Japanese manufacturers have concentrated on the production of high developing and marketing computer input/output devices, particularly facsimile transceivers; CRT and flat panel displays; and matrix and laser printers. This situation has developed from a base of inexpensive, high quality, mass produced consumer products of all types, from word-processors and TV sets to cameras and wristwatches. There are many aspects of the Japanese society and economy which have made this possible. This paper will assess the status of current Japanese I/O devices, and attempt to draw some messages from the ways by which Japanese entrepreneurs have utilized a strong base in mass-produced consumer goods in combination with the underlying nature of the country to develop computer peripherals which in many cases are technological leaders.

Status of Japanese I/O Products

Overview

Computer input/output devices cover a very wide spectrum, ranging from simple input elements like keyboards and "mice" up to high-speed printers and (in some definitions) direct access storage devices and tape drives. However, I will here limit my attention primarily to printers, displays, and facsimile units. Insofar as human input/output is concerned, these are the most interesting. In addition, I will introduce some data concerning storage devices; insofar as low-end storage has many similarities to input/output, the comparison is significant.

Japanese manufacturers have concentrated on the production of high volume products [2], which in this case means "low-end" I/O devices. In the second half of this paper, I will describe some of the reasons behind this. In reporting the current status, then, I will not discuss line printers and other products which can be considered high-end in any detail.

In an earlier paper [3], I showed how the more demanding input/output requirements of the Chinese characters (kanji) used in Japan have been a major factor in the development of high resolution displays and matrix printers, as well as facsimile. This is reflected in the relative status of Japanese manufacturers in different I/O technologies. Wherever the kanji derived requirement is evident, Japanese leadership can be seen.

Where the kanji requirement coincides with a high volume opportunity, the leadership is even more marked. Analysis of the trends will also show that Japanese manufacturers have been repositioning themselves in the direction of higher price and higher function, as the competition from lower cost regions in Asia has developed skill [4].

Overall, Japanese industry leads the world in these areas.

The most striking example of this is that virtually all facsimile machines are made in Japan [5].

Japanese companies also have a large proportion of the CRT color monitor marketplace [5]. On the other hand, they have lost share in monochrome monitors to Asia's NIEs (Newly Industrializing Economies). Japanese companies are very strong in flat panel display technologies: vacuum fluorescent, plasma, electroluminescence, and liquid crystal [6, 7].

Low-end electrophotographic (E/P) printers (the print engines, to be precise) too, are almost all made in Japan [8]. Japanese manufacturers also provide a large percentage of impact matrix printers, particularly those with 18 and 24 wires, which are suitable for high quality kanji printing [8]. Even the 24-wire print head for the highly regarded IBM Quickwriter [9] is manufactured in its Fujisawa, Japan plant. Ink jet printers are still developing, but most Japanese companies are among the leaders [8]. Japanese companies have been successful in the manufacture of fully-formatted character printers, but their presence is much less, since they are virtually all for export, and they are declining in importance [8].

With respect to low-end storage devices, Japanese manufacturers have considerable competition from the US and other parts of Asia, primarily US-based companies [10]. Their share of low-end drives was less than 10% in 1987. However, the leading manufacturer of 3.5" hard disk drives in 1988 was the Japanese subsidiary of a US-based company: IBM Japan [11]. Furthermore, the production of 3.5" hard disk drives by Japan-based companies grew sevenfold from 1985 to 1987; to more than 1.5M units [6].

Optical storage, particularly interactive CD-based storage and erasable storage, is just emerging from the R&D stage. Japanese companies are among the leaders.

Facsimile

Point-to-point facsimile is not, strictly speaking, a computer input/output peripheral application. However, facsimile devices are increasingly being used for this purpose since digital technology is now prevalent.

Because the Japanese regularly use over 7000 different written characters, it was very difficult to handle business communications effectively using coded techniques [3, 12] As a result, facsimile has seen explosive growth in Japan. Furthermore, Japanese manufacturers, in a very competitive environment, have rapidly introduced technological innovation into their products.

One industry survey [5] projected that about 95% of industry unit shipments in 1988 (out of a worldwide total of about 2.5 million units) would be by Japanese manufacturers. Of these, there were six that had at least 5% of the total revenue in 1987, led by Ricoh and Matsushita [5].

As to technology, the change from slower analog group-1 machines to faster analog group-2 machines, and then the switch to digital technology group three, has been very rapid. Group-3 machines grew at nearly a 100% CAGR from 1983 through 1987 according to the same source. They also expect that Group-4 machines will generate almost one third of industry revenue by 1994.

The last few years have seen a trend towards converting what has been essentially a business machine into a consumer product. Although this is not limited to Japan, it has made the most progress in that country, and a significant high volume opportunity is developing: personal fax. One manufacturer has predicted that 10% of Japanese homes will have units within five years [13].

Display

Japanese consumer electronics manufacturers achieved world leadership in television manufacturing in the 1960's. This was the combined result of high domestic demand, effective marketing built around the Tokyo Olympics and the moon landing, and a solid base in transistor manufacturing established to make low-cost radios. This base in display technology went well with the higher resolution requirements of kanji data display, and enabled Japanese manufacturers to achieve a position of leadership in data display technology as well.

In the case of cathode ray tube displays, which earn at least two thirds of total display revenue [6], Japanese companies have about two thirds of the color monitor business (and supply nearly all of the CRT's for the other third). Matsushita, NEC, and Matsushita are the leading producers of color monitors; with Hitachi (which is number one) and Toshiba, they are the major producers of color CRT's [14]. Approximately 13 million monitors were produced in Asia in 1987 [14, 15].
Japanese companies, of which Sharp is the most prominent, have led twice that number were made in the laptop computer marketplace. In 1988, it was estimated that approximately 150K laptop units were manufactured in Japan, and more than approximately 2.25M Japanese word processors manufactured (by more in color capability as well as significant cost reduction in order to become wristwatches, and soon were able to apply the technology to Japanese in demonstrating the largest i.

In addition to thin, the prosperous Japanese home market, combined with strong government leadership, continues to drive innovation in television technology. CRT's with 37' diagonal are being manufactured in quantity by Mitsubishi, and an almost unbelievable number of Japanese are installing TV sets using them in their small homes. Almost one million homes are now equipped with antennas and convertors to receive the direct satellite TV broadcasts by NHK, the national TV broadcasting enterprise. Japanese companies are developing a range of solutions to achieving high definition TV as well as high function TV sets utilizing large amounts of VLSI silicon. It is inevitable that the monitor industry will benefit from these advances before long.

In developing potential alternatives to the CRT, the rate of technical innovation in display technology has been very rapid, and Japanese companies are also strong. Japanese manufacturers are active in the whole range of display technology in addition to CRT's. Light emitting diode displays and vacuum fluorescent displays have mostly been limited to such mundane but profitable areas as automobile dashboard displays. Such uses account for about 15% of the total, and Japanese manufacturers are leaders here.

The AC plasma display panel was invented in the United States, and its significant commercialization was by IBM, which demonstrated technologically with the large-size 3190 panel. However, Japanese companies have recently taken a lead in plasma display shipments, as companies such as Toshiba and Fujitsu have used it as a means for entering the laptop computer marketplace. In 1988, it was estimated [17] that approximately 150K laptop units were manufactured in Japan, and more than twice that number were made in the USA by Japanese companies.

Japanese companies, of which Sharp is the most prominent, have led in electroluminescent display technology, although it still needs improvements in color capability as well as significant cost reduction in order to become pervasive. Liquid crystal display technology has been almost fully preempted by Japan. They were the first to apply the liquid crystal display to wristwatches, and soon were able to apply the technology to Japanese word processors and then to portable personal computers. In 1987, of the approximately 2.25M Japanese word processors manufactured (by more than ten different companies), more than half used simple matrix LCD's. However, the trend has been toward higher function in these products, too, i. e. CRT usage has been increasing [17]. In 1987, Japanese companies achieved approximately $ 700M revenue from all types of liquid crystal display devices [7]. Today, some dozen or more companies are competing in demonstrating the largest size prototype active matrix LCD, and at least half a dozen are already developing their manufacturing skill and marketing pocket TV's utilizing the latest technology. These companies do not seem to be deterred by the need to offer pocket TV's of 3.5' to 6' diagonal at a 200-300% price premium over the most common conventional TV sets.

Nearly all of the companies in the LCD R&D competition are hedging their bets by carrying on development of multiple technologies: simple matrix, active matrix with TIT drive, active matrix with double drive, and simple matrix using ferroelectric liquid crystal materials. All of the companies currently in the CRT TV business are also working on LCD's.

**Printing**

Although printing was invented in China centuries ago, modern "electronic printing" was developed and perfected in the West [18] by overcoming innumerable difficulties in making even a simple kanji typewriter. The situation only began to change when the steady decrease in the cost of electronics made matrix printing and kanji character generators economical. With the invention of the inexpensive simple matrix liquid crystal display and low cost wire matrix and thermal transfer printers, the Japanese word processor became a reality. From that base, Japanese manufacturers were able to establish a very strong position in computer printing.

Manufacturers of small mechanisms - watches, in particular - utilized their skills in high volume manufacturing to move to making wire matrix printers. Non-impact printers developed more slowly, because most Japanese businesses still utilize multipart forms extensively. Nevertheless, some Japanese camera manufacturers took advantage of their optics expertise and achieved dominance in the lower end of the photocopier market.

A few of them have been able to develop another consumer market, the personal copier, which, again, appealed to people who used kanji and were developing an addiction to facsimile. With the development of the injection laser - in which Japanese researchers have played an important part - these vendors were able to produce laser printers which now dominate the low-end marketplace.

In 1987, about 20% of Japanese printer revenue came from low-end E/P; over 90% of these machines were exported. Canon produced about 60% of the total (over 500K machines) in 1987. Canon's production is growing rapidly, although there are at least six other significant competitors now [8].

About 60% of Japanese printer revenue came from wire matrix printers that year. In 1987, the total Japanese production of wire matrix printers was about 11.5 million units. In this, they lead in virtually every segment, since kanji needs 18 wires and looks much better with 24 wires. Japanese manufacturers practically have the higher resolution field to themselves. In contrast, Japanese production of fully-formed character serial impact printers was less than 200,000 units in 1987. Almost 100% of these were, of course, exported [8].

Wire matrix printing is extremely competitive. At least ten Japanese companies currently have a significant presence, with the largest manufacturers, N/C and Seiko-Epson, each having less than 20% of the total. Nearly 90% of these serial wire matrix printers are exported [8].

Innovation has been very rapid in low-end printing. The shift from 9 wire printheads to 24 wire printheads has been made in about five years. In 1987, about 25% of Japanese production had moved to 24-wire heads; two-thirds of these printers were exported [8]. E/P printers are moving from 240 pel inch to 600 pel inch, and their list prices have fallen by about two thirds. Growth rates in shipments of nonimpact printers are projected to be very high, of the order of 40% for E/P from 1985 to 1993. In spite of continuing innovation, on the other hand, wire matrix printers are projected to grow at only 7% [8].

Apart from these two dominant printing technologies, there has been innovation in other technologies, too. Ink jet printer shipments (about 90% exported) currently total only a few per cent of wire matrix printer shipments [8]. However, drop-on-demand ink jet has the potential of price performance and quality competitive with electrophotography at speeds of a few pages per minute, and could grow rapidly. In addition, it has very high potential as a color printer [19]. There are four Japanese contenders for leadership here; one of the key inventions, the thermal jet, was made in Japan, by Canon.

Growth in color printing is being driven by the widespread use of color displays. Future growth will be assured if the electronic still camera is successful. Since this is another important opportunity for moving to higher function products, Japanese manufacturers are very active here. There were about twenty new color printers announced by Japanese companies in 1988.

**Low-end Hard Disk Drives**

In 1986, Japan-based manufacturers received less than 25% of the total worldwide DASD revenue; and - at less than $4B - still only 25% of the total in 1987 [9]. Japanese companies were evidently stronger in high-end DASD than in low-end DASD; they accounted for more than half the non-captive worldwide revenue for drives with more than 500MB capacity, and of the order of 10% for drives with less than 100MB capacity. This is in striking contrast with the printing and display business. One possible explanation for this is the lack of synergy between disk drives and conventional tape-based magnetic recording, in which Japan's consumer electronics companies are world leaders. However, Hitachi, NEC, and Fujitsu do well in high-end DASD, where technology is key to success.
A more likely explanation is that disk drives were not driven by unique
kanji-related requirements. Consequently, low-end drives were not seen as
a high priority opportunity by Japanese manufacturers. They had a late
start as a result, and are only now catching up, as shown by the rapid
growth in production of 3.5" drives [6].

Summary

Japanese manufacturers lead in many low-end I/O technologies. They are
particularly strong where kanji has been a factor. They have built on a
base in consumer products, and have utilized their DP-developed skills to
further refine their consumer products. Nearly every segment experiences
intense competition, even if only among Japanese companies, and the rate
of product improvement and innovation is high. Whenever feasible,
manufacturers are driving their products in the direction of higher function
and higher value. Technological diversity is the rule, both in the industry
and within each participating company. In the remainder of this paper, we
shall see why this could have been expected.

Keys to Japanese High Tech Success

Introduction

Much of the credit for the leadership shown by Japanese manufacturers in
computer I/O products is due to the specific nature of the Japanese society
and economy.

The fundamental driving force has been a post-war dedication to product
and service quality [20]. Rooted in this is a collaboration between three
major elements: the fact that most Japanese enterprises competing success-
fully in the world economy are members of industrial groups, known as
keiretsu in Japanese; a government actively involved in promoting the
success of Japanese business; and a complex infrastructure which insulates
enterprises from many of the vicissitudes of a capitalist economy while
supporting their growth.

Japanese hi-tech enterprises seen in the world economy are manufacturing
oriented. They have many special characteristics that contribute to their
success. Over-shadowing these, however, is the highly motivated Japanese
workforce.

A prosperous home market is very important for the success of manufac-
turers, and Japan has grown to be one of the most prosperous in the
world. This has not only been a general source of large numbers of con-
sumers with significant resources, but it has enabled high tech Japanese
enterprises to benefit from being able to spread their investments over three
complementary business areas: consumer electronics — now more aptly
called consumer high-tech; telecommunications; and data processing.

Within the limitations of a short review, I will relate these factors to the
success story summarized in the first part of this paper.

Quality

Fifty years ago, Japanese export goods were notorious for their poor
quality. After World War II, however, what appeared to be the entire
country adopted the new religion of quality, as preached by the American
prophet Deming and others. The traditional way for a newcomer to enter
an existing market is by means of a lower price. However, the Japanese
reputation for poor goods was such that heroic measures were necessary
here. Today, Japanese manufactured goods, ranging from DRAM's to
cameras, from cars to ships, are considered the most reliable in the world.

Japanese service, on the other hand, has always been exceptional. Even
small provincial hotels and snack bars provide service that most westerners
only dream about. In the data processing industry, where service itself is a
major element of product quality, this tradition has been a powerful
driving force. Japanese attempt to make things which will not break. This
is impossible. Indeed, it is arguable whether Japanese DP equipment is any
more reliable than anyone else's. However, the Japanese response to a
problem almost always makes the customer feel good — even if the problem
can't be fixed.

A key factor in sustaining quality is a stable manufacturing environment
[21]. A long production run of a single product allows the tools to be
debugged, the workers to be trained, and the suppliers to perfect their own
lines. Most of the Japanese products known for their quality, such as cars
and DRAM's, meet this criterion. Even where a product line is evolving,
Japanese manufacturers have adopted a system of incremental improve-
ments, which allows non-disruptive modifications to their factories. On the
other hand, a major change in end-product, manufacturing tooling, or
technology creates severe challenges to product quality. Later I will show
how this is contained in Japanese high tech enterprises.

It is important to maintain a balanced view of quality. Many things which
have not been made over a long time in high volume are of modest quality
in Japan, as elsewhere. The most important factor, however, is the attitude
of managers and workers. Quality is recognized as an end in itself, and is
rewarded. It is not a nuisance, to be traded off for a short term gain in the
marketplace[22].

Interdependence in the Economy

The Industrial Group

Japan's economy has three major elements: a first tier of large businesses
participating in the world economy with great success and providing
employment for about a third of the workers; a second tier of smaller
enterprises including services, which provide far lower benefits and lower
wages, but are essential to the success of the first tier companies, and the
third tier, consisting of such basic elements as forestry, fishing, and the
overpriced but powerful farmers, altogether less than 10% of the employed
[23]. Nearly all of the first tier companies are members of one of the
industrial "families".

Before the second world war, the Japanese economy was dominated by
zaibatsu, relatively tightly organized groups of companies that lent the
country a strongly fascist air. The Occupation broke these groups up, but
the keiretsu soon grew up to replace them. Such a group of companies was
originally centered around a bank, and will include heavy industry (e.g., an
automobile manufacturer), consumer products, tool and equipment
makers, etc., as well as the unique Japanese enterprise, the trading
company. Over the past few years, as larger manufacturing companies have
amassed large capital assets, the central role of the bank has declined.
Associated with the group will be many of their suppliers and customers,
in varying degrees of consanguinity.

Members of a group have a "long term relationship" with one another.
Frequently they own shares in one another, are customers and/or sup-
pliers, pass executives around, lend to or borrow from one another, share
success and spread the burdens. Different members of a group have dif-
cerent specialties. Hitachi's group, for example, includes Hitachi Metals
(52%), Hitachi Cable (55%), and Hitachi Chemical (55%), among others.
The Fujitsu Group includes such companies as Avantest (semiconductor
test equipment - 21%); Copal (flexy disk drives - 6%); Fanuc (NC
systems - 43%); Kanda Tsushin (telephone communication equipment
- 12%) and many others.

Belonging to a group provides security, of financing, sources, and cus-
tomers. It spreads the risk. At the same time, it brings together companies
with different expertise but a common interest. Although superficially
similar to US conglomerates, there is a key difference. The Japanese
keiretsu members work together to promote the long term survival of the
group; they are not concerned with the next quarter's profit. This is greatly
aided, of course, by their owning each other's shares, and sitting on each
other's boards. The "financial community" and outside shareholders have
very little influence.

The key role of a bank, coupled with Japan's very high savings rate,
ensures the availability of low-cost loans. Growth is fueled by debt rather
than equity; cash flow does not derive from gross margins.

Finally, one important characteristic that is not encouraged by the groups
is innovation. The various members know their place, and they stay in it if
they want to receive the benefits of belonging. It is important to remember
that some of the most innovative Japanese companies were able to grow
only in the years after the war before the keiretsu achieved their present
importance. Canon, Matsushita and Sony were not spawned by a group,
and their founders had to struggle hard to gain acceptance.
Active Government Role

The Japanese government plays a key role in promoting the success of its high-tech enterprises. Although I believe it is an exaggeration to describe the situation as "Japanese," it is nonetheless true that the government recognizes industrial prosperity to be one of its main responsibilities. IMITI, the Ministry of Industry and International Trade, recognizes industrial prosperity to be one of its main responsibilities. The most visible agency engaged in this is IMITI, the Ministry of International Trade and Industry. IMITI commissions "White Papers" from academia and industry while also being able to draw on the substantial talent of its in-house laboratories such as the Electrotechnical Laboratory. From these, the agency attempts to establish a long-range strategy for industry and, based on this, to set priorities.

Acting within this framework, MITI then promotes the creation of industrial consortia, partnerships, etc. Some of the better known in the past have included VLSI, Supercomputing, Pattern Information Processing, and the Fifth Generation Computer. Most recently, MITI has promoted the formation of a laboratory to develop one meter diagonal active matrix LCD's suitable for use with high definition TV.

Other agencies, such as the MPT (Ministry of Posts and Telecommunications) and the MOE (Ministry of Education) also play a very visible role in this process. Indeed, as in the case of the International Telecommunication Union, these agencies and ministries sometimes find themselves on different sides of an issue.

What is less visible, but probably more important, is the general legal environment. Most recently, for example, it has been made clear to the world that the laws regulating the financial markets are not very daunting to aggressive operators. Traditionally, though, what laws say and the way they are enforced are often quite different. A law against monopoly, for example, are holdovers from the Occupation, but the Japanese Federal Trade Commission sometimes seems to feel it has a mission to promote, rather than prevent, monopoly. This informal legislation is institutionalized under the term "administrative guidance." A phone call from MITI requesting that a company "voluntarily" join one of the consortia is virtually impossible to refuse, for example.

Finally, as in the US but with less guilt, many top Japanese ministry officials end up in the companies they formerly regulated. This is such a common practice that it has a name, usabakari, literally translated as "descent from heaven." This might include such aspects as a minister making the necessary calls to "place" his retiring subordinates and, also, making the placement so they are not all hired by one company, where they might have undue influence.

The integrated effect of these factors is very positive. However, it is also important to note that Japanese government officials, too, are human, and may choose a poor strategy, or a poor area for cooperation, for example. If this is the case, there are few chances for alternatives to be developed in a timely way, and significant resources might be misapplied. In addition, government guidance can be ignored, evaded, or even fought. MITI's original intention, for example, was to limit Japan to only three automobile manufacturers; it is clear that the manufacturers who opposed this were correct.

Infrastructure

The structure of importance here is the relationship between companies, and the assets the different sides of these relationships bring to the collaboration. Japan is a small country with a very advanced economy. Its roads, water supply, medical care facilities, and so forth are very advanced, although clearly behind those in the US, Scandinavia, and much of Western Europe. However, this infrastructure is not unique, and little of this Japanese infrastructure makes a unique contribution to high tech success.

Just as the members of a group maintain a long-term relationship with one another, Japanese companies maintain long-term relationships with their vendors, their customers, and even their competitors. Although they are superb businessmen with no superiors when it comes to deal-making, they are much less prone to risking potential damage to one of these relationships for a short-term gain. A good supplier, "is forever," so to speak, while a quick profit is ever present. When a good supplier needs a break, has cus-

...tomers are likely to oblige. When they, in turn, need some quick action or a lower cost, they get it.

Such relationships naturally result in many explicit partnerships. Companies with a common interest in a specific area will join together to exploit it, taking advantage of their well-developed reciprocal understanding. It is not uncommon, in fact, for companies which are unyielding competitors in one area to have a long-term relationship, or even a close partnership, in another area. Two well-known copier/printer or competitors, for example, have an OEM relationship in which, among other things, their engineers meet regularly to discuss common concerns.

This is only a specific example of another Japanese practice, known as dan-go, literally translated as "talk together" [24]. In the negative sense, dan-go can mean little more than a group of competitors getting together to divide up a market, or to fix construction bids (as in one recent case involving construction at the US naval base in Yokosuka). In the positive sense, however, it can also mean competitors meeting informally and unofficially and dividing up a business such that each company can make an otherwise risky investment addressing only a portion of the opportunity, secure in the knowledge that he will be free of competition for a while.

Traditional economic theory suggests that such cartels are unstable and not innovative in any case. Obviously, the many 100-year old Japanese companies—many of which have little in common with their original purpose but the name—show that they are doing something right—albeit possibly illegal.

Vendors are extremely responsive to their customers' requirements. Of course, this is good business. They will work overtime, drive their own vendors hard in turn, engage in "flexible development," provide loans and samples, etc. to a good customer. This is partly because they know it will lead to continuing good business, partly because they have little choice: many vendors are captive, practically subsidiaries, of a single big customer, except that they pay lower wages and have lower benefits.

Customers, too, are faithful to their suppliers. This is reflected as much in the housewife who prefers her expensive local grocer to the supermarket as it is in the computer maker who might continue to give business to a local job shop in preference to establishing his own model shop. Often referred to as an informal trade barrier—which it well may be—this Japanese predilection, too, has its own benefits. For one, such a relationship makes it easy to purchase complex items with minimal paper work; and changes can be quickly made, with penalties and payments left to be resolved by "mutual consent.”

The overall view of this structure is one of interdependence. Not only of members of a group with one another, but of groups with each other, and of groups with the government, and with the second tier companies. In some ways, of course, this limits everyone's freedom of action. On balance, however, it has provided a sturdy base on which Japanese companies have been able to build their growth.

Highly Motivated Workforce

There is little doubt that Japanese workers are among the hardest working and most effective in the world. Without them, the success that these companies has achieved would have been impossible. However, there are three factors in the employee motivation equation as well.

The Japanese 'lifetime employment’ system is world famous. It is also frequently misunderstood. It applies, in the first place, only to the top tier of companies. Moreover, it is supported by an early compulsory retirement age—slowly being increased from 55 to 60. Also, it has the natural consequence that there are surplus workers in parts of the economy; the post office and (only recently privatized) Japan Railways have been examples of world-class over-staffing. Apart from this, though, companies which practice lifetime employment have large cadres of non-permanent, or part-time, or even contract workers, who form a buffer with virtually no job security.

For the beneficiaries of the system, however, it is very favorable. Companies recruit a new "class" of hires every year, at a stable level with few reductions in hiring level even in bad years. Annual salary increases go to all—although potential leaders get somewhat more—and so, too, do promotions, for a while. Eventually, however, all but the most effective leaders achieve their highest level, where they continue to get raises and respect, if not added authority. Since promotions come slowly, everyone
learns his job well, and the most senior managers are always senior in age, too. At the same time, careers often involve moves between departments and functions, with those with the brightest prospects getting the broadest exposure. The result is not only a loyal workforce, but a well-trained one.

The one factor that has fundamentally made the lifetime employment system work is the Japanese culture. In a severe recession, or even in a so-called "sunset" industry, lifetime employment is impossible. Recently, we have seen layoffs in coal mining, for example, and even the railway system had to find a way to reduce its employment when it went private. True, this is done with much advance notice and discussion, in the Japanese way, and there are usually nice severance payments, but the inescapable fact is that lots of people have lost their jobs [23].

This is particularly painful for Japanese workers. They take great pride in their work, even if menial (much like workers in Victorian England), and identify their employment with their own meaning in life. This is, no doubt, a twentieth century reflection of the long tradition of belonging to some kind of group that the Japanese have, probably related to the shogunal ideology involving reciprocal obligations between lords and subjects. To a surprising extent Japanese have transferred their loyalty from the feudal lord to the modern company president — and he has managed to accept enough of the feudal lord's obligations to make the system work.

As a natural consequence, Japanese work hard. They surely work long hours, and they take few vacations and little sick leave. They seem to prefer working to being at home with their families, in fact; they certainly spend far more of their waking time there.

Foreigners do not always realize how important it is that everyone in the Japanese private sector is not strong unions in the Japanese private sector are not strong [23]. They are company rather than industry unions. That means that a strike hurts only one company. Since workers know that what's bad for the company can be very bad for them, truly destructive strikes are rare. Also, work rules are relaxed and, in any case, workers are willing to bend them when necessary. If workers have reached their legal maximum overtime hours but a deadline must still be met, they readily continue to work without "punching in.

In this short space, it is not possible to list all the ramifications of this type of work force, but the conclusion is clear: this type of attitude among workers would help all but the most decadent and backward country make great progress.

Manufacturing Oriented Enterprises

I find Japanese companies can best be understood if they are viewed as overgrown factories, on the style of a 300 person facility. It has a single owner or, perhaps, is closely held by friends and relatives of the founder(s). The owner started the business, and still understands its products better than anyone else. He built a factory and equipped it with tools, and he knows the rest by name. They have been with him for a long time, and there is a mutual expectation that as long as the company makes money, they will have a job. They have some kind of medical and retirement benefits, but these are probably modest. If there is a good union, and the company is well run, the head of the union plays golf with the owner. To a remarkable extent, that describes some of the largest and most successful Japanese manufacturers.

Thanks to the keiretsu system, a Japanese CEO does not have to worry about financial markets, public shareholders, and the like. His first job is to keep his permanent workers busy, and to fully utilize his factory and tools. His view of the market is a long-range one, and his recognition is that long-range survival in a competitive world requires growth in market share. Profits are OK, of course, but it is a rare Japanese CEO who makes more than ten times his average worker's salary, and he would not expect a Lee Iacocca type bonus even if his profit did set a record in one year. After all, he will still be there in five or ten years, as will most of his associates, and his compensation and recognition are based on this long-term performance. Recognition, in particular, derives from leadership in many things, only one of which is profit.

The principal unit in the Japanese high tech enterprise is the factory, and the plant manager (usually translated as "works" manager) has great responsibility. Since his task is to make things, and to keep his resources utilized, he is responsible for finding new things to make — he has a development mission and, in the case of major "works" he will have a research task, too. He has the long range outlook, and has to plan for survival and growth. Naturally, he knows his business best and even in the largest enterprises the works manager will have considerable autonomy in making investment decisions.

With a long range outlook, and survival key, major upheavals in the product line are a bad idea, as already noted. The plant must tool for relatively long production runs. This implies a relatively mature market or, in the case of a developing market, at least a stable base of standards and applications. One can develop a business case based on a multi-year outlook, but must be reasonably sure the base product will have a long enough life cycle. This must somehow be reconciled with a marketplace in which several skilled participants are continually fighting for new business. The answer is incremental improvements. A "product" might be developed, shipped, and obsoleted in a year, to be followed, however, by something that is only slightly different, or only a minor variation. In this way, the useful life of the tools and training, as well as the total base needed to write off an investment, can be extended.

In spite of this, Japanese companies are technologically innovative. In this area, they differ from my simple model. They have a very broad menu of products. On top of that, their technology development is multifaceted. Even in such a narrow area as "active matrix LCD displays", nearly every Japanese participant is working on different types of liquid crystal material, on diode as well as TFT drive, on both amorphous and poly-silicon processes. This enables them to reduce the risk of surprise; however, the challenge — which they are facing today in this case — is to find a way to shift from CRT's to LCD's incrementally. One historic solution has been to start with a small production level aimed at a high value, "niche" application; for example, TV's on the back of airplane seats. As they and their suppliers gain experience and improve quality while reducing cost in such applications, more and more opportunities are available. The key is the long horizon, in this case, along with the interdependent economy.

So risk is reduced. It is also eliminated, and there are always winners and losers. However, it is rare for anyone to lose so badly that he goes out of business; in the final analysis, some other member of his group can step in, with the help of the bank, and rescue the unfortunate — possibly, of course, at some cost to the senior managers but only rarely to the workers.

Prosperous Home Economy

Japan has the second largest economy in the non-communist world [23]. Its per capita income compares favorably with that in the US and the most advanced countries in western Europe, being in the top ten of OECD countries since 1984. Its well-paid workers, although living in remarkably poor housing, demand the latest and most advanced consumer goods, and are willing to pay high prices for them [23]. Today, for example, nearly a million Japanese houses are equipped to receive direct satellite broadcast TV, and they are buying TV sets with giant (37") CRT's in spite of the high cost and lack of space in their homes. Since the post-war recovery, and well before the actual magnitude of the economy achieved parity with the leaders, Japan experienced very high sustained rates of economic growth. In addition, the Japanese economy has been protected by both formal and informal trade barriers which make entry by foreigners very difficult.

1 Although the large Korean minority are treated as foreigners, they look and speak Japanese, many having grandparents who were born in Japan, and only their passports and alien registration cards indicate a difference.
This situation has been a tremendous benefit to Japanese industry, and to high-tech, in particular. It has, for example, enabled local manufacturers to learn how to reduce the cost and improve the quality of their products in the home market while realizing a price that covers most if not all of their marginal expenses. It has protected companies that introduce new technology by creating an effective barrier to foreign competition with comparable or superior technology. It continues to enable Japanese manufacturers to earn higher margins at home while pricing their export goods to achieve maximum market share (whether or not they do so by selling below cost). Thus, the prosperous economy both benefits from and contributes to the success of its members.

**Interdependent High-Tech Markets: Consumer, Telecom, DP**

Japanese manufacturing enterprises participate in several complementary marketplaces. Most of them are leaders in consumer electronics products. Many have been in the telecommunications manufacturing and development business, developing their expertise as protected suppliers to the national telecommunications monopoly, NTT. They naturally took advantage of their high tech experience as the data processing industry developed, and began to manufacture DP equipment. In a cycle with the right feedback, they have been able to utilize this DP expertise, in turn, to further develop their consumer and communications products.

This three-fold target for development has numerous advantages. It spreads development cost over a wider base. It spreads the risk of introducing a new technology. Where necessary, it offers a choice of high value-add niche applications. At the 1988 Tokyo Electronics Show, one could see LCD displays used in portable VCR’s, Video telephones, and TV camera viewers, as well as pocket TV’s and data displays. Participating in these areas also offers multiple paths to brand-name recognition and tie-in advertising. A quality image can be utilized for a new product or technology. In summary, the combination makes investment in new technology much more affordable; the risk is reduced, and the potential return is magnified.

This is directly and obviously relevant for I/O technology development. In addition to the LCD situation, for example, facsimile development has been synergistic with nonimpact printing, optical scanners, and telecommunications technology. Personal copiers provided a base for low-end laser printers, now dominated by Japanese manufacturers. Electronic scanning, developed for facsimile, is now widely utilized in consumer home video cameras and is moving to the electronic still cameras, in addition to laser printers and other DP applications. Similar scenarios can be constructed for magnetic and optical recording. It is important to be alert for the appearance of yet newer technologies which can follow this path.

Nevertheless, the different viewpoint of management also plays a vital role. Not only can the early introduction of a product be nurtured through the existence of multiple distinct markets, but management is able to program a return over a much longer time period.

**All the Ingredients Go Together**

It is very difficult to make a linear argument that ties together all of the keys to Japanese success in high technology. Many of the elements interact, and reinforce one another. It is not at all clear that there is a subset which is sufficient, and it is certainly not clear what is cause, and what is effect. For that reason, the lessons to be learned from this type of analysis are more easily descriptive than prescriptive. To take only one simple example, “Quality Circles” are neither necessary nor sufficient to ensure product quality. Many Japanese companies with excellent reputations don’t have them; many US companies with reputations for modest quality do.

**Conclusion**

Japanese manufacturers have become world leaders in computer input/output technology. Their position is particularly strong where they have been able to develop a large manufacturing volume and where key-related requirements forced them to innovate. Thus, their strongest products are in what is called “low-end” applications. This situation is a particular example of the general course that has been followed since World War II by manufacturing oriented Japanese companies. The nature of Japanese society as applied to the world of high technology appears to be the primary enabling factor. It is not at all clear how well one could apply these factors to another country.

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**References**


