasts sharply to the U.S. case where many regional experiments are underway using incompatible technologies but there is no national system.

In terms of competition for the auto industry, there is the question of how much this system will be integrated into each vehicle and to what extent Japanese cars so equipped might be used outside of Japan. For the electronics industry, there is the challenge of building these multi-function vehicle automation systems at prices consumers will pay, as well as the related issue of infrastructure construction. Finally, from a software standpoint, there is quite a lot of custom systems software here and some very specialized databases.

One of the key indicators of how the system is developing in the first year will be market acceptance: how rapidly these systems are purchased. A second question relates to how well the system really works in Tokyo traffic conditions. Third, the infrastructure requirements of this system will be significant, including a lot of construction and interfacing of systems. The question remains how well these developments will be integrated into new vehicles.

Michael Cusumano

From our discussion this morning and my own research, it appears that Japanese are quite good at working with particular kinds of software systems, for example infrastructure systems, information systems used within organizations, and database management systems. But for both historical and strategic reasons, we have not seen much innovation from Japanese in terms of packaged software systems.

Software Development in the Automobile Industry

Ten years ago when I first started studying U.S. and Japanese companies, I was surprised at how bad software processes were in many large U.S. companies as compared to those in Japanese companies. This was partly because in the United States we had a lot of university-trained programmers working in the industry. But in Japan, since universities were not training many people, companies had to rely on a disciplined engineering process to do anything useful with technology as complex as software. As a result, Japanese have done quite well in applying a disciplined engineering process in areas where software development is important to their competitiveness. They have encountered relatively more difficulty in areas where the technology is less well understood and entirely new ways of thinking are required.

There are many things U.S. and Japanese industrial companies should be learning from American PC firms. The conventional software development techniques pioneered in the U.S. defense industry or at IBM or its Japanese software factories are not really as appropriate for
continuous redesigning as they are for designing in discrete phases. Increasingly, the latter approach will be less appropriate for the complex, rapid-innovation systems we are likely to see in the future. Rather, what will be required is a faster, more flexible system which synchronizes team members as they go along, precisely the approach used by American PC software companies in capturing this very fast-moving market and staying ahead of everyone in the world. As systems get bigger and more complex, the whole world will be converging around better processes.

II DISCUSSION

Q: Where does software rank in terms of productivity or quality or cycle time or number of products?

Anderson: Although software is used heavily in the production process for almost every single automotive component, it comes second to the process design, the way work- ers work together, and the way the inter-plant political organization works.

Bruns: An interesting case in point is the Nummi plant. This was the worst plant within General Motors, and they switched to the Toyota system as a joint experimental effort. The turnaround of that plant is a remarkable management story and software is not a part of it.

Q: Earlier we talked about how Toyota has a very good system for handling certain deep, dense information, and how American companies are starting to adopt social software. Do you see Toyota responding to this?

Anderson: I will make a sweeping statement: all manufacturing process improvement is now irrelevant in comparison to the gains to be made in distribution and supply chain management. The battle is in distribution and that will force the weaknesses in the Japanese system to the fore. Japanese have solved virtually everything from the assembly plant on back with lots of good systems, but they do not yet know how to link those solutions to their 150 markets internationally. That is where Internet/Intranet software will dominate and where BMW and Chrysler will become the leaders in understanding how that type of software relates to manufacturing.

Rapp: It was announced in the Japanese press that Toyota is buying 25,000 PCs for their people in Japan. How do you relate to that point that Toyota is not making a big move to connect its people?

Anderson: Of course, Toyota will eventually connect its people, but they will not allow their engineering drawings to flow through America On-Line accounts and be taken out independently by their employees. The point I want to make here is that not all Japanese electronics firms
VERTICALLY INTEGRATED SOFTWARE:
STEEL AND SEMICONDUCTORS

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A n analysis of competitiveness in the steel industry
reveals that falling behind in the use of computer
technology will leave a company forever playing catch-
up. This is because the capital cost of acquiring the latest
process technology and making globally competitive
steel is so high.

The Japanese steel industry has been using statistical
process controls and software programs to manage the
rolling of its steel since the 1970s, whereas U.S. integrated
steel companies have been doing this for only ten years.
Now the whole trick with steel is controlling the tempera-
ture as it heats and cools, since temperature affects the
grain structure. Accurate control of the temperature will
result in quality steel, otherwise the steel will have internal
wallows and can easily crack. Although these internal defects
are difficult for the naked eye to spot, they can be detected
through computerized quality inspection systems. Unfortu-
ately, some two-thirds of the large pipe made in this
country is still inspected the old-fashioned visual way, and
thus on occasion has been known to crack.

If computer software does not work correctly, it will
have negative consequences for the competitiveness of the
company using it. Oregon Steel, for example, decided to
install an advanced, fully automated bar-and-rod mill. But
because it was a new mill, it did not have the skilled
programmers required to run the system correctly. A
programming error caused a nine-month production delay,
resulting in major losses for the company.

There are other kinds of problems which result from
playing catch-up this late in the day. A recent blast
furnace explosion at U.S. Steel took out 25 percent of the
company’s production and 6 percent of the sheet steel
supply in this country. The explosion occurred essentially
because U.S. Steel wanted to increase production without
building another blast furnace, a process that required
spending production. Not only were they putting more
oxygen into the blast furnace to speed up the melting of
the iron ore, but they were mixing in another kind of iron
ore at a higher temperature. Computers are essential to
manage an operation like this. Again, the computers and
the software programs all worked right but the workers
could not handle the higher temperature because they did
not have the requisite knowledge, skill, or experience.

My final example, and the most painful one, is Inland
Steel. Inland entered a joint venture with Nippon Steel
to build a finishing plant that would take basic sheet steel
and continuously roll it to a very high quality finished
product, with the entire process run by computers.
Although the operation seemed very impressive, there
were so many quality defects that GM had to cancel
Inland as one of its suppliers. While we do not have the
full background on the GM decision, informed observers
speculate that something had gone wrong on the manage-
ment side at Inland Steel, particularly with how they
trained workers handling maintenance on the computer-
tied machinery in the mill.

The Japanese, on the other hand, have been success-
fully working with this type of computer technology since
the mid-1970s. As a result, they can move one step
beyond. Rather than just making continuously finished
steel, the Japanese are now bonding different materials
together to produce clad steel. With the use of computers,
for example, they can produce sound-dampening steel which combines a layer of plastic with two layers of steel.

There are, of course, companies in the U.S. steel industry of which we can be proud. One of the best companies, Nucor, uses a computer-controlled process to make steel from scrap. Relying on a young workforce willing to take risks, the company has used computers to invade the world of big steel with a low-cost sheet product. Nucor is now building its third mill and planning a fourth into the stainless steel market.

Clearly, Ford and GM cannot be competitive if they do not have good steel. Caterpillar just sent word to its suppliers that it wants plane steel made with the dimensional accuracy and surface finish of sheet steel. But U.S. steel companies cannot supply this quality steel because it requires a computer-controlled rolling mill process. Consequently, a company's ability to use computer technology in its steel making process, and, more importantly, its ability to finance that use is critical to a nation's overall competitiveness.

Robert Leachman

Through the Competitive Semiconductor Manufacturing project at Berkeley, we have been measuring manufacturing performance and analyzing the underlying practices of circuit wafer fabrication plants around the world, particularly in Korea, Taiwan, Japan, the United States, and Europe.

First we measured processes associated with cost-time to bring products to market; while prices are still high; cycle time, or how long it takes to produce a finished circuit from blank wafers; and on-time delivery to manufacturing customers who are trying their own production schedules to chip supply.

On all of these measures, we found a wide range of performance. A factory producing many different products has a harder time than one producing a few, and there are a lot more problems with new products than with old. We also found that the kinds of computer systems used in a company depended heavily on what types of behavior and ways of thinking were important to that company. These differences notwithstanding, the leaders were always very good at problem solving and the solutions often involved the use of computer systems to contain or eliminate losses.

Companies have developed three basic types of solutions to boost yield and loss problems: statistical process control (SPC), integrated die yield analysis, and computer integrated manufacturing (CIM). Statistical process control, which uses normal distribution statistics to establish statistical control over individual process steps, is now heavily computerized, and the limits are constantly updated as the process evolves. The area of integrated die yield analysis also involves a massive amount of on-line data collection, including measurements on the product, monitoring of production conditions, and the audit trail of processing. This huge, rich database is then matched against end-of-line electrical data. Regular process engineers can conduct correlation analyses to find out what low-yield lots have in common and why yield loss has occurred. The last computer area is the CIM area, and this primarily involves mistake-proofing. By connecting equipment to a central computer, the steps for performing a particular process can be automatically downloaded into a machine without depending on people to book them up manually. Similarly, all machine measurements are automatically uploaded, so by not having workers punching information in on keyboards, costly mistakes are avoided.
As far as line yield is concerned, prior to 1990 the only way to be mistake-proof was to have tremendous discipline in manual checks and process control methods because most of the processing equipment could not be hooked up to computers. Throughout the 1980s, the Japanese had a clear advantage in line yields, but by the 1990s, as the computer-connectivity of equipment improved, this advantage shrunk.

In examining the different areas of yield, throughput, cycle time and delivery, we discovered that those who were good at innovation tended to invent the better business processes since there was no commercial software available to do the job. But now that good commercial software has begun to appear, it is often better than the home-grown solutions that were embedded a decade earlier. Therefore, while the Japanese used mainframe solutions in pioneering much of the yield improvement area, they have been slow in the transition to better commercial products that Americans and Koreans are now using. At present, Americans are ahead in planning and scheduling areas, but the next big battleground is equipment throughput and here the Japanese and the Koreans are tied for the lead.

ROBERT A. MYERS

The question of software as an element of competitive advantage is not unique to semiconductors or steel, nor is computerization of a factory either necessary or sufficient for competitive advantage. All of the information processing that goes on in a factory depends on having good information in the first place.

For many years, IBM was the largest transistor manufacturer in the world, and we are still one of the top ten in the world. We are, therefore, supposed to be a very knowledgeable and productive user of computers. Nevertheless, we discovered a few years ago that the yield on our Japanese semiconductor plant was substantially higher than the yield on our New England semiconductor plant. As only one of many important differences, in the Japanese semiconductor plant, workers remove their shoes and put on slippers when they enter the building. Then they go into a clean room where they replace the slippers with booties and put on a whole clean uniform.

Our semiconductor plant in New England gets a lot of snow, meaning there is frequently salt in the parking lot which gets tracked into the plant. This was poor clean room practice—nothing to do with computers.

Therefore, as we learned from the Toyota case this morning, automate when everything works right, but do not automate for the sake of automation. There are numerous examples of how the installation of heavy computer iron can cause a company to lose sight of good human processes. Computers can be important to competitiveness if they are used right, but very dangerous if they are not.

DISCUSSION

Q: Throughout the 1980s, one of the key barometers of competitiveness in the semiconductor industry was claimed to be DRAM production and factory capability. But when we look at the actual results in semiconductor manufacturing in the 1990s, the number one producer in the world is neither a Japanese nor a U.S. company but Samsung, a Korean company. My question to the panel is what is the role of software in this situation?

Leachman: Samsung is now the largest DRAM merchant in the world and it has been quite successful. The other two large Korean companies, Hyundai and LG, have also come a long way. Samsung embraced the TPM (total productive maintenance) religion early and developed software to support it, so their throughput numbers are very good. But that is not the only ingredient to success. In order to keep ahead of the leading generation, a company has to invest an enormous amount of money in the

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memory business, and Samsung has done that.

Of course, there certainly are local differences in software strategy depending on the strength and weaknesses of the situation. I am continually astounded that in Japan and Korea there are fabs with no mistake-proofing which still get near-perfect line yields. That does not seem possible in China or the United States, where the only fabs with great numbers have mistake-proofed the process.

We have also found that language problems have little to do with the country. The most difficult interview we ever did was at IBM because their internal language was so different from what is standard in the rest of the semiconductor industry, whereas we understood what the Japanese and Koreans were saying without translation.

Myers: The number one software Samsung applied to becoming the number one DRAM supplier was money. Samsung was willing to spend whatever it took. A second factor in their success was a mistake by the companies who licensed Samsung some of their technology, believing they could still stay ahead. The same issue is now arising in the Taiwan and Singapore fabs. There is a bidding war between the current semiconductor manufacturers who need money and the up-and-coming manufacturers who are prepared to pay anything for a license. Luckily for current big players, the last several years have been so successful that they are not very hungry.

Crenian: In steel, POSCO and China Steel in Taiwan can build a new computer-controlled plant at incredibly low cost and make commodity steel. These companies eventually will move up the line to produce higher value added steel, although they are not there yet.

Q: What about the marvelous comeback of U.S. integrated steel over the past four to five years?

Crenian: Yes, but that is because things got so bad that they had to shut down capacity. By remaining 25 percent short on capacity, the industry needed only for the economy to grow and prices to rise. Meanwhile, companies are making less money because of high pension costs.

Q: In the semiconductor industry, how do you evaluate the role of the U.S. government and the industry's relationship with the government? Up until the early 1980s, the industry was arguing that quality was a form of disguised dumping by the Japanese. Our industry at that time mounted what is considered the archetypically successful effort at engaging U.S. government lobbying on its behalf. Was that lobbying effort successful for the industry or did it allow firms to postpone what was really necessary, which was taking their competitors seriously?

Myers: My research revealed that by the mid-eighties the Japanese semiconductor industry did not have higher quality than the American semiconductor industry. In fact, by 1986 quality was no longer an issue. On government involvement, it is viewed by the industry as having been a positive factor.

Leachman: With semiconductors, any quality problem can be turned inward into a yield problem, which can be addressed by increased screening and more stringent testing. That was the line the Americans took to remove the quality issue from the market place. But there was still a cost issue the Americans had lower yields because they had to do much more screening. But during the transition from the 1980s to the 1990s, they solved this problem too with better process control and statistical analysis. That was not something that Sematec had much to do with.

Where Sematec has helped a lot is to have to do with standards and the health of the American semiconductor equipment industry. There indeed were problems with American equipment. Sematec has done a tremendous amount toward getting everyone to agree on equipment standards and having a regular, continuous dialog between manufacturers and equipment suppliers, the kind of things that Japanese MITI-type organizations do. Sematec forced group behavior and standards to increase rationalization. This was not as big as solving productivity issues but it certainly helped and the industry's attitude is that it was a positive thing.

Q: Is the software used by fabs for testing yields, etc. customised by each company or is it a generic product? Is it copied or licensed from one place to another?

Myers: Any transfer process includes the software involved. On the other hand, the Japanese all develop their own software which they are not likely to share without tremendous compensation. In the United States, much of the software is home grown, and we do not market it either.

Leachman: The term software includes a variety of components, such as collection systems, applications for scheduling, planning, statistical yield analysis, and so on. There are commercial versions of almost every product, but these are never leading-edge. Thus the very best places we have seen always include a strong home grown software component, although more and more this involves commercial software tools, such as standard statistical packages and relational database software. As far as statistical yield analysis is concerned, most companies do this on their own by building up from standard commercial tools.
Enhancing Competitive Advantage: From Consumer Electronics to Financial Services

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Use of Embedded Software in the Electronics Industry

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Software and Delivery of Commercial Banking Products

WILLIAM RAPP
Discusant

I will focus on Hewlett-Packard (HP) and the laser printer market place in addressing the role embedded software has played in the electronics industry. In 1993 the laser printer market was comprised of approximately three million units, with HP holding a 57 percent market share. Today HP has about 60 percent of the laser printer market. Interestingly, in the predecessor dot matrix market, Japanese companies, not HP, held the dominant share. Yet as laser printers became the dominant technology in the late 1980s and early 1990s, HP was able to recapture that market and retain its lead.

One of the keys to HP’s success is they were there first. As the market leader they established the ground rules. In addition, the company made a well-managed and deliberate effort to capture and maintain market share. They understood user needs, and they spent an enormous amount of advertising money investing in brand image. Software also plays a major role in this story. In the mid- to late-1980s, HP developed its printer control language (PCL), which turns the binary digital language of computers into a page format. PCL is HP’s embedded software, and they have used it to maintain and dominate this marketplace. HP has dominated the laser printer market because of the inherent qualities of the language and critically, because of the alliances the company has been able to create with software companies that have prevented competitors from coming in and duplicating their controller. In addition, HP has stayed ahead of the competition by continuously introducing new features in their printer control language, controlling the functionality of the product.

A critical point is that the independent software vendors, the Microsofts of the world, gave preference to the proven track leader in developing drivers for their products. While Japanese companies have developed hardware features that should enable them to gain a competitive advantage in the market place, the independent software companies have not had the resources to apply to those features. Thus, in the end, the software does not speak to the hardware.

The competitive dilemma created by HP’s strategy is
that it puts all other vendors on the defensive. By trying to re-engineer HP's latest move, the competition is always at least one year behind in the introduction of new products.

From a marketing perspective, this puts them in a defensive position, and it inhibits product differentiation since independent software vendors will not support the features they do develop.

Another part of HP's strategy was that it kept Canon at bay. Canon was the one competitor HP thought could challenge them in this market place. But Canon is in a supportive alliance with Hewlett-Packard, building the internal engines for HP's laser printers. By tying Canon into a high-volume, low-margin alliance, HP prevented for years its one potential contender from entering the laser printer market with its own brand product, although Canon has entered aggressively the ink-jet market.

In this case, clearly it was a conscious management strategy that used a variety of elements—hardware differentiation, software differentiation, strategic alliances and partnerships—to create a very powerful and very successful marketing engine that returns large profits to Hewlett-Packard. HP was able to use software as a key weapon in its overall competitive strategy to maintain market leadership and to place competitors in a continuously defensive mode. Thus PCL has become the de facto standard, and HP, working together with the independent software vendors, has created an alliance that its competitors have been unable to break.

As a result, the competition has now decided to change the playing field to a market in which HP's PCL language is not a dominant factor, namely the ink-jet market. While HP remains the largest market share holder, other companies are mounting a serious challenge, and a whole new set of dynamics is emerging.

**PATRICK T. HARKER**

In our recent study of the retail banking industry, we explored how the strategic choices of banks affect profit making, with a particular focus on how human resource technology and design of delivery processes affect measures of customer convenience.

Based on a survey of approximately 80 percent of the retail banking industry by asset size, we found that 17 to 20 percent of the non-interest expense of most commercial banks arise from technology expenditures, the largest of any industry of which I am aware. Indeed, most of the discretionary spending in this industry is on platform, branch or phone center automation, all front office expenditures. Basically the back office is already considered fully automated. Therefore, the financial services industry is by and large people and software, and the two cannot be separated.

We found a negative relationship between high-performance workplace practices and outcomes. This is not surprising given this is an industry trying to create a high-performance workplace with a part-time workforce. Although there are exceptions, very few of the places we studied implement high-performance work practices in anything more than a piecemeal fashion since such practices only make a difference when coupled with a very large investment in technology. Banks can waste enormous amounts of technology and training trying to reach high levels of performance when they actually provide nothing more than a commodity product.

Most people in this industry are betting that the phone will be the dominant channel toward which people move in the future, except at places such as Citicorp, which is investing heavily in electronic banking. The problem here is one of economic rent. As banks build more and more ATMs in an effort to get people off the
teller lines and off the telephone, they find transactions in every channel have risen uniformly for an identical number of accounts. So what banks are starting to do is change their customers for going through teller lines or requesting to speak with a real human being on the phone when their question could have been answered by the automatic voice response unit.

By focusing on what technology can actually do, and not what is just around the corner, we made some interesting discoveries. For example, 50 percent of large banks and over 50 percent of small banks cannot make an address change on-line. Although banks aspire to be high-tech institutions, they still cannot change an address without paperwork. The problem is the integration of software as different banks with different systems merge into one organization. The integration problem is one of the biggest faced by many retail banks, and it is ultimately a problem of management. Many retail banks are forced to adopt customized software solutions: it's the only way to integrate numerous disparate systems after a merger. These institutions are having trouble gaining the benefits of substantial technology investment.

One of the big questions for the future is whether banks will be able to develop technology platforms and distribution channels that will integrate the services they provide to the customer better than the customer can provide himself and thereby gain more of that customer’s borrowing business. At the same time, computer and particularly telephone technology are allowing the customer to make better business choices. What does that mean? Where do most people get their mortgages? The cheapest place. Where do they get their credit cards? The cheapest place. More and more the bank is just a public utility that people use for access to the payments system. Many retail banks are betting the house on technology investments to provide integrated services to sell to consumers. At the same time, technology is letting the consumer choose anyone he/she wants to do business with.

The real battleground is small business. The retail banking industry has already lost the upper end of the market and they are now losing the middle. The small business sector is where there remains a true need for integration. A major competitive question will be whether retail banks can provide integrated services better than AT&T, GE Capital, and other non-bank competitors.

III WILLIAM RAPP

In analyzing the use of embedded software in financial services, particularly during the collapse of the Japanese bubble market in 1990–1991, we find only eight foreign firms making money in this industry, and they made more money than all Japanese investment banks combined. What did they do differently? First, all eight firms were heavily involved in arbitrage or derivative products, areas that require heavy investment in portfolio management and trading technologies. In fact, in 1992 these companies accounted for 45 percent of the arbitrage on the Osaka Stock Exchange Index versus 33.4 percent for all Japanese securities firms. Part of the reason for their success has to do with the fact that index futures and options permit institutional holders of securities tremendous flexibility in moving their assets and in converting cheaply from one kind of market or foreign exchange basis to another. Conversely, Japanese firms had large numbers of personnel committed to the brokerage business as opposed to selling derivative products.

Because the primary appeal of this type of activity is
the Japanese investor appeared to be portfolio switching, we investigated what is actually required to do this. What we found were tremendous databases and very sophisticated software technology, all of which was custom-made within the operation. Interestingly these derivative products and databases tended to be very interactive. For example, one of the ways of pricing options or trading in the market is through examination of the historical data. The better the data, the better the trading strategy, and the more likely a firm is to have successful customers. Also with customized software integrated into the delivery process, firms can develop new products quickly. And the relationship between commissioned trading and profitability means that a firm's ability to trade interacts with its ability to deal with customers. Conversely, because they continue to use mainframe-based hardware and software developed by wholly-owned subsidiaries, Japanese houses do not benefit from this same flexibility.

**DISCUSSION**

**Q:** When did your firm begin to understand the dynamics of what was going on in terms of leadership in the laser printer market, and when did that produce new decision making?

**Curran:** We saw what was happening by watching competitor firms, but there is a dedication in many Japanese companies, my own as well, to their own internal software that they have developed for the Japanese market. They are many times unwilling to listen to the market in the U.S. and do not put primary emphasis on making product compatible with the standards of this marketplace.

**Q:** When Microsoft tried to acquire Intuit software, the banking industry took the case to the SEC because it would have lost a lot of business if Microsoft started setting the standard for transactions. Why didn’t the banks develop their own software?

**Harker:** They did build some home-banking systems. The problem with that type of software is that less than 30 percent of customers who have the software actually use it in any one quarter. They might use it for the first month, but then they go back to balancing their checkbook at the ATM machine. There is deep skepticism in the industry about how fast customers can be pushed to an electronic channel. So some banks are offering the software for free, and others are charging consumers for using non-electronic channels. No clear strategy has yet emerged.

**Q:** Are banks doing customer research? Other companies, particularly providers of services such as cable television, are demonstrating very clear front-end customer-service strategies, making it very easy, for instance, for customers to dial an 800 number and pay their bills with a credit card.

**Harker:** Banks do that too, but we are confused. Sometimes we want to do everything by telephone even though we realize physical presence is still important.

**Q:** This year several banks, including Bank of America, are testing a smart card. The Japanese government has shown interest in this technology. Do you think it is possible for something like that to actually come into use here?

**Harker:** Yes, but there are a lot of people who have a deep distrust of this type of technology. There is concern about institutions knowing too much. It is also a kind of technology that is a little more expensive for the bank to put out.

**Q:** I am astounded to hear that teller use has gone up as a result of ATMs.

**Harker:** Yes, many banks have even decided to change their physical layout so that customers have to walk past a bank of ATMs plus a person who tries to encourage them to use a machine. But Friday afternoon banking with tellers is still at high levels since most Americans work for small businesses and their primary goal on a Friday afternoon is to exchange their checks for cash. Indeed, rather than cutting back on Friday afternoons, banks are extending hours to Saturdays and Sundays.

**Q:** It would seem that Japanese companies should have had an advantage in printers with different pictographic character sets. Why haven’t we seen it?

**Curran:** Japanese companies do have great strengths in image-based technologies but they have not been able to convert these strengths into superior products, leapfrogging in the standards area. This is because most companies are very market-focused, watching the leader. It is safer to follow the leader and gain in relative position over one's competitors than to leap-frog and get ahead of the market leader.

**Myers:** Actually, Konj simply requires another font generator within the machine. The biggest problem American printer manufacturers had for a long while was in refusing to put that character generator in their machines. In essence, they offered Japanese manufacturers a competitive advantage, and the Japanese took it.
SESSION FIVE

Where from Here?  
An Open Discussion

Hugh T. Patrick  
R.D. Calkins Professor of International Business  
Director, Center on Japanese Economy and Business  
Columbia Business School

Richard R. Nelson  
George Blumenthal Professor of International and Public Affairs  
Professor, School of Law; Professor, School of Business  
Columbia University

This final session, led by the above-named panelists, was an open discussion ranging widely over a number of the themes raised in the first four sessions.

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Photography by Robert A. Rippie, except where otherwise noted. Design and production by Mark Green.
日本経済経営研究所

「競争手段としてのソフトウェア
-- 日本とアメリカの比較 --」

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