THE DIGITAL FLOOD

The Diffusion of Information Technology Across the U.S., Europe, and Asia

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CHAPTER 7

Computing Comes to Japan

It seems fairly certain that during the next decade the computer industry will develop to a point where it will exercise a powerful influence on the national economy and the social structure of every industrialized country in the world.

—Shohei Kurita, *1973*[1]

No nation generated more interest and controversy about its use of information technologies than Japan. The Japanese underwent one of the most dramatic, rapid, and extensive transformations in their economic and political makeup experienced by most industrialized societies in the shortest period of time. The size of its economy expanded from being ranked lower than other major industrialized economies in the world in 1950 to the second largest by the early 1990s. Although devastated in World War II, by the early 1960s it had returned to being Asia's most industrialized economy. A decade later Japan had become a major exporter of steel, automobiles, semiconductors, telecommunications equipment, consumer electronics (such as TV receivers and radios) and by the 1980s, computers to other Asian nations, the United States, and Western Europe. Its relatively closed economy and aggressive export practices set off pan-Atlantic diplomatic protests, trade tensions, and public policy countermeasures that smoldered for years.[2] Academics, public officials, and other commentators heralded Japan's enormous economic growth of the 1960s–1980s as bordering on ideal approach. Many touted it as the model of national economic performance that other firms, industries, and nations should emulate. Observers of the IT experience were emphatic on the point. Tom Forester, an influential IT writer working in Australia, reflected the conventional views of the 1970s and 1980s: "Japan is about to overtake the US to become No. 1 in information technology, the key strategic technology of our times."[3] Even after the economic crises of the early 1990s were well underway, Westerners were still being admonished to learn

from the Japanese. Two distinguished Japanese scholars, Ikujiro Nonaka and Hirotaka Takeuchi, typical of many writing about quality management practices and knowledge management in the 1990s, presented managerial advice to the West, "a universal model of how a company should be managed based on the converging of management practices found in Japan and the West." Even in the face of economic hard times, they declared Japanese companies would "emerge stronger from the current recession, since the seeds for continuous innovation have already been sewn."[4] By the late 1990s, many observers were dismayed with the economic troubles faced by Japan during that decade, a malaise that continued into the next one.

The ever-shifting performance of the Japanese economy had other features, however, that evolved more slowly, or, seemed quite stable. Major Japanese telecommunications and electronics firms became the primary providers of IT, for instance. These were companies that had been in existence for decades, and continued to be major participants in the economy during the second half of the twentieth century. The close triad relationships and collaborations among leaders of firms, large national banks, and government agencies—often referred to as the Iron Triangle—remained a signature feature of Japanese economic activity during good and bad times. In fact, consensus among non-Japanese observers of Japan's economy held that the triad's behaviors made it very difficult for these three communities, and most specifically high-tech industries and banks, to respond quickly enough to changing economic and technological innovations with new products and business strategies. Instead, they sustained long standing business practices when on the face of things these should have changed. Practices requiring more rapid transformation included opening up earlier, and to a greater extent, more of the economy to world trade after an embryonic industry's need to stand on its own became obvious to government agencies, in particular the Bank of Japan and the Ministry of International Trade and Industry (MITI). Other needed changes included reducing the negative aspects of lifetime employment practices, allowing more wide-spread competition among entrepreneurs in technology-oriented industries, and make possible—and accessible—Schumpeterian gales of "creative destruction" to become a more common feature of the local economy.[5]

The Japanese story displays contradictions and dichotomies; positive and negative economic performances; optimization of public policies and investments that enhanced the early surge in development of local IT industries, but also failures to keep up with global technological innovations; outstanding and innovative business practices (such as Total Quality Management (TQM) and just-in-time manufacturing), yet others too that made it difficult for firms to change their business practices to remain competitive in the world economy. The list of contradictions is long and important. Core to that story is the role of information technologies, their vendors, and users.

As a result of these difficult, various, and serious conflicting currents of activities, it should be of no surprise that our understanding of Japanese events evolved substantively over time. Swings in views and understanding had many phases of causes and effects. Sometimes these were the result of specific events, such as World War II, later imposition of a new constitution and national government on Japan by the American occupation forces, followed by economic recovery and expansion, then recession. In its wake Japanese activities spawned a massive body of publications in Asia, United States, and Western Europe almost in the same quantity as about the North Americans. Two byproducts of that commentary have been the widely conflicting perspectives on Japanese events and, second, about its culture and functioning of its economy and business. In the process this discussion generated a great deal of misinformation and confusion about the country at large, often reflected in studies published by Western media and in the rhetoric of politicians, policy makers, and business executives in the pan-Atlantic community. The history of Japanese information technology (IT) was not immune from inclusion in this conflicting analysis; indeed, it was often at the center of it, because computing was beginning to play a crucial role in Japan's economic affairs by the end of the 1960s. During the 1970s and 1980s its export practices for semiconductors, computers, and robotics heightened diplomatic and trade tensions in ways reminiscent of similar problems in the 1960s and 1970s with textiles, consumer electronics (specifically radios and television sets), and steel, largely with the United States. American firms accused the Japanese of "dumping" onto the U.S. market products at below costs, or, at least for sale below what American companies could charge, in order to "buy" market shares in violation of U.S. laws and trade practices.[6]

The reasons for so much Interest in Japan are thus not difficult to identify. The most obvious was the size and characteristics of its economy. Mentioned earlier, it boasted the second largest national economy after that of the United States for roughly the last three decades of the twentieth century and the first in the next century.[7] Some of its industries became highly advanced in manufacturing, telecommunications, semiconductors, and computing, which spun off myriad business practices viewed as innovative around the world, particularly in the manufacture of automobiles, consumer electronics, and processing by small steel mills. Its personnel procedures were often admired and to varying degrees emulated, such as team-oriented work groups, continuous quality improvement; but, others rejected, most notably and categorically its life-time employment practices, criticized largely by Americans as too rigid and limiting managerial flexibilities. At the same time other Japanese industries remained complex, inefficient, and ineffective, such as its telephone network, wholesale and retail industries, and, to a considerable extent, its financial sector. Japan's practice of discouraging imports

of non-Japanese goods into its economy, while basing a large portion of its own economic development on extensive exports to the West, posed an enormous problem for dozens of countries all over the world, often swaying many of the authors of academic studies and "think tank" policy statements, for instance.[8]

As Asia's most advanced economy, other emerging regional ones looked to Japan as a role model to emulate (1970s–1980s); became hosts to Japanese manufacturing plants (1970s–1990s), which helped diffuse know-how about high-tech manufacturing and use to other nations in the area; or evolved into economic rivals (1990s–2000s). Japan exported many of its most technologically advanced products into Asian consumer and industrial markets, although most of the attention outside Japan focused on pan-Atlantic–Japanese trade, not on Japanese activities in other Asian markets. A long-time student of Japanese industrial practices and resident in Japan, Gene Gregory, summed up the situation in his well-informed study of this nation's role in electronics with the blunt statement that "by 1970, East Asia had become the epicenter of the world consumer electronics industry, with Japan in undisputed leadership."[9] The core skills underpinning consumer electronics were evident in IT as well within the next decade.

Japan's style of industrial organizations (*keiretsu* described later) in collaboration with government's managed economic development and highly protectionist trade practices stamped the country's economy with some unique ways of functioning. However, while many commentators argued the case for Japanese exceptionalism, largely with respect to its business practices, these were no more mysterious or so differentiating than those evident in many other nations. Yet, many particular Japanese practices were featured in some exaggerated style by commentators.[10] As Japan's history with IT demonstrates, many of its activities reflected common patterns of behavior and motives evident elsewhere around the world, such as use of IT to reduce labor content of work, competition of computer hardware vendors for profitable sales, and a healthy appetite for export business. Reading memoirs by Japanese executives serve as a useful, yet partial, antidote to the arguments in favor of Japanese exceptionalism.[11] Just as the pan-Atlantic community began worrying about Japan's rapid expansion into their economies, Ezra F. Vogel, a leading expert on the Japanese, reminded Westerns that "I became convinced that Japanese success has less to do with traditional character traits than with specific organizational structures, policy programs, and conscious planning."[12] Vogel's observation is supported by the fact that these were the same categories of influences evident in other countries with respect to economic performance in general, and more specifically to the business practices of its IT suppliers and their local customers.

Japan had many of the prerequisites evident in other countries which also embraced digital technology that proved so essential to their rapid diffusion.

Japan had a highly educated workforce, although like many advanced economies, more often than not it seemed to need more engineers and programmers of all kinds than it had.[13] Japan built a large and productive industrial sector, beginning in the late 1860s, over a half century before most other nations in Asia. Its timing mimicked approximately that of the United States and West Europe's Second Industrial Revolution, although to be more exact the pan-Atlantic community entered the Second Industrial Revolution by the 1840s. It was the demonstration of the results of that economic and technological transformation that led senior public officials to embrace what was the West's Second Industrial Revolution, but Japan's first. Eight decades later the Japanese began rebuilding and modernizing many factories and whole industries almost from the ground up as a result of the nation's devastation during World War II. This reconstruction meant Japan could embrace the latest American and European technologies and managerial practices with less effort than required of experiencing the slower, more difficult refurbishing of existing systems, factories, and firms as occurred in many American industries in the postwar period. William Chapman, observing Japan's economic growth in the postwar period did not mince words: "Virtually all of Japan's modern miracle can be explained by events that took place on that empty landscape left by war and occupation. The elements of success were formed by the special circumstances of the times, by decisions men made, by the interactions of people and social forces, and sometimes by the sheer luck of the draw." More to our point, "New institutions were developed and new relationships between them were constructed, not because of any cultural predisposition but because certain choices were made and certain understandings took root," including the "cooperative labor-management system" which "was almost entirely newborn."[14]

Japan's workforce has long been admired for its work ethic and discipline, particularly after its lifetime employment practices were affirmed during the 1950s. Yet, as in Western Europe, its workers were no more disciplined; indeed, Japan experienced considerable labor unrest in the 1950s while the Europeans did not. Both had excess labor in the 1950s so salaries remained lower than in subsequent years when their labor forces proved insufficient in quantity to meet demand. Per capita GDP rose along with the cost of living. Each region achieved a common *de facto* commitment among government, management, and labor to rebuild their nation as a national objective. Like Europe, the Japanese recovered economically by the mid-1950s. Japanese firms proved willing and able to learn about other nations' technologies and business practices, adopting them quickly and effectively, as its history of patent agreements and industrial partnerships with American and European firms made quite clear.[15] A CEO of NEC, one of Japan's leading IT suppliers, Koji Kobayashi, devoted an entire chapter in his memoirs to how his company learned from others around the World, citing specific examples of knowledge transfers that came from General Motors in the United States, of required

readings by his managers about foreign business practices, and of visits to other countries and their firms.[16] Each of these types of activities contributed substantially to Japan's ability to learn about IT and to participate in its subsequent development and adoption, particularly between the 1950s and the end of the 1980s.[17]

This chapter presents evidence, however, that Japanese adoption and use of IT is not a tale of consistently stellar performance. Some industries used a great deal of computing, others were bereft of knowledge about what the technology could do. The image of Japanese as an economic powerhouse for many decades proved partially illusionary for in many ways its eco-political environment was slow to adapt to global economic and technological changes. IT did not contribute to the nation's productivity to the extent evident in many pan-Atlantic nations. The evidence suggests problems evident in centralized national economic policies in Communist Europe and China appeared similar, if fewer, in Japan as well. Over time the ability of the nation's economy to innovate its manufacture and use of IT slowed, certainly by the mid- to late 1980s, while simultaneously a consumer electronics renaissance flourished, continuing to the present, fueled by products that had embedded in them highly advanced electronic technologies.

Our narrative, therefore, offers a partial antidote to the widespread image of Japan as one of the most advanced users of computers, qualifying that image with a more nuanced account of its diffusion. While the vast majority of historical and economic literature on Japan focused on its export business, and largely on the supply side of the story, addressed as well here, attention is needed on the role of IT within the nation to provide a more rounded, albeit brief, view of Japan's involvement with IT. The bulk of its experiences with IT continued to sit squarely in Wave One, but with increasing evidence of consumer uses of digital technologies suggesting a march into Wave Two underway by individuals, if not also by some enterprises by the end of the 1990s. That tension separating and simultaneously overlapping the two waves needs to be set in context because consumer electronics has an enormous presence across Asia, Latin America, and Africa with more significance for the way life and work unfolds than in the pan-Atlantic community. Japanese products dominated many niches in this industry world-wide. I want to emphasize more than earlier observers that Japan's experience with IT served as a propellant pushing this technology into the rest of Asia. Put in counterfactual terms, if Japan had not been an advanced industrial economy that made and used IT, and if the Japanese had not embraced export and outsourcing strategies for growing their economy, adoption of computing by the rest of Asia would, in all likelihood, have occurred at much slower speeds and probably to a lesser extent, perhaps more as occurred in Latin America, South Africa, and parts of the Middle East where other national less technocratic economic role models proved more influential.[18]

JAPANESE SOCIETY, ECONOMY, AND INDUSTRIAL STRUCTURE

Because local economic and political circumstances conditioned the course and rate of diffusion—a key theme of my global study of IT diffusion—Japan's circumstances must be explained. In 1945, Japan had a population of just over 76 million residents, two-thirds more than either Italy or Germany and almost half as many as the United States. Japan's population was young then and within twenty years expanded to nearly 99 million; in 2000 it exceeded 127 million.[19] In 1950, 60 percent were under the age of 40, prime candidates for the local workforce. Japan's highly mountainous terrain forced the majority of its population to live on the coasts, resulting in an urbanized society for more than half its residents.[20] This demographic feature is an important attribute because the diffusion of knowledge and technology concentrated largely in urban regions, as in other nations, such as in Silicon Valley in California and Boston in the United States, or around London and Amsterdam in Europe.[21]

Table 7.1 documents Japan's fast growing and large national Gross Domestic product (GDP), an economic circumstance essential, indeed prerequisite, for IT diffusion in any country, since the technology was expensive and only economies with complex manufacturing and services industries could afford to use these tools for the entire period of Wave One. Tables 7.2 and 7.3 demonstrate that Japan also enjoyed a high per capita GDP and economic growth, also indicators of affordability for IT in both Wave One and Wave Two. Rapid growth is part of Japan's IT experience. Per capita GDP data in particular provide a snapshot of the obvious trend during its best recent decades to illustrate how quickly Japan had become an economic powerhouse, impressive to many nations around the World, not the least of which its Asian neighbors. In subsequent chapters, when we examine economic performance after the later takeoff of IT in those nations, such as in China and India, essentially in the late 1980s, 1990s, and beyond, how Japanese connected to their achievements is described.

Economists increasingly view Japan's economic evolution as having passed through four to five periods, each important to our story. The first, beginning with the end of World War II and the nation's occupation by the United States, covers the years 1945 to 1950 at which time the Korean War erupted. During this initial period, Japan rebuilt much of the damage it had suffered during the global conflagration and implemented an American-style constitution drafted largely by the American occupation forces and approved by the Japanese Diet. The Japanese government brought its economy under control by redesigning the Bank of Japan, dampening inflation, and launching reindustrialization, largely on the backs of prewar enterprises, such as those in telecommunications, which would prove so crucial to the introduction of computers into the country.

Table 7.1 JAPAN'S GROSS DOMESTIC PRODUCT (GDP), 1945–2008 (GEARY-KHAMIS DOLLARS—INTERNATIONAL DOLLAR—IN MILLIONS)

1945	102.6
1955	248.9
1965	586.7
1975	1266.0
1985	1851.0
1990	2321.0
2000	2628.0
2008	2904.0

Source: www://ggdc/net/MADDISON/orindex.htlm (last accessed 11/11/2011).

Table 7.2 GDP PER CAPITA, JAPAN COMPARED TO SELECT OTHER ASIAN ECONOMIES, 1950–2008, SELECT YEARS (1990 INTERNATIONAL DOLLARS)

	1950	1973	1993	2008
Japan	1,921	11,434	19,478	22,816
South Korea	854	2,824	10,232	19,614
Taiwan	916	3,448	11,929	20,926
Thailand	817	1,874	5,666	8,750
China	448	838	2,342	6,725
India	619	853	1,390	2,975
Indonesia	803	1,490	2,994	4,428
New Zealand	8,456	12,424	14,031	18,653
Australia	7,412	12,878	17,853	18,653

Source: Angus Maddison, *Monitoring the World Economy, 1820–1992* (Paris: OECD, 1995): 250; www.gglc.net/Maddison (last accessed 10/1/2010).

Table 7.3 JAPANESE GDP GROWTH RATES, 1961–2008, SELECT YEARS (PERCENTS)

1961–70	10.2
1971–80	4.5
1981–90	4.0
1991–03	1.2
2003–08	1.0

Source: *OECD Economic Survey*, various years.

The start of the Korean War in June 1950 signaled a second phase. The war led to a rapid and massive increase in demand for heavy industrial goods by the Americans, most notably steel, which helped speed up Japan's economic recovery and launched this second era normally viewed as extending to 1970. This war prompted a nationwide economic surge as it did in the United States and in parts of Western Europe by creating demand for many products needed for the conflict, such as steel, but also outputs from many industries, in large part for Japan because it was so near Korea. This surge in business proved sufficient to make computing affordable and practical, raising the nation's GDP and causing complex organizations to grow large enough to serve as logical candidates for using computers. Unemployment declined and sale of existing inventories soared in many industries, creating demand for new products and materials. Observers in Japan reported that U.S. demand for Japan's goods "proved to be powerful enough to reanimate Japan's economy, which, due to the disinflationary policy, had been in a coma."[22] As a consequence, in the two subsequent decades (1950–1970) Japan reindustrialized massively to such an extent that these years assumed their own name—High Growth Period—a time characterized by many annual growth rates in real GDP of about 10 percent, while inflation hovered at 5 percent. Japanese prosperity proved tangible. Political stability usually prevailed and after labor disquiet in the 1950s subsided unions became stable as well.[23] As in so many other countries with advanced capitalist economies, Japan enjoyed a brief period of near idyllic economic performance.

A third period extended neatly across the decade of the 1970s, ending in 1980 when Japan's relative stability ran headlong into numerous political, economic, and technological head winds, including many from IT innovations that caused managers to begin questioning the continued practices of existing ways of doing business. It is crucial to keep in mind that as Japan's economy expanded in the 1960s its indigenous IT companies ran out of local customers and, thus, in conjunction with government economic development policies, began expanding sales through aggressive export trade. Almost every segment of the IT world participated: semiconductors, consumer products, computers, IT peripheral equipment, telecommunications, and even the most primitive robotics and other industrial equipment. Software proved to be an exception to an otherwise impressive array of exports, uncompetitive for a complex set of reasons discussed later. Prior to 1980, the government had already implemented a variety of measures that protected Japanese industries it considered strategic to the nation's interests from being overrun by foreign competitors. The strategy was to protect these Japanese firms until they matured and grew to sufficient strength to compete effectively in world markets. All IT industries were deemed worthy of this attention and protection by government, most specifically the Ministry of International Trade and Industry (MITI).[24] During this period the Japanese

government implemented various measures to constrain IBM's success in the national computer industry, while funding R&D and other initiatives to help local computer suppliers mature and expand sales with competitive products at home, against IBM, and abroad.[25]

The fourth period began after 1980, a time when many developing problems came to a head, characterized by demand of governments around the world that Japan open its markets to free trade, which it liberalized to a limited extent.[26] Changes in domestic political leadership also took place. Rapid introduction of new technologies became available worldwide to which Japanese IT and telecommunications firms responded much too slowly, such as distributed data processing brought about by minicomputers and PCs, and later the Internet. This fourth era extended right into the new century and because of our proximity in time to this period, it is not yet clear that one can declare definitively that a fifth one now exists.[27] But historic change was in the air. As two observers of this time noted in the 1980s, "Japan seemed invincible . . . whereas in the 1990s and the beginning of the new century, Japan seemed unable to do anything right."[28]

But much is clearer about events of earlier years. From the early to mid-1950s through the 1970s, Japanese businesses and government agencies sorted out how they would work with each other, how competition would occur. They funded and exploited R&D, promoted foreign trade, and implemented monetary policies to protect the nation which saw itself as alone against the World and handicapped by expensive energy, most notably oil and electricity. These events have been the subject of hundreds of books and thousands of articles. In the 1970s and 1980s observers wanted to explain why the Japanese economy performed better than seemingly everyone else's. Most sounded the alarm that "Japan, Inc." was going to take over such advanced industries as consumer electronics, semiconductors, and automobile sales worldwide, especially after it had taken the lead in consumer electronics and was well on its way to doing the same in various classes of semiconductors.[29]

Beginning in the late 1990s, observers wanted to explain why Japan's economy failed in the latter 1980s and did so miserably throughout the decade and beyond in sharp contrast to the spectacular period of growth in the 1970s and 1980s. To achieve their explanatory objectives, economists, political scientists, and even Japanese business executives advanced various concepts, also applied to the role of IT. These Japanese, American, and Westerner commentators used such descriptive notions as *corporatism*, *bureaucratic*, *neomercantilist*,[30] *political economy*, and outright *protectionist* or *autarkic*.[31] Most focused on similar themes: close collaboration among private enterprises and with large government agencies, the powerful role of banks in funding companies designated by the national government as worthy of protection, and national trade practices.[32]

The dialogue proved complicated because different nations had varying economic models that became the lens through which their observers judged Japanese activities. The Anglo-American form of economic behavior, normally characterized as "liberal capitalism" did not reflect, for example, what France, Germany, South Korea, and many other nations practiced, which could be more precisely described as "non-liberal capitalism." In the latter group's approach, the state played a more proactive role, placing less trust in Schumpeterian free market forces than did the Americans, for example. It is into the non-liberal camp that Japan fit and it is this dichotomy in how economies and public policies unfolded that helps explain many of the IT trade battles that flared up, beginning in the late 1950s and extending variously to the present. Ultimately, the most important motivation for many to look at Japanese business practices and public policies resulted from Japan's highly successful foreign trade results.[33]

One of the most useful of these descriptions of Japanese eco-political behavior for understanding IT's story comes from Marie Anchordoguy, who has been examining the role of IT and other technologies from both economic and political perspectives for over a quarter of a century. Anchordoguy describes the Japanese ecosystem as "communitarian capitalism." In her words, "Communitarian capitalism is an economic system characterized by an activist state and a number of private-sector organizations that manage markets to promote development and national autonomy in the context of the broader goals of social stability, predictability, and order."[34] Most confusing to many Westerners, therefore, was its byproduct, "elaborate social conventions about how the state, firms, and individuals should behave in given situations. The rigidity of these customs binds community members into a strong collective identity."[35] In the realm of IT trade when Japanese faced transformations in the global change in technology it proved unable to respond as quickly to these as could other economically advanced nations. This is a problem discussed at length in this chapter.

From an end user's (consumers of IT) perspective in Japan adoption of computing for competitive reasons did not necessary require speed or as elaborate forms of cost justification as in many other national economies. Social stability proved generally more important than maximizing short-term profits at an individual firm, particularly in large enterprises; management valued full employment, providing it resulted in an increasingly productive workforce.[36] Following World War II, Japanese society desired security, stability, a way out of the humiliation and horrors brought on by the war, and return to international legitimacy and economic well-being. In particular, public officials valued national and industry-wide successes more than those of individual firms. One government official stated clearly the objective: "Japan's system prefers no big winners and no big losers."[37] Another declared that "all companies should survive."[38] These objectives varied slightly over the past six

decades with the greatest shifts coming only in the late 1990s and early 2000s, when deteriorating economic conditions, transformations in technology, and rising unemployment forced all players to change their behavior. Companies, however, sought growth, protection, and independence from too much collaboration and sharing of patents and R&D results among their competitors. Elsewhere, even protective West European regulators were prepared to let some firms die, while the Americans considered the birth and death of enterprises positively essential for a healthy capitalist economy.

The national banks served as the key stockholders, behaving more like stakeholders. Individuals played a far lesser role in Japan than they did in pan-Atlantic economies. Banks funded private enterprises with an expectation of longer term, not quarterly or even in some instances, annual returns on investments. Often financial officials and retired government regulators served on the boards of these firms, creating the close symbiotic relationships at the heart of the Iron Triangle. In short, banks were the primary owners of firms across multiple industries. Companies aligned with a particular bank formed an enclosed market, an ecosystem, where they overwhelmingly bought from and sold to each other. A company that made computers, such as Fujitsu, sold its products to other members of its bank's invested firms, and to a lesser extent to others outside its circle, and, conversely, if a corporation wanted a machine and Fujitsu was part of its ecosystem it would tend to acquire its products. Customers of IT were routinely discouraged—but not necessarily prohibited—by government officials from selecting a foreign made system, such as those sold by Americans, even by IBM Japan, even though it manufactured locally and employed Japanese nationals. The concept of the enclosed community was encapsulated in a Japanese word, *keiretsu*, which loosely translated referred to industrial groups, a core concept to keep in mind when thinking about how one bought and sold IT in Japan during the second half of the twentieth century.[39]

If Japanese banks ran into difficulties with their investments, government agencies would backstop them, much like an insurance agency. Public officials declared which industries needed protection and aid for the good of the nation, thereby putting the state in the business of managing markets, literally down to the level of determining which companies and products should thrive (or not), and in what product categories.[40] Within such controlled limits, firms were expected to compete, for example, on excellence of products, although they had to share risks, even negotiate joint solutions to problems, with the result that they often had similar goods priced almost the same. In such an environment, it was very important to hold onto existing customers.

In IT that meant most vendors and their customers adhered to IBM's S/360 standards and notions of centralized computing, but with enough proprietary software (or changes to IBM's) to prevent (restrict) a customer's ability to move easily to another vendor. This strategy proved increasingly ineffective

when decentralized data processing came to the fore in the late 1970s and spread in the 1980s. Changes in technologies highlighted that incumbent vendors were inadequately prepared to respond quickly enough to these disruptions to their prior centralized computing, stable ecosystem, let alone allow the demise of a company unable to react to changes adequately in time. The process of creative destruction that flushed out insufficiently responsive vendors unable to adapt had "been blunted," in Anchordoguy's words.[41]

There were several primary government players in this system, including the Bank of Japan, of course, but also MITI with its enormous legal power dating from the late 1940s and not challenged successfully by rivals, foreign suppliers, customers, or even local economists until the late 1980s. Its authority did not diminish until the 1990s and early 2000s. In its heyday (1940s-early 1980s) MITI dictated who received import and export licenses. It funded R&D and other initiatives, persuaded firms what they could or could not do (euphemistically known as giving "administrative guidance"), and prioritized industries its officials believed most essential to the nation's economic welfare. For example in the 1950s, it favored heavy industries, such as steel and ship building, giving these economic and financial help, while sheltering them from global competitors. After the oil shock of 1973–74 with its resultant higher costs of oil, MITI's officials concluded that they needed to promote industries that used less fuel, such as electronics, and to reduce support for others that consumed a great deal, such as steel manufacturing and shipbuilding. MITI used its economic power, legal authority, and influence to get a chosen industry access to foreign technologies so that it could quickly produce and sell these both within Japan and on the world market. MITI's facilitative role exerted a profound influence on activities of local IT suppliers, IBM, and other American IT firms all through the period.[42]

By favoring some firms at the expense of others, and in collaboration with Japanese banks, MITI discouraged new enterprises from forming, because they would not be able to obtain venture capital. This practice left existing vendors with fewer incentives to change than those in other more competitive economies where new rivals emerged constantly, challenging incumbent companies in industries experiencing the kind of technological turbulence that occurred in telecommunications, semiconductors, computing, software, robotics, consumer electronics, and later, biotechnology—all industries that MITI chose to support with the exception of consumer electronics. Between the 1970s and mid-1980s, IT, telecommunications, and other firms acquired access to technologies and produced goods off the backs of these. They and MITI expanded trade outside Japan, while government officials blocked competition at home from non-Japanese firms through trade barriers created to shelter indigenous companies, and with technology licensing agreements designed to give local firms access to non-Japanese technologies. Japanese enterprises, however, were also often forced by government to collaborate in

sharing patents and in co-developing technologies and products. This practice resulted in costs of transactions (internal expenses) and technological collaborations to remain relatively low when compared to those in pan-Atlantic nations, although the expense of products to their customers remained higher, since there was less domestic competition over prices. Rather, intense domestic rivalry centered on quality of products and service.[43]

Between 1950 and 1980, MITI and other government agencies negotiated over 25,000 licensing agreements with non-Japanese companies around the world worth some $6 billion, including with most key U.S. IT and West European IT vendors. Those arrangements reduced and, in some instances, eliminated the requirement of Japanese firms having to invest time, resources, and energy to develop similar technologies and products. This strategy of rapid adoption of existing technologies, combined with fast turnaround in producing products based on these, often with some incremental innovations, when coupled with protection from foreign competitors at home, went far to account for the rapid speed with which Japan's economy became so modern and up-to-date in its high technology product offerings by the mid-1970s.[44] Some Japanese firms refused to play by MITI's rules, however, and so were denied as much access to funds, permits, and development projects as made available to those that collaborated with government initiatives or that were deemed to be in an important industry. Through the 1960s, in addition to technology transfer agreements and licenses to sell in Japan or export, MITI also applied currency controls to supply low cost capital to targeted industries (such as those in IT) and to exercise benign neglect to those it was not interested in helping. To be sure, MITI was a large agency in which intra-agency and interagency priorities conflicted, but MITI's achievements with respect to effects on the IT world were as it generally desired, particularly in the startup decades following World War II. Japan built from scratch competitive industries in semiconductors, IT peripherals, computers, and, despite its lack of interest, consumer electronics flourished too.[45]

Particular policies proved enormously problematic for many global vendors of IT eager to compete in Japan. Their imports were subjected to high tariffs, which helped local vendors be more competitive in home markets. Just as important, MITI did not allow foreign companies to invest directly in local firms to get around tariffs. That meant, for example, American companies had to license their technologies and products to local firms at low prices, which reduced the yield they might otherwise have obtained if they could have invested directly in Japan. MITI's officials often confronted individual Japanese managers who requested permission to acquire a foreign computer to convince them to buy from indigenous vendors, or delayed issuance of requisite permissions. MITI implemented all these strategies in the 1950s and continued to use these to one degree or another to the end of the century.[46]

Simultaneously, however, what one would characterize as normal capitalist rivalry existed in Japan that on occasion became part of the Japanese IT diffusion story. If not initiated into MITI's inner circle of select industries or companies, and into the *keiretsu* ecosystem, firms competed with rivals as anywhere else in the World. Yet, they usually experienced enormous difficulty convincing local banks to invest venture capital in them as these were some of the most conservative financial institutions in the industrialized world. Banks insisted on tangible collateral, such as land, unlike venture capitalists willing to invest on the basis of a patent or good business plan, as so frequently occurred in the United States with emerging technologies and practices.

The perfect example is Sony, a firm established after World War II that sold the world's first transistor radio. MITI's officials thought radios were trivial, overlooking the fact that Sony's founders acquired a license from Western Electric in 1953 to use transistors—soon a core component of computers—to embed in its initial products. Sony acquired knowledge of electronics from a combination of staff educated in Japan before World War II and later by establishing a U.S. subsidiary with a laboratory in New Jersey, home to many high-tech consumer and computer operations, most notable RCA, a giant in American consumer electronics in the 1940s and 1950s. Sony's engineers added to their knowledge of electronics, and specifically about transistors; one member of the original team forming Sony, Leo Esaki, received recognition for his work with a Nobel Prize in 1973. The firm succeeded, often having to obtain funding for expansion and R&D outside of Japan. It went on to introduce innovative products, such as the CD-ROM (compact disk-read only memory), which gave computers video and audio capabilities, the Walkman in 1979 of which it sold over 200 million units over the next 30 years, the DVD, and the Sony PlayStation. In 1982 it entered the personal computer market where it remained competitive, offering new products over the next three decades. Like Toyota, Honda, Canon, and Kyocera, Sony was an outlier in the story told in this chapter of what computer vendors and MITI did, following its own strategy and finding its own way to success.[47] More telling, Sony could also respond to new opportunities and changes in the market *quickly enough* to become a world-class competitor in its chosen markets, demonstrating, like other exceptions, that firms in Japan could be managed effectively, avoiding some of the problems local vendors experienced with their more lethargic strategies and tactics.

MITI's and Bank of Japan's efforts, the cumulative results of the *keiretsu* system, along with such other developments as stable political regimes, culminated in the high water mark of Japanese economic success in the period 1980–1985. The period stood in sharp contrast to the difficulties faced by many other nations at the time. Japan avoided inflation stimulated by governments in other nations, largely in response to the second oil price increases of 1979–1980 and subsequent bouts of inflation. The banking system

was carefully managed, the internal economy isolated from global effects, and exports expanded, as discussed below for IT products. But in 1985, the Bank of Japan made some errors too, driven by the government's decision to assuage complaints from the United States and European countries that Japan had closed off its domestic markets from their firms for such products as semiconductors, computers, and automobiles, signing the Plaza Accord in September 1985.[48] As the dollar simultaneously declined in value, and to make it possible for foreign vendors to sell in Japan per the accord, the Bank of Japan took steps to slow appreciation of the yen. The bank expanded the money supply and credit that fall (1985). Expanded cheap money and flawed policies designed to liberalize finances led property values to rise rapidly—the real estate bubble economists talked about afterwards—diverting investments from technology and to those that led to the bubble which burst in 1989–91. The economy began to seize up, investments in capital goods (such as computers) slowed, while the public reduced its expenditures on such things as new homes and consumer electronics, instead increasing their savings.[49]

Central to our story is that Japan's national government continued to nurture development of indigenous suppliers of IT available in its national market that competed effectively around the world. At the dawn of the new century, four out of the World's ten largest manufacturers of computers were Japanese: Fujitsu, NEC, Hitachi, and Toshiba. In telecommunications (another protected industry) NEC and Fujitsu made the global top ten list; but, the greatest success came with semiconductors where the Japanese held six out of the top ten positions: NEC, Toshiba, Hitachi, Fujitsu, Mitsubishi Electric, and Matsushita. Martin Fransman, a leading authority on Japan's high-technology industries, cautioned, however, "while Japan's computer and communications companies have dominated global markets in areas such as memory semiconductors, optoelectronic semiconductors, microcontrollers, and liquid crystal displays, they have been significantly less successful outside Japan in crucial markets such as mainframe computers, workstations, servers, personal computers, microprocessors, packaged software, and complex telecommunications equipment."[50]

Success in some sectors of the IT market resulted from being able to ride the wave of overall economic expansion of Japan's economy which could use its products, where local competition proved effective, and demand lubricated with government backed initiatives, especially when they responded to the specific needs of customers in the local economy. But, effectiveness and support at home did not necessarily mean that they would be as successful outside Japan against other competitors. For example, while the Japanese were enormously effective at home selling mainframe computers, where demand for this technology remained strong, they did not develop as successfully product lines in minicomputers and PCs, let alone software—all new classes

of technologies which grew in importance outside Japan in the 1980s. If the local market, which shaped the products and work of indigenous IT vendors, caused these firms to introduce goods attractive at home but not abroad, then these enterprises did not do as well worldwide.[51]

Path dependencies, or "learnings," acquired by Japanese vendors from their customers played an enormous role in shaping their ability to compete, regardless of MITI's or any other government agency's policies, suggesting a limit to the influence of governmental and banking actions. As in the case of Communist European government policies, constraints existed, diminishing the ability of officials to pick "winners" and "losers" or to define realistically features of technologies needed in both domestic and foreign markets. So, was there evidence of an underlying private sector strategy?

Economist William K. Tabb best summed up the role—indeed contribution—that the various IT industries and their users played in Japan's economy in the past half century when he argued that "Japan's pattern of rapid growth was one of moving continuously upscale to more sophisticated process technologies and product mix."[52] It is the short answer to the complicated question asked by almost every observer of the Japanese: How did Japan go from being such a devastated nation at the end of World War II to being the second largest economy in the World? As with so many other nations, IT played an integral role in the economic evolution of whole industries and economies. The Japanese were not exceptional, rather generally more like the others.

ORIGINS OF JAPANESE COMPUTING, 1950S–LATE 1980S

While many aspects of Japanese IT diffusion paralleled events in other countries, as with those other nations, however, it had its own unique features as well. Specifically, the origins of computing in Japan are rooted in different traditions from those of the pan-Atlantic world. For one thing, motives for developing and using these technologies and, consequently, their funding, did not spring from military requirements of the Cold War so evident in the R&D activities of the Soviet bloc, the United States, Great Britain, France, Sweden, and a few other nations. In Japan's case, incentives to create IT competences grew out of civilian economic needs for foreign trade and national economic development. Therefore, sources of funding, incentives for developers of computers, and practices of local vendors often displayed a pattern of their own, just as in every country there were specific local features of adoption and evolution. Second, and largely unique to Japan, the majority of computer development came out of the pre-existing telecommunications industry, particularly during the 1950s through the 1970s, but as in many other countries, also included work done at government agencies and universities. Paths of learning by which Japanese engineers came to acquire knowledge about the technology,

and found support for their work, originated less from universities and, of course, not at all from the nearly nonexistent military–industrial complex. This stood in sharp contrast to the experiences in many other nations where local electronics firms, office appliance suppliers, and military laboratories collaborated in the development and early diffusion of IT, most notably between the 1940s and the end of the 1960s. Although a few universities participated in the early decades of computing in Japan, theirs' was a diminutive role when compared to those of Western academic institutions.[53]

Third, those Japanese companies engaged in developing and diffusing computing did so across a broader set of digital technologies than their cohorts in the West. A firm built computers, manufactured semiconductors, wrote software, sold telecommunications technologies which had embedded in them digital technologies, and later diffused all manner of ITs into such spill-over products as consumer electronics and robotics. In the West, these various classes of digital technologies (lines of business and products) emerged from companies that specialized in one or few of these. Intel made semiconductors, not semiconductors *and* computers; Zuse built computers and avoided offering robotics, or, becoming a software powerhouse, and so forth. A few limited exceptions existed, of course, such as IBM which for many decades manufactured semiconductors for its own use in its products, did basic research on all manner of IT, introduced computers and software, but rarely robotic devices and never consumer electronics with the one notable exception—the PC. The Japanese case presents a situation in which the transfer of knowledge about IT across an entire supplier's enterprise occurred quickly, often effectively, facilitating development of computing.

Yet in the beginning, Japanese computing briefly mimicked Western experiences, starting with early activities at universities and public research laboratories in the 1950s. The first relay computer was designed and built at the Electrotechnical Laboratory (ETL), an agency within MITI, in 1952, a remarkably early date given that the Japanese economy was still recovering from World War II and the positive economic effects of the Korean War were just starting to be felt. A machine built at the University of Tokyo in 1958 came into use as well, using parametric oscillation of magnetic ferrite cores, called the Parametron (PC-1). The Electrical Communication Laboratory (ECL), a department within the Japan Telegraph and Telephone Public Corporation (M-1) constructed a similar device. Eventually these experimental machines led to commercial versions developed by Hitachi, Nippon Electric Company, Fuji Communications Manufacturing Company, Oki-Electric Industry Company, and other firms. The following year scientists at the University of Tokyo had a vacuum tube computer, a project that had taken them six years to complete. Japan's first digital computer appeared in 1956. Additional early design and construction of computing equipment took place at the University of Osaka. In the private sector Fuji Photo Film Company put a system into

operation a system in August 1956, named Fujic, considered the first electronic computer built in Japan for production work. The first Japanese computer to use a CRT and vacuum tube technology was built at Tokyo's university in collaboration with the Tokyo-Shibaura Electric Company, called TAC; it went into use in early 1959. Table 7.4 catalogs various systems built in the 1950s, demonstrating that quite early in the history of computing numerous projects were underway in Japan involving a small but diverse group of academic, government, and private sector firms.[54]

Several patterns are observable from the data in this table. First, a variety of organizations and companies became involved quite early in constructing machines. Second, they built them for each other, borrowing knowledge from collaborators and European and American sources (note the use of the British-styled Mark series). Third, there existed a considerable number of early systems. If we had extended the table to include machines that went into use in 1959, over 15 additional systems would be listed coming online at the rate of one to two per month.[55] Additionally, most of the work occurred in the Tokyo area where knowledge sharing occurred quickly from one organization to another, a point not lost on observers of the Japanese scene trying to understand why computing spread rapidly at the time.[56]

Behind the production process evident in the table, American computers began to come into Japan which local producers learned from, beginning in 1954. Simultaneously in that same year five local firms were already manufacturing transistors under licenses from American firms: NEC, Fujitsu,

Table 7.4 EARLY COMPUTERS IN JAPAN, 1952–1958

Developer	User	Machine	Operation Date
ETL	ETL	ETL Mark I	December 1952
ETL	ETL	ETL Mark II	November 1955
ETL	ETL	ETL Mark III	July 1956
Fuji Film	Fuji Film	FUJIC	August 1956
ECL	ECL	M-1	March 1957
Hitachi	Hitachi	HIPAC-1	August 1957
FCM	Sakura Film	FACOM 138	September 1957
ETL	ETL	ETK Mark IV	November 1957
NEC	NEC	NEAC-1101	January 1958
Tokyo Univ.	Tokyo Univ.	PC-1	March 1958
FCM	Canon Camera	FACOM 128 B	April 1958
HEW	HEW	H-1	October 1958
NEC	JEIDA	NEAC-2201	October 1958
NEC	Tohoku Univ.	SENAC-1	November 1958

Source: Japan Electronic Development Association, J.E.I.D.A. and Its Computer Center (Tokyo: JEIDA, undated [circa 1959], CBI 714, Box 5, Charles Babbage Institute, University of Minnesota, Minneapolis.

Hitachi, Matsushita, and Toshiba, each endowed with extensive skills in electronics of all kinds accumulated over many decades. The first three became the major suppliers of commercial computers in Japan; each was also expert in the development and manufacture of telecommunications. As the table also demonstrates, nonprofit organizations were some of the first to experiment with computers since it was not clear to local telecommunications and electronics firms that there was a commercial market for such devices until about 1955, and so, many chose to proceed cautiously into the new technology. The two most important early players were MITI's ETL, and Nippon Telegraph and Telephone (NTT)'s Electrical Communications Laboratories (ECL), which transferred their work on computers to NEC, Fujitsu, Hitachi, Toshiba, Mitsubishi Electric, and Oki, beginning in the late 1950s.

With initial imports of American computers starting in 1954, along with licensed production of transistors in Japan that same year, Fujitsu and other firms approached MITI with the recommendation that it foster development of an indigenous computer industry; a suggestion put into action with the passage of enabling legislation in 1957 (Electronics Development Provisional Act). This law authorized funding of R&D subsidies to these companies, loans for the acquisition of these new products, accelerated depreciation of manufacturing plants and production of such machines. In the first five years (1957–1961), however, financial aid barely reached $1 million, so the process of assistance proved slow to arrive in the beginning.[57] Of all the vendors, the one which most enthusiastically committed itself to the new market was Fujitsu, leading to its early production of new systems (see table 7.4).[58] At Fujitsu a young generation of engineers wanted to pursue computers, including a future chairman of the board, Taiyu Kobayashi. He approached senior management to commit the firm, despite the old guard's reluctance. The transitions by these various companies to computers mimicked much of the same process of transformation into this industry that IBM underwent internally with Thomas J. Watson Jr. during the early to mid-1950s, leveraging a new opportunity at a time when—in the case of Japan—other communications firms had a stronger position in the locally known and less risky telecommunications market on which they were more focused. At IBM the issue concerned tabulating equipment versus computers. In each instance, entrenched interests advocated the status quo, others favored emerging new products and markets, and both sides competed internally for support and, ultimately, for control over the destiny of their enterprises' futures.

NEC was in a strong position in the telecommunications market, yet also saw the opportunity to sell computers by the late 1950s. Management decided to use that technology to complement its sales of telecommunications products, developing what famously became known as its "C&C" strategy, involving early online computing and communications.[59] Hitachi, weaker than Fujitsu or NEC in the telecommunications market, had a stronger presence in

consumer electrical and electronic goods markets, and looked to similar firms in the United States for its business models, most notably RCA and General Electric (GE). Like the other two Japanese firms, it entered the market for computers in the mid-1950s, as did Toshiba and the smallest of the firms, Oki.[60] Meanwhile MITI established an Electronic Industries Section and the Electronic Industry Deliberation Council to coordinate its response to this new market. Membership on the Council included vice-ministers at MITI and from the Ministry of Finance, presidents of various electronics firms, president of the Japan Electronic Computer Company (JECC beginning in 1961 after its establishment), and academics, for a total of some 40 individuals who, over the years, coordinated many IT-related activities and built consensus around national strategies and collaboration by individual firms.[61] MITI was clearly organizing to support local firms.

Takeoff on the supply and demand sides in Japanese computing occurred in the 1960s, although not obvious at the start of the decade. Japanese firms entered the decade with experience building small, expensive computers that were technologically several years behind those manufactured in the United States. Demand for these systems remained quite limited, but interest was growing in government, banking, telecommunications, large machine manufacturing, and automotive firms. In 1962 and 1963 combined all Japanese vendors built 5 large computers, while an additional 44 came into the nation from foreign vendors, largely American. However, medium-sized systems (in the same range as IBM's 1401s and 650s) proved more popular, with 197 manufactured between 1960 and the end of 1963, although in this class of machines, foreign products also came into the country (122 systems). During these same years 128 locally built small computers were installed, while another 130 came from outside the country.[62] This surge in demand began in 1960 with mid-sized systems, an interest in computing not lost on local firms, or MITI. Fujitsu set up a separate computer division in 1961, while MITI's experts in the industry began sorting through what actions to take. MITI wanted to expand the capabilities and capacities of local firms, and chose to negotiate licensing of American and European technologies to reduce the technological innovation gap and bring quickly into Japan IT expertise and ability to make systems. In quick order agreements were signed: Hitachi with RCA (May 1961), Mitsubishi Electric with TRW (February 1962), NEC with Honeywell (July 1962), Oki with Sperry Rand (September 1963), and Toshiba with General Electric (October 1964). As Tasiyu Kobauashi, the senior executive at Fujitsu recalled years later, "it was, of course, the easiest method of obtaining such technology."[63]

As in so many other countries, there was also the issue of IBM's role. IBM's Japanese presence began in 1925 when a local agent for the company rented the first products. IBM established a local company in 1937 (Watson Business Machines Company of Japan, Ltd.). In 1949 IBM regained control over its

local properties confiscated during World War II. It installed its first 650 in Japan during 1958 at the Atomic Research Institute and the first 704 in the country the next year at the Government Meteorological Agency. In short, it participated in the embryonic Japanese computer market from nearly the beginning. The domestic history of IBM in Japan mirrors that in many European countries with plants established or expanded all through the 1960s and 1970s, along with opening of sales offices in major cities.[64] IBM could sell directly in Japan because it had been present there before laws passed in the 1940s prevented foreign companies from doing that; other American suppliers of computers had to participate through technology-sharing agreements. The major events for IBM, however, were the ongoing negotiations between IBM and MITI on how to sell its new products in the late 1950s. IBM refused to establish an operation dominated by Japanese firms, as proposed by Fujitsu and later MITI, leading to protracted negotiations. IBM's lead negotiator, James W. Birkenstock, recalled that in late 1960, during an impasse, MITI's lead negotiator, Akasawa-san, attempted "to bully me into acquiescence," stating "that unless IBM accepted MITI's terms, MITI was prepared to impose severe sanctions on IBM Japan, crippling its current operations and clouding its future."[65] That threat did not deter Birkenstock. MITI eventually gave IBM permission to operate in Japan, while the company agreed to cross-license patents with five Japanese firms for five years.

In the 1960s, demand for IBM's systems remained strong, because their quality proved superior to that of local firms at the time and there existed availability of supply; but, MITI pressured buyers to buy local first. IBM's corporate records regarding its Japanese operations are full of letters complaining about the constraints put on its ability to sell computers, such as the government requirement for permission to open sales offices and for users to obtain authorization to acquire IBM's imported or even locally manufactured products. An internal report, dated December 20, 1967, noted that the only two countries in which IBM's dominance of local mainframe markets hovered below 50 percent were Great Britain and Japan (46–50 percent in GB, 47 percent in Japan). The author of the internal report noted "IBM, however, has been and still is the single dominant factor in the Japanese marketplace, and government policies and administrative measures appear to be directed specifically at curtailing the importance and growth potential of IBM Japan." The same report commented that "demand for computing in Japan is far in excess of local supply capability," going far to explain the desire for IBM's machines, while opining that "all six major local manufacturers must be characterized as being weak."[66] At the time, local firms only participated in 25 percent of the Japanese market, so the issue of what to do with various American and European firms was serious to MITI and Japanese providers.[67]

IBM's introduction of the System 360 in April, 1964, precipitated as much of a shock to local firms as in other countries. Hitachi, NEC, and Toshiba

collaborated with their American partners to upgrade their product offerings. Fujitsu, which did not have an American ally, went it alone, updating its product line by introducing the FACOM 230-60 in 1968; the first installation of this system took place at Kyoto University. Japan's most important telecommunications company, NTT, installed Fujitsu systems after concluding that this supplier had finally acquired the necessary capability and market presence to be a competitive supplier of digital products. MITI launched R&D projects to help local firms upgrade their products, most notably the Very High Speed Computer System Project (VHSCS), conducted between 1966 and 1972, specifically to bring all locals up to technological snuff. The term used to describe such efforts was to "catch up." It was through this project that MITI cajoled local firms to specialize in parts of the market to optimize each company's limited resources and capabilities. Hitachi, Fujitsu, and NEC worked on time-sharing computing; the weaker Toshiba and Oki on peripheral equipment for mainframes. NEC specialized in memories, while the technologically most advanced of the group, Hitachi, focused on high-speed logic devices.[68] But, local firms could only offer new products as fast as their American partners could develop new devices, since they were dependent on the latter's technological innovations. Meanwhile local users were urgently demanding S/360s for the same reasons as their cohorts in the United States and Western Europe.

Hardly had local suppliers begun to introduce new products when IBM brought out its S/370 line of computers in 1970. That event put into high relief the continuing slow reaction by Japanese technology firms to evolving digital technologies, which still was deployed while a measured response was underway with respect to the S/360, first shipped to customers by IBM a half decade earlier. Historian Alfred Chandler, Jr. used the word "stunned" to describe how officials at MITI reacted to this product's introduction, because it once again made clear that Japanese vendors were technologically behind and within those companies how badly so.[69] MITI called for mergers of local firms, as did Europeans in their own home markets, but Japanese vendors refused. MITI then proposed a "New Series Project" to stimulate collaboration among its companies to which they reluctantly and slowly acquiesced in the early 1970s.[70] Simultaneously, Fujitsu negotiated an arrangement with American computer engineer Gene Amdahl and his new enterprise to provide him funding he desperately needed to build computers based on the S/360–370 technology that he could sell, some of which he had earlier developed while at IBM. This arrangement provided Fujitsu with a rapid infusion of detailed technological information about IBM's systems which the firm applied to its products. During the 1970s Fujitsu continued to increase its share of ownership in Amdahl's firm.

At the same time Japan's exports of computers and peripheral equipment did well. In 1974, for example, 20 percent of all Japanese exports went to the

United States, grew to 31 percent the following year, jumped to 75 percent in 1976, and then began declining to the 63–66 percentile range for the rest of the decade. The surge of sales in the United States reflected the rapidly growing use of computers in the United States versus Europe, and favorable monetary exchange rates. Dollar flows quantify the results: $16.7 million in 1974 to the United States, up to $99.7 million in 1976, similarly the following year ($96.9), and in 1978 to $218.1 million, all convincing evidence of the continuing growth in demand for computers in the United States. However, demand also grew worldwide as total global sales increased in dollar volumes: $83.2 million in 1974 and increased steadily over the next few years to $331.1 million in 1978, with a third of that year's sales going to Europe and Asia combined. Sales kept expanding over the next several years at similar rates of compound growth. One final set of statistics makes our understanding of the results more explicit: number of systems installed. As the dollar volumes went up, so too did the number of computers sold. Amdahl led the pack with a worldwide total of 189 between 1975 and 1978, of which another 100 went into the U.S., and in the following year 200 went into the United States. Data on Hitachi indicates it did not enter the export business for computers until 1978, when it sold 31 systems and a similar number the following year. Most of these machines would have been sold to existing users of computers seeking to find a less costly alternative to their own indigenous suppliers.[71]

Meanwhile, IBM continued to do well in Japan, notwithstanding public pronouncements by the firm and the American government, overcoming a concerted effort by Japanese public officials to dampen its activities. By 1977–1978, at the height of IBM's success with S/370s and follow-on products around the world, business volumes demonstrated both growing demand for computers in Japan from this firm and indigenous ones. Using 1978's data to illustrate events, IBM Japan sold $1.4 billion worth of products, roughly the same amount as did Fujitsu, and more than Hitachi ($900M), NEC ($800M), or combined Toshiba, Mitsubishi, and OKI ($600M). Because Japanese firms were in many lines of business, their data processing revenues cited above only represented a portion of their total revenues. Fujitsu's business was largely in data processing (69 percent), although published accounts suggest it was higher; only 12 percent for Hitachi, 27 percent for NEC, 23 percent for Toshiba, 29 percent for Mitsubishi, and 35 percent for Oki, while for IBM Japan it was 96 percent.[72] Clearly, attention from Japanese vendors had to be spread across a much broader set of issues than those concerning computers to such divergent ones as markets for appliances, electrical equipment, consumer electronics, and, of course, electrical components.

Because I argue that having effective sales and other field personnel in the computer business exhorting customers to install and use computers contributed importantly to the rapid diffusion of IT, knowing the number of such IT protagonists is useful, if nearly impossible to find. IBM's internal

market analysts routinely collected such information and, while probably not always 100 percent accurate, were, nonetheless quite reliable. Using data from the late 1970s, for which we have evidence, for the seven firms (including IBM) there were in 1978 a combined 30,000 sales, sales support, and sales agents. Fujitsu had 9,200 (two to three times more on average than the others), while IBM had 5,075.[73] Sales is a labor intensive activity so these numbers suggest a very active, dense market for IT products in industries that routinely used computers, such as banking, manufacturing, and government.

MITI was uncomfortable with Japanese companies being dependent on IBM's technology and that of other American vendors, who themselves were increasingly reliant on IBM's standards and, thus, also had to react to the pace of product introductions by the large American company, rather than chart their own courses. MITI's New Series Project, however, worked well to strengthen the technological capabilities of local firms to offer products that competed locally and abroad with IBM on functionality, cost, and reliability with the result that by the early 1980s, Japan had a vibrant computer industry. In effect, it had caught up to the Americans. By the early 1980s Japanese firms were exporting machines to Europe, which they marketed through local vendors, such as Siemens, Machines Bull, and Olivetti, which is why Europeans reacted in panic as they saw a Pan-European Trojan horse attack on their local industries by what appeared to them to be a highly coordinated "Japan, Inc."[74] Japanese sales in the United States also occurred in the same decade.

Figures 7.1 and 7.2, created by internal IBM marketing analysts in the late 1970s, illustrate the thick network of relationships two major computer vendors had created to diffuse its products around the world. No major geographic IT market was overlooked. Japanese exports were conducted with an organized infrastructure that grew early in its ability to sell and manufacture wherever it made economic sense to do so. This kind of information would have been known to officials in MITI and, of course, to other Japanese vendors and to their funding banks. Indeed, the evidence from these graphics suggest Japanese suppliers did this earlier and more effectively than the Americans, and far beyond what the Europeans proved able to do since the latter barely could break out of their domestic markets, let alone outside of Western European ones.

Table 7.5 briefly tells us a great deal about trade in computers. Leaving aside specific numbers and just looking at the broad pattern of behavior, several things become obvious. First, both imports and exports rose through the period, with the one exception—and a significant one at that—occurring briefly in the early 1990s when exports declined by nearly 50 percent between 1992 and 1995. Exports rebounded and continued their historic growth, with smaller declines occurring in 1998–1999 and again in the early 2000s. Second, a similar pattern manifested itself with imports. Third, the data tell us that

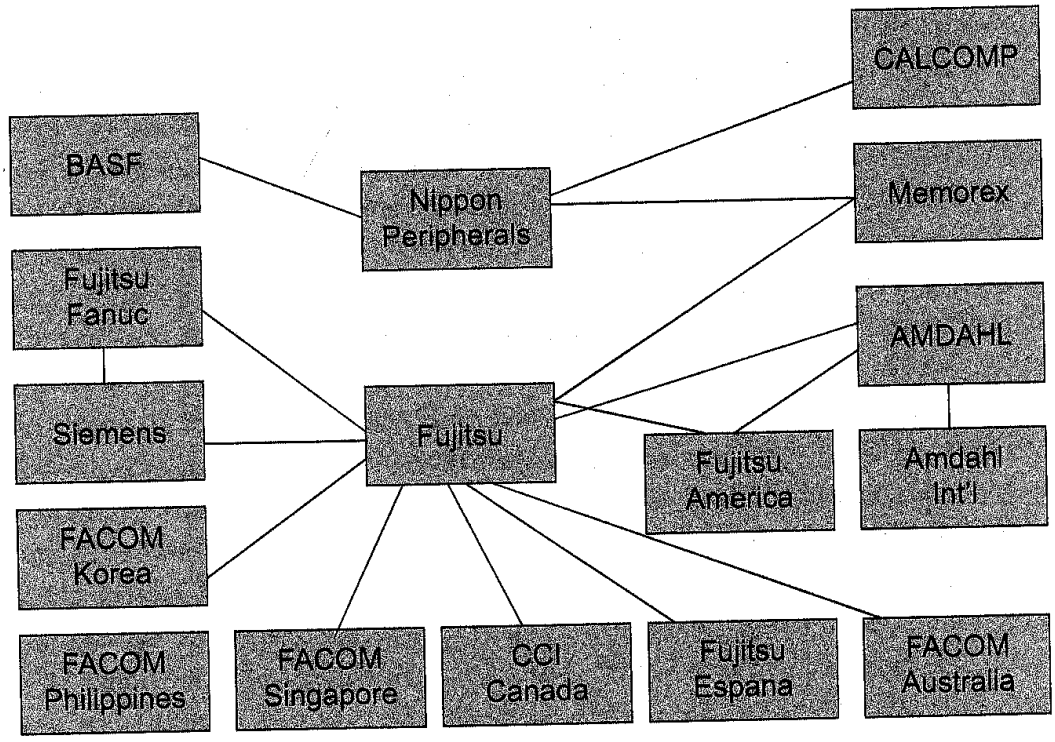

Figure 7.1
Fujitsu overseas relations, 1979
Source: "JCM & IPS Status in Japan & U.S.," RG 5, Box 46, folder 3/4 IBM Corporate Archives, Somers, N.Y.

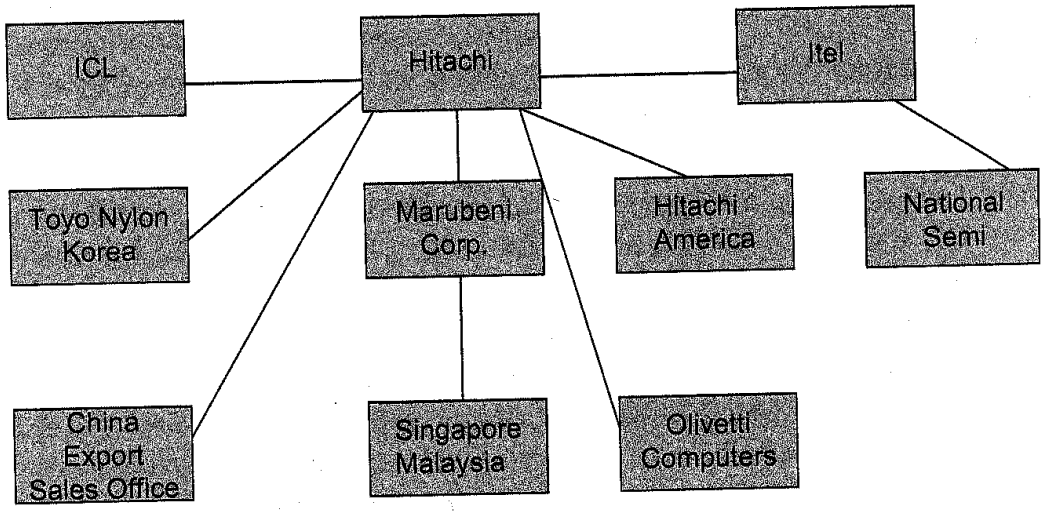

Figure 7.2
Hitachi overseas relationships, 1979
Source: "JCM & IPS Status in Japan & U.S.," RG 5, Box 46, folder3/4 IBM Corporate Archives, Somers, N.Y.

regardless of MITI's attempts to slow imports, they occurred and grew through the period. Fourth, MITI's efforts, and those of indigenous companies, to export were enormously successful, particularly in the 1980s and then in sustaining high volumes through good and bad economic times during the 1990s.[75] Anchordoguy concluded, however, that both imports and exports

could have been better had the local industry been more effective, particularly in its software business.[76] Nonetheless, the data documents an expanding adoption of IT in Japan and a strong export business over the course of some 35 years. Finally, table 7.6 documents the growth in the presence of locally made computers over the early "catch up" time, indicating both the growing strength of Japanese vendors and results of MITI's strategies. Besides a steady march toward reducing the rate of foreign participation, which happened relatively quickly (although never shut off), keep in mind that the overall market kept growing, as documented later in this chapter. So, the actual number of domestic and foreign systems increased during the last three decades of the century.

As to specifics underlying the data, Fujitsu, NEC, and Hitachi developed complete lines of computer products from mainframes to personal computers in the 1970s, the latter product line introduced in the early 1980s.[77]

Table 7.5 JAPANESE COMPUTER TRADE, 1975–2000, SELECT YEARS (¥ MILLIONS)

Year	Imports	Exports
1975	50,000	5,000
1980	75,000	20,000
1985	105,000	220,000
1990	210,000	390,000
1995	600,000	310,000
2000	780,000	590,000

Source: Data consolidated from Marie Anchordoguy, *Reprogramming Japan: The High Tech Crisis under Communitarian Capitalism* (Ithaca, N.Y.: Cornell University Press, 2005): 144–146.

Table 7.6 DOMESTIC AND FOREIGN COMPUTER INDUSTRY MARKET SHARES IN JAPAN, 1958–1982, SELECT YEARS (EXPRESSED AS PERCENTS = 100%/YEAR)

Year	Domestic	Foreign
1958	6.9	93.1
1959	21.5	78.5
1962	33.2	66.8
1967	47.2	52.8
1972	53.2	46.8
1977	66.4	33.6
1982	74.0	26.0

Source: Marie Anchordoguym *Computers Inc.: Japan's Challenge to IBM* (Cambridge, Mass.: Harvard Council on East Asian Studies, 1989): 168–171.

Vendors and customers still had to adhere to IBM's standards, relying on IBM's software (operating systems) and derivative programs (such as programming language compilers and applications written to order using these tools). Mitsubishi Electric and Oki Electric became technologically weaker vendors in this schema, which MITI's officials concluded needed to play lesser roles. MITI assigned them the mission to build mid-sized IBM-compatible computer systems, rather than the largest ones, with the former focused on mainframes, the latter on peripheral equipment for these systems. After 1978, OKI narrowed further its focus to the manufacture and sale of banking automated teller machines (ATMs).

Non-Japanese observers of the local computer industry agree overwhelmingly that MITI and the government played an extensive role in protecting and funding development of an export-oriented computer industry in Japan. Japanese commentators sidestepped the issue.[78] Circumstances changed over time as MITI's power surged in the 1960s and 1970s, then began waning in the 1980s. The West's perspectives in the 1980s and early 1990s remained rooted, however, in perceptions about MITI and Japan set in earlier decades.[79] By the early 2000s, even Japanese commentators were criticizing some of MITI's earlier efforts, suggesting that it had compromised Japan's ability to transform and compete as technologies and global trade evolved.[80] Business historian Alfred D. Chandler, Jr. suggested that the key Japanese firms benefitted from over seven decades of experience in electronics, including their ability to manufacture transistors and later semiconductors, minimizing more than others MITI's influence.[81] Yet others, with a variation of his observation, pointed to the Japanese telecommunications expertise, combined with their strategy of developing various types of products within the same firm, such as mainframes, peripheral equipment, semiconductors, and digital telecommunications switching devices.[82] Anchordoguy argued that the broader strategy of an ecosystem of customers, suppliers, MITI and other government agencies, in combination optimized cooperation, leveraged competition at functional levels, and worked within the framework of communitarian capitalism to emerge successfully.[83]

The evidence suggests all of these views were correct to one degree or another and so debates about emphasizing one mitigating influence or another is less important for our purposes than recognizing that each affected the nature and rate of diffusion of IT in both Japan and around the world. MITI's protectionism and funding of R&D took cost and risk out of the process of innovation, giving the industry time to flower. Clearly, learning and expertise about electronics proved crucial to the effort. Funding/ownership mechanisms of the banks and the *keiretsu*-oriented market also helped. An aggressive export orientation expanded the market to a size that made it possible for Japanese firms to achieve economies of scale necessary to compete locally and abroad against larger American suppliers. Below we discuss MITI's role in

encouraging local users to adopt Japanese computing, a story which helps fill in the picture of the local digital eco-system.

Before turning to adoptions, there were four components of the Japanese supply side of the story that need various degrees of attention—semiconductors, PCs, software, and robotics—all of which demonstrated the contours and limits to success in the world of Japanese computing. Combined they contributed to the digitization of large swaths of Japan's economy and exports. Semiconductors became the central concern around the world regarding Japan's export strategies, PCs a late Wave One event, software the major gating factor after hardware affecting adoptions, and robotics, which promised to be a core competency of the Japanese economy in Wave Two computing.

ROLE OF JAPANESE SEMICONDUCTORS IN JAPAN

Many scholars and journalists have looked at the global semiconductor industry's spread and, in particular, the role of Japanese semiconductors. That export success on the part of Japanese electronics companies, beginning in the 1960s and extending nearly to the end of the century created enormous alarm in the United States and in Western Europe because governments and local vendors believed that losing domestic capabilities to produce and sell semiconductors posed threats to national military security (a U.S. Cold War concern), loss of potential trade, and ability to nurture indigenous computer industries (West European perspective). Such a turn of events represented the loss of initiative in building an Information Society (a shared pan-Atlantic perspective), with the height of concern occurring in the late 1970s and 1980s.[84] The Japanese proved most successful in dominating world trade in this class of digital technologies over all other types, such as computers or peripheral equipment. While the subject is interesting, we need not retell that story here. The issue to address here is how diffusion of semiconductors supported the broader spread of computers. To begin with, one cannot build a computer without ICs, nor can one manufacture almost any major industrial machine or vehicle without this technology—it had become nearly ubiquitous by the mid-1980s with Japan supplying a large quantity of the world's needs for such technologies.

Able to copy, cross-license, and manufacture various types at highly competitive costs, Japanese suppliers clearly facilitated diffusion of ever-less expensive machinery and IT around the world in the 1970s and 1980s through its success in selling various semiconductor products. To be sure, the Japanese lost ground in this trade by the late 1980s to other Asian rivals. As with computers, in semiconductors Japan's manufacturers pursued similar strategies with predictable results: all chasing better, faster, cheaper, similar products and marketing results, including similar niches for memory chips, logic chips,

and microprocessors, products which over time evolved faster than Japanese vendors could keep up with. That technological evolutionary cycle led to extending marginalization of Japanese suppliers in the 1990s and subsequent decline in their global shares in sales. Along the way similar events occurred with computers, replete with American and European accusations of Japan of dumping (1970s–1980s), concerns of pan-Atlantic firms that specialized in the development and sale of semiconductors (for instance in the United States, Intel and Texas Instruments), and international agreements to address these issues (1980s and 1990s).[85] By 1988, Japanese suppliers had hit their high water mark in exports of semiconductors (51.2 percent) then declined steadily to 28.1 percent of global market share in 2001.[86]

From a statistical perspective one can see why concern existed about Japan. Between 1970 and 1974, 95 percent of all 1Kb dram (dynamic random access memory, most widely used in PCs and terminals) chips were produced by the pan-Atlantic community, Japan only 5 percent. The next generation of 4Kb drams (1974–78) demonstrated a shift with 85 percent made by Americans and Europeans, while the Japanese now provided 15 percent. For 16Kb ICs (1978–81) the Japanese produced 40 percent of the total and in the early 1980s—when the storm over exports peaked—64Kb product shipments indicated that Japan now owned 70 percent of the market, the Pan-Europeans 30 percent. By any measure that was an impressive growth performance for Japan, made even more impressive with every passing generation of ICs which were more complicated to manufacture.[87] Meanwhile, other nations had gotten into the game, most notably South Korea with its drams, which cost less for it to make and sell than Japan, contributing to the further decline of Japanese success.

Before leaving the supply side of this story, it should be noted that the same level of concentration that existed with computer vendors did too in semiconductors. Depending on which specific semiconductors (or ICs) one measured, roughly six companies dominated between 66 and 70 percent of production in the 1970s and 1980s: Fujitsu, Hitachi, Matsushita, Mitsubishi, NEC, and Toshiba. The same vendors dominated manufacturing of computers at similar percentages (60–75 percent depending on what kind of computers one looks at). A similar story can be told about advanced manufacturing for such devices as computerized machine-tools (80 percent by a handful of firms) and by the mid-1980s, industrial robots (74 percent).[88]

Use at home was impressive—a circumstance often overlooked by students of semiconductor diffusion. Electronics firms early on understood the importance of semiconductors, certainly by the 1940s, and when transistors (later ICs) appeared in the United States, they negotiated patent usage rights and were able to create their own versions all through the second half of the twentieth century. As demand for chips increased in the 1970s and 1980s, both the number of Japanese workers familiar with the technology and manufacturing

capabilities expanded, thereby further diffusing use of IT in both that industry and subsequently into other devices, such as various consumer and industrial products. As with computers, however, the Japanese lagged the Americans in the 1950s and 1960s as they relied on the latter to set the pace of innovation. Nonetheless, by 1966, Japanese firms were producing nearly 300,000 integrated circuits.[89] By the late 1960s, manufacture of ICs took off in a substantial manner, stimulated by local then global demand for these to embed into electronic calculators and in larger IT devices, such as peripheral IT equipment and computers. Production of discrete IC devices jumped from 177,647 in 1970 to over 420,000 in 1983, at a 6.9 percent annual growth rate.[90]

Domestic consumption in this take-off period demonstrates that a healthy appetite existed in Japan for such items. In 1970, nearly 70 percent of all production went to local customers. One could argue that this was because the quality was insufficient to compete on the global market and thus had to be sold within the sheltered one, but the argument can also be made that exporting capability for such products was just being developed too. Regardless of explanation, local consumption increased all through the 1970s. Japanese customers also imported chips from other countries—an action often overlooked in complaints about Japan's "dumping" activities. By 1983, the internal Japanese market was consuming a total of about 125 percent of the volume of chips manufactured at home; in other words, local demand grew faster than domestic vendors could meet. Imports outpaced consumption of locally made devices until the second half of the 1970s when local productive capacity and quality began catching up with domestic demand, a need Japanese semiconductor manufacturers were able to serve in the late 1980s.[91]

Where did domestically consumed ICs and other semiconductors go in the 1970s and 1980s? The question is important as it sheds some light on the diffusion of IT in Japan. By the start of the 1980s, 58 percent were going into consumer electronics, such as video tape recorders, audio equipment, calculators, watches, and television sets. The other 42 percent were deployed in industrial products: computers (16 percent), telecommunications (10 percent), office equipment (4 percent), automobiles (2 percent), and 10 percent into various devices, such as manufacturing tools.[92] That diffusion meant individuals and firms in other product lines were becoming more reliant on IT with which to do their work and in their products. Local demand reflected unique differences among various markets. For example, using 1982, by which time Japanese IT use was in full swing, 51 percent of all demand for ICs in Japan came from consumer electronics, while for that same category U.S. demand was for 11 percent of its own consumption, and in Western Europe 25 percent of its own needs. In the United States, demand for these was most for computers (40 percent vs. 22 percent in Japan and 25 percent in Western Europe). Both the United States and Western Europe allocated about 20 percent of their supplies of semiconductors to telecommunications. Industrial

equipment reflected Western Europe's large appetite, particularly in West Germany: 11 percent in the United States, 25 percent in Europe, and at the time 17 percent in Japan. We see the Cold War's effects on U.S. demand that year, which amounted to 17 percent of all American needs for ICs, as compared to 5 percent in Western Europe, and in Japan, zero demand since it was not a major player in Cold War military affairs.[93]

By tracing where semiconductors and other types of integrated circuits went into Japan, we can observe diffusion of digital technologies across specific industries and sectors of the Japanese economy. This diffusion was slow in the 1960s, picked up speed in the 1970s comparable to rates of consumption in Western Europe, and in the 1980s proved extensive, particularly by manufacturers of consumer electronics, industrial equipment used in other Japanese manufacturing industries, and, of course, by suppliers of computers to each other and to members of their respective *keiretsu* ecosystem.

JAPANESE PERSONAL COMPUTERS

Of all the modern economies, that is to say those which were the earliest adopters of computing, Japan was one of the latest to use widely personal computers. Even three decades after development of this class of computing, it had not diffused as extensively as in so many other countries, including in other Asian countries. A brief recounting of Japan's experience suggests that local circumstances do affect deployment of technologies, in this instance, computing. PCs are important components of late Wave One computing and so we need to understand its role in Japan. Japanese computer vendors acknowledged early the arrival of PCs. By the late 1970s NEC, Fujitsu, and Toshiba were manufacturing these; in fact, NEC claimed 5 percent of the U.S. market as early as 1980, before IBM even had a product. NEC brought out its first Japanese language IBM-clone PC in 1982, the first such product introduced in Japan (PC9800), aimed at the business market. It quickly dominated 80 percent of Japan's tiny market, although NEC had been selling kits people could put together since 1973.[94] Hitachi had introduced such a product in 1978, Sharp in 1979. NEC did well by creating retail distribution channels, rather than just selling to business customers. By 1994, approximately 70 percent of its PC sales went to individuals through 900 branches of Micom Shop and over 7,000 other retail outlets. NEC recognized early that sales would occur if software application packages existed in Japanese, so it created and commissioned such products sooner than its rivals. In 1986, NEC had acquired, written, or was selling over 3,400 software packages; two years later some 6,700, and in 1990, nearly 9,600.[95]

Japanese PCs experienced limits that keyboards for online terminals had as early as the 1960s, namely complexity of the Japanese language which had

thousands of characters that obviously could not be accommodated by keyboards. As occurred later in China, which had the same problem with Chinese (progenitor of the Japanese language), a shorter set of characters were introduced for keyboards and online systems in the 1970s and 1980s. In the second decade (1980s), software packages using the language were ported over to PCs, albeit late in that period. When IBM introduced a Japanese language PC at the start of the new decade (1991 with the DOS/V operating system), all vendors quickly began using this software, which also made it possible for non-Japanese companies to introduce products for sale in Japan, such as Microsoft. Fujitsu, and Toshiba quickly licensed IBM's software. Apple appeared with a Japanese version of Macintosh soon after and in 1993 Microsoft came with Windows 3; others followed quickly, including Compaq. Much of the PC story in Japan is one of much activity in the 1990s, with firms scrambling to protect their local market share from the Americans, to provide Japanese language software and hardware, and to export, particularly newer forms, such as laptops (Toshiba beginning in 1994). Fujitsu demonstrated Japan's successful penchant to export after building a domestic base of business, becoming the third largest global producer of PCs by 1996. While there is a chicken-and-the-egg debate about who wrote the necessary facilitative software, the unique features of the Japanese language constrained deployment of online systems in the 1960s–1980s, and, later, PCs. For some early adopters, they had to rely on English-language-based PCs.[96]

SPECIAL ISSUES OF SOFTWARE IN JAPAN

The Japanese PC story hinted of a profoundly important technological issue looming in the background—the role of software. One cannot operate computers without software and that of most manufacturers outside of Japan used English or some European language, relying largely on IBM's technical architectures and centralized style of computing. Equally important, however, is the role software began to play in influencing the rate and nature of IT adoptions in the country. This is not to diminish the story of supply side computing in Japan, which proved essential to understanding acceptance of computing in Japan in the 1950s through the early 1980s, the period in which Japan caught up with the rest of the global computer industry. The types of software relied upon by end users slowed Japan's transformation through Wave One computing, keeping many organizations locked into centralized mainframe-oriented uses of IT longer than their cohorts in most other advanced economies. As a result, I believe the delay may have extended Japan's dependence on Wave One computing for at least one decade, with a few notable exceptions discussed below. At a minimum we must conclude that software in Japan remained a crucial element of that nation's experience with computers not to be sidelined by hardware's immanence in Japan's history of IT.

Data on the smaller extent of adoption of software in Japan and small volumes of exports of local software products out of the country stood in sharp contrast to the enormous success the Japanese experienced with hardware adoptions and exports—there is no disagreement on these points by experts. Much of the debate, instead, focused on the question of explaining why. The complexity of the Japanese language has been cited by some, while other experts pointed to inadequate education in computer science and programming, still others to the fact that the closed world of the banking industry's support for and dominance of a half dozen hardware firms constrained innovation.[97] Clearly, each of these circumstances played a role. Of all the effects on the spread of software through the Japanese economy, the most influential was evidently the construct of the computer industry itself, in other words, the supply side of the story of diffusion. When combined with an education system that encouraged conformity rather than innovation and the practice of vendors promoting closed technical standards, impediments to adoption appeared.

In the 1950s and 1960s, hardware providers included software in the rental prices of their machines, such as operating systems and utilities. They wrote to order application software for customers, all of whom were large and thus justified tailored systems—the practice evident in the West at the same time. Beginning in the 1960s software packages emerged in the West that were more reliable and less expensive to acquire and maintain, so sales took off. Meanwhile in Japan individualized software continued to be written and expensively maintained. Each Japanese hardware vendor effectively nurtured and defended its proprietary systems all through the 1950s–1980s to limit the ability of their customers to move to other suppliers. Locally developed systems were designed for the Japanese market, were unique to their customers, and were written in Japanese (for instance, data on a screen appeared in Japanese). No large market existed for Japanese-specific products overseas. They were limited in Japan by the size of the domestic market. Not until the 1990s did Japanese firms and individuals for their PCs begin extensive acquisitions of packaged software, most of it imported. But, we must return to size, because it is an important issue. In China, where similar problems with language existed, the size of the population guaranteed a market for software larger than that of many other nations, ensuring there existed economies of scale and commercial incentives to service domestic demand.

Japan and its language combined was a far smaller market. In 2000, for example, of the top 20 global software firms, only Hitachi made the list, simply because of its large volume of revenues earned domestically.[98] Yet, all through the 1960s–early 2000s domestic sales of software continued to grow, reflecting expanded use of computing in general across the nation. Even in the challenging economic times of the 1990s, domestic sales went from about $9 billion in 1996 to over $17 billion in 2002.[99] This closed system worked within

Japan. As for imports, in the 1960s and early 1970s, these were barely measurable, took off gradually in the second half of the 1970s when the adoption of computing expanded enormously, then doubled roughly every four years, beginning in 1984 and continuing to the end of the century.[100]

The sheltered, fragmented nature of the market centered around standards and products of a customer's preferred provider (byproduct of *keiretsu* or communitarian practices), which meant that the centralized approach to IBM computing upon which local vendors relied not only translated into dependence on American standards, but also meant the rate of change would be dictated by whatever IBM did with its own operating system (OS)—the foundation upon which mainframe programming rested. This occurred despite efforts by MITI to break this dependence. When IBM announced in 1969 that it would offer software apart from hardware (unbundling), and began sharing technical standards, an explosion of software innovation unleashed all over the Western world. MITI chose not to allow its firms to follow suit, because Japan's largest hardware providers resisted taking the risk of losing their customers in such an open market that inevitably would emerge as it had already in the United States. Coupled to government inaction on unbundling with user loyalty to their suppliers made clear that innovation would be constrained, and competition in software more restricted. Not until the government was forced to open its IT markets more fully in the late 1970s and early 1980s did the situation change slowly, as the import data on software suggests.[101]

MITI, however, understood the problem in its broader context—the need to break IBM's technological standard's hold on Japan that clearly had been locked in with the introduction of the S/360. So, as part of its campaign to fund and promote development of hardware responses to S/360 through its Super High-Performance Computer Project (1966–1971), MITI promoted development of software. Officials used the vehicle of their newly established Japan Software Company (JSC), a joint venture among Fujitsu, NEC, and Hitachi funded by the Industrial Bank of Japan, for the purpose of developing a local OS and common technical standards for software. Because the hardware firms were reportedly losing money with such sales, they were reluctant to converge on standards, desperately seeking ways not to share and collaborate, seeking, rather, to protect their customer sets from migrating either to IBM's very attractive products or to other local rivals. IBM's standards were not displaced with innovative systems. Instead, Japanese vendors chose to improve the efficiency of writing software—the software factories of the 1980s that received so much attention all over the world—which focused on economies of scale, much as in routine (repeatable) manufacturing processes, and less on what really drove software adoptions around the world, namely, better code (continuously innovative, hence changing and dynamic) that did useful things.[102]

MITI's efforts failed; indeed JSC collapsed in 1972. IBM's unbundling made it possible for local vendors to use the American firm's operating system as the platform of choice upon which to situate their proprietary software and tailored customer applications through their closed standards. Since most software came bundled with hardware, a vibrant local software market did not really exist, let alone flourish, in Japan in the late 1970s–early 1980s. MITI tried other measures in addition to the failing JSC, such as establishing the Information Processing Promotion Association (IPA) in 1970 to support small independent software firms, but this too failed due to inadequate funding, insufficient protection of software copyrights, and, of course, resistance of the main hardware providers to open their markets.[103] With little venture capital, inadequate training of programmers, lack of an entrepreneurial spirit in a society that resisted business risk and avoided failures meant that the best and the brightest programmers and systems analysts preferred to work for firms that either sold hardware, or companies that used existing software and standards. This behavior largely preserved the construct of the existing market for IT in Japan long after technological innovations around the world had led to more specialized and diverse providers of IT. Customized software—always very expensive and difficult to upgrade—remained the form of new adoptions of applications in the 1970s and 1980s. It was made affordable because the local economy was booming.

Then in 1982 employees from Hitachi and Mitsubishi were snared in a U.S. Federal Bureau of Investigation (FBI)–IBM sting in the United States trying to steal IBM's design specifications for its operating systems. Hitachi, like so many others reliant on IBM's standards had felt the pressure to acquire quickly access to the company's technical specifications so that it could build products for its customers before they agitated for permission to buy from IBM. To cut to the end of the story, both companies and the Japanese nation were humiliated by the incident. Hitachi and Mitsubishi were compelled to pay IBM for access to its technologies, for prior uses of its software, and fines, all substantial. All other Japanese vendors using IBM's operating system too had to pay to use IBM's software. Fujitsu quickly signed an agreement with IBM for permission to use the latter's software. Hitachi's settlement cost it about $46 million and it now had to pay similar amounts going forward for legal use of these. In the case of Fujitsu between 5 and 10 percent of its annual profits now went to IBM.[104] Regardless of affordability for these firms, which they could sustain, the national humiliation once again called attention to Japan's structural problems with software. R&D projects funded by the government proliferated in the late 1970s through the 1980s to develop local software and technical standards, but these too enjoyed limited successes, because Japanese hardware vendors continued to resist unbundling, hurting customers in the process who might have wanted to step out of *keiretsu* practices. Even development of a local operating system called TRON (Real-Time Operating System

Nucleus) for PCs largely failed in the 1980s (it still exists), because microcomputers standardized quickly on Microsoft and IBM PC technological strictures. Again, the Japanese butted against IBM's influence in the world market.

Increasingly in the 1980s, MITI and local users of IT became concerned about the closed standards defended by local vendors, while around the world technological shifts occurred as markets and users moved rapidly from just using centralized mainframe computing to additionally distributed processing with minicomputers, PCs, and networks. All of these new forms of computing required different software, hardware, programming, and management of IT. Yet, one can criticize Japanese users too for continuing to rely on the increasingly backward computing because they were too reluctant to force their suppliers to change their ways, such as by demanding unbundling of software.[105] Right into the 1990s, Japanese vendors and customers remained stuck in early Wave One computing, which increasingly meant relying on more expensive, inferior digital tools, often software that inhibited transition of customers into new practices required by changing global market dynamics in the 1990s and beyond, such as to distributed processing. This occurred despite a few changes in the 1980s that allowed foreign software firms to enter the local market, albeit with tepid results. Marie Anchordoguy pointed out that a specific consequence for the Japanese was their late realization of the importance of the PC as a tool for organizations, not just individuals.[106]

While changes came in the 1990s that began to mitigate the situation, discussed below, there were two areas of software development that did prosper, and so necessary to discuss briefly: software for industrial machines (such as machine tools and robotics) and game software. These two classes of computing applications diffused so extensively in Japan that one must conclude they served as additional domestic paths of diffusion for IT, although not in the form of computers, rather as devices that contained computing and software. As demand grew in manufacturing to produce smaller lots of products and to change quickly what was produced to meet ever-growing demands for various goods in the 1960s and 1970s, Japanese manufacturers developed new processes, called flexible manufacturing systems (FMS).[107] Additionally, automation held out the real possibility of reducing expensive labor content by as much as 95 percent in some instances, leading to subsequent speculations about the "unmanned factory," an aspiration never achieved. However, numerical control tools and robotics developed rapidly in the 1960s and 1970s, each with software that was stable; that is to say, caused machines to do repeatable tasks and that could be embedded in these with fewer changes than required of software ensconced in PCs, for example. By the early 1980s, just over half of all machine tools installed in Japanese factories were programmable, in other words, numerically controlled. That capability led Japanese manufacturers of N/C tools and industrial robots to have products they could also export, reinforcing further development and deployment of such technologies and, in the

process, fostering further use of IT in manufacturing industries.[108] Over time relatively simple two-dimensional functions of these devices went into automotive, aerospace, semiconductor, and other manufacturing plants around the world, not just in Japan. CAD/CAM applications spread rapidly, beginning in the 1960s and extended to the end of the century to such an extent that such applications became ubiquitous.[109] As with other IT initiatives, government policies fostered export trade in such software-driven technologies, and influenced the nature of software R&D projects in the 1970s and 1980s, reinforcing such notions as "software factories" and "Fifth Generation" computing.[110]

While such developments were extensions of patterns of IT diffusion evident with computers and systems in large enterprises, video software, also called games software, took a different path. Briefly, Japanese vendors entered the global market in the early 1980s in a substantive way.[111] Nintendo introduced an interactive software-based videogame console and game in 1983, building on the firm's prior experience with arcade games. It proved popular in Japan, resulting in domestic sales of some 2.5 million consoles and 15 million cartridges.[112] As in other IT sectors, Nintendo began successfully exporting its products to other countries, making it possible to build up resources and capabilities at home in IT, both in the hardware and software development and manufacturing. A second vendor, Sega, also enjoyed similar success with its products in the 1980s, but Nintendo controlled the world and Japanese markets for video games. By the mid-1990s, Nintendo's standard dominated over 80 percent of the world's supply of games, mimicking IBM's over mainframe standards in the 1960s–1990s. Sony became another major participant in the highly competitive video game business, a market less regulated or influenced by public policies than such earlier sectors as mainframes and semiconductors. Sony has dominated domestic and global markets with its PlayStation products since the mid-1990s. Between 1995 and late 1998 it sold 40 million PlayStations worldwide.[113]

This success stood clearly in sharp contrast to the malaise evident in other segments of the Japanese software industry. Why? Anchordoguy has convincingly argued that "as new players in a new industry, the game makers were relatively insulated from the institutions and practices of communitarian capitalism."[114] Her explanation extends to customers as well, in this case individual Japanese citizens who purchased this software and its related hardware, not a firm tied to a *keiretsu* network or subject to government pressures. Individuals bought products that were priced competitively, offered attractive functions and reliable performance, and were new forms of entertainment. As they became used to such forms of amusement, they demanded more innovative products, happily served up by firms that increased their use and abilities in software development all through the 1990s and beyond. Video games became the first ubiquitous use of IT across large swaths of Japanese society, presaging the arrival of many Wave Two uses of computing, including extensive use of cell phones (which also offered games).

To set the historical record more thoroughly complete one should also acknowledge that the availability of digital hand calculators in the 1970s began the process of introducing the Japanese public to the use of digitally based goods, albeit in a small way; nonetheless, it created an appetite for digital products that would become a hallmark of the Wave Two environment. In 1965, Japanese vendors manufactured some 4,000 units; a decade later production had climbed to 30,000. By 1985, annual volumes had exceeded 65,000 units; thereafter, production took place in many other countries in Asia. However, about two-thirds of Japan's annual production of these products went into its export market, while less than a couple thousand entered the local market each year by the late 1970s.[115]

ROLE OF ROBOTICS IN JAPANESE IT

Japan is an important source of robotics and other closely related innovative products.[116] Its reputation as the source of these rests on the early diffusion of this technology in industrial applications both at home and as export products. In the 1990s it introduced consumer robotic devices as well, such as mechanical pets and humanoids, all cute and friendly looking, attracting enormous amounts of media coverage around the world. Before looking at Japanese robotics, however, recognize that research, manufacture, and diffusion of robotic applications occurred in other countries as well: Germany in the manufacture and use of these devices, in the United States with important research done over the past four decades at the Massachusetts Institute of Technology (MIT), and the manufacture and sales globally by various American vendors, beginning in the early 1960s. However, one can conclude that robotics played an important role in Wave One diffusion of IT in Japan at an impressive speed if we are to gauge diffusion and reliance on this technology by the number of robotic units installed.[117]

The history of robotics in Japan has a long and complex history, which for our purposes, can be briefly summarized. Industrial robots were the first type of modern robotic devices invented, and that happened in the United States at the start of the 1960s. In 1967, the first use of robots in Japan occurred with imported American devices, which in subsequent years went into use in various manufacturing industries. They were also soon manufactured in Japan, beginning in 1968. By 1980, annual production had approached 19,400 units (see table 7.7).[118] By 1980, there were some 70 Japanese manufacturers and, to put that number in perspective, at the same time there were 26 in the United States, 33 in West Germany, and 18 in Great Britain (see table 7.8). Other countries also had a handful of producers, typically less than 10, many only one. Smaller producers included most West European countries and Canada.

Table 7.7 PRODUCTION OF JAPANESE ROBOTS, 1968–1980, SELECT YEARS

1968	200
1970	1,700
1972	1,700
1974	4,200
1976	7,200
1978	10,200
1980	19,400

Source: Kuni Sadamoto (ed.), *Robots in the Japanese Economy: Facts About Robots and Their Significance* (Tokyo: Survey Japan, 1981): 131.

Table 7.8 NUMBER OF ROBOTS INSTALLED IN JAPAN, 1979–1990, SELECT YEARS

1979	9,000
1981	21,000
1983	47,000
1985	93,000
1986	116,000
1990	240,000

Source: Frederik L. Schodt, *Inside the Robot Kingdom: Japan, Mechatronics, and the Coming Robotopia* (Tokyo: Kodansha International, 1990): 115.

The number of local installations of robots grew extensively. Early applications in Japan centered on labor-saving tasks in manufacturing, improving versatility of performing repeated actions (movements) on a production line, for instance, manufacturing semiconductors in collaboration with N/C tools.[119] By the late 1970s users in Japan included electrical machinery manufacturers (accounting for a third of all deployed robots in the country), followed by the automotive industry (slightly less than a third of all installations), then a string of additional industries: plastics molding and processing, general machinery manufacturing, metal working, textiles, chemical, steelmaking, and shipbuilding, amongst others. Most robots manufactured in Japan listed in table 7.8 were installed domestically, being either of insufficient quality to compete on the world market, or because local manufacturers had yet to generate sales overseas.[120]

In the 1980s, diffusion of robots in Japan increased rapidly and extensively. By the end of 1986, there were 116,000 installed in Japan and for comparative purposes, 25,000 in the United States. At the time Japan probably had installed about 60 percent of the world's inventory in its homeland, making

this country the "Robot Kingdom," to use a phrase widely embraced by Japanese media at the time.[121] To be sure, robots in the 1970s and 1980s were fairly low-tech devices, but they increasingly used IT components (such as semiconductors) linked to computers (N/C machines, PCs, and other intelligent machines), largely in manufacturing. Robots became one of the earliest IT-infused devices that widely captured the public's attention in Japan, leading to widely attended "robot fairs," for example, through the 1980s and beyond.[122]

Japan's experience with robots demonstrates the local style of learning and deployment of IT. Rather than simply buy American or European robots the Japanese negotiated licenses to manufacture these machines for which there unfolded rapidly a growing demand, and for a device they later improved upon. Such circumstances accounted largely for why there were so many companies in Japan making these devices. Kawasaki, for example, licensed with firms in Norway (Tralfa) and West Germany (VFW). American companies specialized in robotics while in Japan many were large multiproduct enterprises, just as in such IT goods as semiconductors and computers, including Kawasaki, Yashawa Electric, and Kobe Steel. All could invest capital and personnel in the manufacture and sale of these devices. Their products were expensive, suggesting that had these been less so and functionally richer that perhaps more would have been installed in Japan. They improved in performance and reliability, particularly as electronic components shrank in size and IT memories increased in capacity during the 1970s and 1980s. The rationale for customers to acquire this technology mimicked reasons for installing computers: to lower labor costs, due to increased quality, and to perform more tasks not possible by humans.[123]

Robotics took off in Japan because the country had a well-trained pool of mechanical design engineers and others familiar with electronics working in companies experienced in these fields of knowledge and skilled in the manufacture of electronic devices, such as industrial equipment and consumer appliances. There existed a natural domestic market for these new devices, including automotive and other transport manufacturers, consumer electronics firms, and other enterprises that were sophisticated consumers of technologies. These uses were motivated by growing shortages of skilled workers in the last three decades of the century, not just because they were increasingly expensive. Early market acceptance led to increased innovations that fostered a foreign trade market too. By 1987, over 300 manufacturers of robotic devices operated in Japan, spawning intense competition. In turn that led to more innovations, also to more users of these devices, enhancing technical capabilities of the industry as a whole. Encouragement in the development of robotics in Japan came from local expertise and markets (global too) for Japanese numeric control devices, motors, optical scanners; sensors and, of course, myriad digital technologies. One segment fed off the other in a mutually supportive cycle of innovation, competition, and consumption.[124]

HOW JAPANESE USED COMPUTERS

Who used computers in Japan, and how, demonstrate clearly that the Japanese acted very much like their cohorts in North America and Western Europe at roughly the same time. For example, large organizations became early adopters, used batch punched-card data processing in the 1950s and 1960s, and relied on the same types of systems as did the others. In the 1960s and 1970s they embraced online computing, and concurrently distributed processing, albeit often later than in the pan-Atlantic world. In short, users and applications did not reflect a Japanese exceptionalism; rather, their experience offered additional evidence that there were common patterns of use—hence diffusion—of IT from one region and nation to another for similar reasons, although with degrees of difference. For instance, reducing labor content of work in Japan during the 1950s and early 1960s was less of an issue than in the United States since in the former labor costs were low and paternalistic employment practices discouraged displacing workers far more than in the United States. Yet, both focused on automating human work. By the early 1970s, even this difference between the two communities regarding labor's role in the use of computing was diminishing.[125] The same factors that either propelled or constrained diffusion in Japan included availability and cost of hardware, supply of qualified software programmers and systems operators, and functionality of hardware–software–telecommunications systems (for example, batch versus online computing, centralized and decentralized systems). The one major exception—already discussed—was the Japanese propensity to write their own application software rather than rely on packaged software products, at least until the second half of the 1980s when demand for pre-written code increased, mimicking rapidly patterns of adoption already underway in the pan-Atlantic community.

Users represent as important a group as the suppliers in extending reliance upon information technologies in Japan. IT vendors were, of course, also users of computers for the same reasons as banks, insurance companies, other manufacturers, and government agencies. The role of users—think customers of IT—is quite opaque in the extant literature on Japanese computing, which overwhelmingly focuses on the supply side of the story and foreign trade.[126] However, as everywhere else, without customers there would be no diffusion. The rate at which they could absorb the technology determined the extent and speed of diffusion of IT. Thus, their experience is the flip side complementary to the traditional story told of Japanese supply-side computing. While users await their historians, various industry associations documented some patterns of adoption and activities which suggest who used computers in Japan and how.

Population counts of installed computers, reviewed in more detail later, make it clear that use of this technology outside of experimental cases commenced in the late 1950s, indeed, in 1959 if we rely on extant inventory counts. In that

year the private sector began installing such equipment, including banks, securities firms, electric utility companies, manufacturers of large consumer products (such as refrigerators), and transportation, iron, and steel manufacturers in support of routine work. Some of the largest enterprises in these industries were initial users, but by the late 1960s computers began to appear in ever smaller firms. In addition to the industries already listed, power and gas utilities, local public services, machinery manufacturers, cooperatives, and textile manufacturers also embraced computing. By the mid-1960s they used computers at service bureaus or their own installed systems. Among mid-sized firms were users in foodstuffs, precision instrument manufacturing, glass, cement, nonferrous metals, construction, mining, paper, and pulp industries. Ranked in extent of use, as measured by the amount of money spent on these systems, by 1968 securities firms had become the most extensive users, followed by power and gas utilities, next insurance, and in fourth place, other financial companies. Government agencies came in fifth, not surprisingly, since they did not have the large military establishment which led to more extensive governmental uses of computing as in the Soviet Union, France, Great Britain, and the United States. Behind government were users in electrical appliance, machinery, iron, and steel.[127] In short, Japanese adoption reflected a similar pattern of participants evident in other industrialized countries.

Extensive users of data were early adopters of computers, such as the Meteorological Agency, Japan Telephone and Telegram Corporation, and Japan National Railway—all of which began using these in the late 1950s. Surveys of IT adopters in the late 1950s and 1960s reported that early applications of IT involved processing routine office transactions, although, as one Japanese report at the time noted, at a level of utilization "lower than that of the U.S."[128] By the mid-1960s, newly installed systems tended increasingly to be online versions rather than batch processing, while optical and magnetic scanning surged ahead in the financial, electrical power, and gas industries, partially as a workaround for the complex Japanese language. A detailed national survey was conducted in September, 1968. It evidenced that over 74 percent of firms used computers largely to perform clerical computations, which concluded "indicates that they are intending to overcome the increased burden of office work by mechanization," but also that overall the extent of deployment across the entire economy remained low.[129] Clerical computation took place most extensively in personnel and labor management, sales, finance, accounting, and inventory control. Other areas included production, R&D, and engineering. When computers were being used for more advanced applications, such as analysis, planning, and forecasting—areas of far less deployment (the remaining 25 percent)—sales ranked the highest, followed in descending order by R&D and engineering, production, planning research, and inventory management.[130] The same study concluded that "only a small number of companies have reached the stage where computers are used for judgment work or management decision-making."[131]

Migration from batch to online systems occurred in the largest firms, particularly those with most geographically dispersed workforces. It was, thus, no surprise that the Nippon Telegraph & Telephone Public Corporation (better known as NTT and in Japanese Nippon Denshin Denwa Kosha) would be an early pioneer in the use of such systems, a case watched by many other Japanese organizations. By the end of the 1960s it had 70 online systems, leveraging its internal telecommunications skills and infrastructure, making it possible for NTT to apply its existing knowledge to rely rapidly on I, C, and T. One of the largest and earliest online services was offered by NTT to banks, linking 62 banks to their respective branch offices, creating a new source of revenue for itself. In turn, that success stimulated development of new online systems at NTT in the late 1960s and early 1970s in mathematical programming, process control, office management systems, and in IT operations in general.[132]

Because many companies were reluctant to invest capital or to long-term rental agreements in the expensive technology with their initial applications, did not have the skills to manage such new tools, or wanted to experiment before making extensive financial commitments, many turned to time-sharing options. An undetermined number of enterprises opted for this approach in the 1960s, finding universities had the most extensive facilities they could access, such as at Osaka University with its NEC 2200-500 system and at Tokyo University which had installed an HITAC 5020 system. Each was equipped with MULTICS and MIT's Project MAC, both American-built software systems. Unlike in the United States, where access to computing systems was typically online using CRTs, in Japan most users of online processing relied on teletype printer/terminals which could print Katakana (Japanese script) characters. For more data-intensive or high-volume transactions, even large enterprises had to pool resources to afford computing, encouraging their reliance on systems at universities. NTT was the only firm in the 1960s outside of government able to mount its own large computing initiatives.[133]

There is broad consensus across dozens of studies of Japanese computing that an important agent facilitating diffusion of computing was the work of the Japan Electronic Computer Company, better known as JECC. Established in August, 1961, with a capitalization of $3 million raised equally from each of the Japanese computer companies, it was essentially a hardware leasing firm. Since no single vendor could afford to bear the burden of R&D for new systems, MITI wanted them to collaborate, yet compete. One way to do that was to buy a computer and associated peripheral equipment from a vendor once a customer had committed to acquiring these it then lease back the system to the customer and pay the vendor up front for the cost of the equipment. This immediately moved cash back to the IT manufacturer, obviating the need for the vendor to recoup the cost of the system over the life of a lease. It could use the money sooner to build others or to invest in R&D. That process reduced risks of declining values of equipment as new generations of

less expensive systems appeared. JECC's strategy proved to be a stunning success. In the 1960s alone, vendors' sales to JECC went from $3 million (1961) to $230 million (1969). As one commentator reflected on its success, he noted that JECC was "more than a computer leasing company to the Japanese," it represented "a spirit of cooperation, a spirit of solidarity which links all Japanese companies into an invisible union against outside encroachments."[134]

More to the point, the government funneled, or facilitated, loans and subsidies for JECC to lubricate the process of inventing, manufacturing, selling, and buying computers by making funds available at each stage of diffusion while tamping down financial risks for vendors and customers. If a customer returned a machine to JECC, the agency sold the machine back to the original manufacturer at a discounted rate of depreciation, thereby taking a considerable amount of financial risk off the vendors while making it possible for users to change systems from time-to-time. JECC could affect the rate of diffusion by its terms and conditions for leases as well. Its successful and extensive influence on the ebb and flow of supply and demand served as a generous conduit of funds, indeed some $2 billion by 1981, largely generated with low-interest loans backed by the national government. Its influence can be quickly measured by the fact that it funded the majority of installed systems: 65 percent of all domestically installed ones in the 1960s, 30 percent of those in the 1970s, and over 10 percent in the 1980s.[135]

But, just as important, JECC in Wave One facilitated preservation of an orderly competitive environment "by managing a price cartel."[136] Its dominance and positive influence supporting diffusion declined after the catch-up phase with the West had been achieved by the mid-1980s when different economic dynamics made its services less necessary to both vendors and customers. By then, funding came from many sources, unlike in the beginning when banks, for example, proved reluctant to invest in the new technology and customers were too wary to buy the systems outright, let alone acquire funding for leases. In short, JECC was a successful catalyst in getting the Japanese to start adopting computers.

Financing was only one important part of the diffusion story. As salaries rose in the 1960s and early 1970s, largely due to shortages of qualified labor for various jobs, not just in IT, automating manual functions increased. Evidence from the growth in IT populations suggests the growing diffusion across multiple industries. Between 1967 and 1973, for example, the number of card-punching service bureaus increase threefold, part-time IT service providers fourfold, software development firms threefold, and business data processing service bureaus also threefold.[137] IT staffs were widely diffused across many industries by 1973. One survey suggested that 143,217 IT professionals had diffused across a sample of 3,867 companies and government agencies, working with 6,770 computers.[138] In this particular study, 17.1 percent of all users were banks, surpassing electric and electronic equipment manufacturers

themselves (12.8 percent of total), which included computer vendors. Wholesale, retail, and other commercial establishments accounted for 9.6 percent of the group; government agencies 6.7 percent, and data-processing service bureaus also 6.7 percent.[139] NTT still laid claim to the largest network of online systems in the country. Yet online telecommunications systems had appeared as early as 1964, used by various companies, most notably and earliest the Japan National Railway and Japan Airlines, both firms for managing reservation systems. By law, NTT dominated provision of networks until 1971, when other telecommunications competitors were allowed to offer networking services to meet growing demand. Table 7.9 documents the extent of adoption of online systems using telecommunications by all manner of industries, firms, and agencies.

Industries that relied on computers proliferated at a large rate in the late 1960s, setting the base for extended use of IT for ever-increasing numbers of applications by firms all through the 1970s. That pattern can be quickly illustrated with table 7.10. Of 35 categories of industries tracked by the Japanese government at the time, seven had no systems installed in 1965; in 1970 only one did not (foresting/hunting). The table lists the top 10 users in 1965 and their number of systems installed that year and also in 1970. The total for all systems was 1,683 in 1965 and 7,933 in 1970, a goodly increase, which does not account for the users in addition to those who relied on service bureaus to do much of their mundane data processing. User organizations reported use of IT across a broad spectrum of applications: "personnel and labor" (22 percent), "sales" (18.9 percent), "accounting and finance" (17.6 percent), "stock control" (inventory) (15.7 percent). Nearly 70 percent characterized their applications as clerical, while additionally 31 percent also for forecasting and planning.[140]

By the start of the 1970s, evidence of the benefits of using IT began circulating among organizations. Table 7.11 summarizes their observations as of 1971. These data track reasonably well with American and West European experiences with the exceptions of reduced inventory costs and reduction of clerical costs, which U.S. firms routinely ranked as highly significant benefits of automation in the 1950s and 1960s. Unquantifiable indirect effects (benefits) reported at the time included the following responses: "easier to grasp business situation" (number one), "improved company image" (ranked second),

Table 7.9 JAPANESE TELECOMMUNICATIONS SYSTEMS, 1965–1973

1965	6	1970	139
1966	12	1971	213
1967	22	1972	330
1968	40	1973	490
1969	84		

Source: Japan Electronic Computer Co., Ltd., *Progress of Computer Industry in Japan* (Tokyo: Japan Electronic Computer Co., Ltd., undated [circa 1974]): 29, CBI 32, Box 631, folder 22, Charles Babbage Institute, University of Minnesota, Minneapolis.

Table 7.10 SAMPLE INDUSTRIES USING COMPUTERS, 1965 AND 1970 (NUMBERS OF INSTALLED SYSTEMS BY INDUSTRY)

Industry	1965	1970
Electrical machinery	168	718
Chemical & petroleum	134	436
Transportation machinery	110	356
Finance	109	620
Universities	99	285
Textile	88	173
Service bureaus	85	614
Iron & steel	82	299
Insurance	74	130
Government (national)	71	202

Source: Japan Computer Usage Development Institute, *Computer White Paper* (Tokyo: Japan Computer Usage Development Institute, 1971): 46–47, CBI 32, Box 551, folder 2, Charles Babbage Institute, University of Minnesota, Minneapolis.

and "better information flow in firm" (third), with "greater accuracy and speed in judgment and decision making" a close fourth.[141]

Because government users in the pan-Atlantic community were early users of computing, what can we say in comparison about the Japanese experience? As in other industrialized nations, public officials used computers, and did not simply promote their use through MITI and other administrative mechanisms. Some of the earliest evidence dates to the start of the 1970s, and can be reasonably relied upon to reflect activities of the 1960s, since it took years to build up an inventory of systems and applications. Use of computing by large national agencies, cities, and prefectures (local governments) proved extensive. In 1960, the city of Osaka became the first municipality to start using a computer, followed soon after by Nishinomiya, Sapporo, and other large urban centers. In 1962, Kanagawa Prefecture became the first local government to do the same, followed by Tokyo Metropolis, Osaka Prefecture, Aichi Prefecture and others, spilling over into towns and villages by the early 1970s. To be precise, as of early 1973, a total of 1,874 local governments used computers in support of administrative functions, including 38 out of 47 prefectures, although all prefectures relied on computing, some through service bureaus. In short, the evidence indicates that just over half of all local governments appropriated one form of computing or another by early 1973. Because of their use, people all over Japan became familiar with the technology. At the time over 4,500 IT government workers served in such work as agents of diffusion. Prefectures represented the fullest adopters of computing which one report of the time "attributed to the fact that small-scale computer systems" were "so inexpensive and easy to purchase."[142]

Table 7.11 MEASUREABLE BENEFITS/EFFECTS OF COMPUTER USE REPORTED BY JAPANESE ORGANIZATIONS, 1969–1970 (RANKED BY NUMBER OF FIRMS REPORTING THE BENEFIT AND PERCENT)

Benefits/Effects	Percent Reporting Experiencing this Effect
Accuracy and speed in processing	34.4 (740 firms)
Reduction in personnel expenses	24.0 (123 firms)
Better customer service	12.0 (257 firms)
Simplification of file management	7.5 (162 firms)
Reduction in inventory	6.1 (132 firms)
Reduction in non-personnel expenses	5.7 (123 firms)
Reduction in delivery period	4.7 (101 firms)
Efficient use of funds	3.9 (83 firms)

Source: Japan Computer Usage Development Institute, *Computer White Paper* (Tokyo: Japan Computer Usage Development Institute, 1971): 57, CBI 32, Box 551, folder 2, Charles Babbage Institute, University of Minnesota, Minneapolis.

In addition to administrative computing, local governments also used small systems for monitoring environmental pollution, in support of medical facilities, and to conduct scientific tests and research, applications not normally in evidence across the pan-Atlantic community at the local level.[143] Less understood, however, is the extent to which local and state governments were in the grip of the *keiretsu*-communitarian ecosystem so evident with respect to the national government, across the private sector with large firms, and smaller ones operating in the shadow of their major customers.

As extensive as early adoptions were, particularly in the 1960s, a similar concern existed in Japan as in the United States across all industries about the lack of an adequate supply of qualified IT professionals, particularly programmers. This was an important, indeed acute, issue for Japanese users since they preferred software systems designed for their own organizations. A group of American visitors to Japanese facilities in 1973 called attention to the lack of sufficient programmers as a reason why even more systems were not deployed. Indeed, "the greatest shortage seems to be in the supply of application programmers," with the brightest choosing to work elsewhere.[144] Systems programmers too—those who wrote operating systems for computers—for instance, were largely employed in the more attractive career of working in large enterprises such as Hitachi and Fujitsu. Yet, the dearth of programmers did not hold back increased reliance on computing in the 1970s as members of the various industries cited in the last several tables continued to add applications, many of them online. Some systems were now national in scope, each deploying thousands of terminals. These included applications for banking, motor vehicle registration, seat reservations for railroads, and even horse race betting systems deployed by the Japan Racing Association.[145]

By the late 1970s both computer vendors and their customers had built up programming staffs across dozens of industries, making it possible to write and implement IT systems across the economy. The market for packaged software, however, remained small because, as one observer at the time noted, "Japanese users are not yet aware of the value of software, therefore they are not willing to pay separately for software."[146] But, the braking forces on software's diffusion were complicated by causes that made it appear less valuable than the hardware itself. A contemporary explanation suggests the circumstance faced by users: "As software costs are rising and although many computer users have large dp divisions, they cannot keep pace with the growing demands."[147] Hardware vendors sought to speed up development of systems, hence their interest in such concepts as software factories and structured programming. One survey of programming languages showed Japanese relied almost entirely on American-developed compilers already proven to be relatively productive: Cobol (by 60 percent of users), followed in descending order by Assembler (most widely used in the United States in the 1950s, less so in the 1960s, and only with a few legacy systems in the 1970s), Fortran (largely by engineers and scientists), and just starting, PL/1.[148] MITI's own assessment of IT results of the 1970s noted that manufacturing firms enjoyed the most progress in using computers, which facilitated rapid diffusion of IT to its suppliers and customers. MITI officials believed systems had evolved to such a point that office work could be done as "common use" with computers, while large retailers with multiple branches began using computers (much as their American and British counterparts).[149] MITI attributed IT's diffusion in the 1970s to three circumstances, which historical evidence supports: advances in semiconductors and computers, availability of highly educated and "favorable labor management relations," and "appropriate government measures to promote technological development."[150]

The pattern of applications used, and by whom, did not change substantively in the 1980s. Momentum toward greater reliance on computing for daily work spread from the largest organizations to ever-smaller ones as accessibility increased and costs of computing declined, and joined the rest of the world in managing problems of adoption, as observed across the pan-Atlantic community. For example, in 1987 users were still complaining about the lack of an adequate supply of programmers, now known as "software professionals," leading to more collaborative efforts with other firms, joint development projects and subcontracting programs to overcome the problem. As in the West, the percent of IT budget for software rose while unit (hardware) or expense of a transaction done digitally declined. The fastest growth rates in IT expenditures occurred in banking, securities, and insurance industries.[151] The locked-in, mainframe-centered *keiretsu*-styled patterns of adoption and use of computing continued to characterize Japanese computing all through the 1980s and deep into the 1990s as well.

Besides affecting types of uses and tools used by corporations and government agencies, this enclosed approach to computing extended to the adoption of private networks in the 1980s and 1990s. Use of private networks and software inhibited the adoption of open systems and multiple technical standards during the second half of the 1980s and early 1990s. As one student of the process noted at the time, "in the early 1990s Japan had numerous islands of computer networks that could not communicate with each other."[152] That circumstance slowed adoption of interconnected supply and value chains already being used rapidly by other Asian, American, and European industries, indeed whole economies.

Given the enormous economic problems faced by Japan in the 1990s and the simultaneous spread of personal computing and other types of digital consumer electronics, what did users do in that decade? How did external forces affect their work, such as deteriorating economic conditions? Did they change their style of computing or uses? The biggest technological event of the decade was, of course, the rapid diffusion of the Internet around the World, adding to the mix of questions and issues. Worldwide, Japanese competitiveness in IT declined as vendors in the United States and elsewhere introduced new Open Systems products, others for use with the Internet, and customers embraced these. Japan was not immune from the process, just slower to respond. By the end of 1993, the adoption of open architectures in PCs had helped to lower the costs of this technology, stimulating acquisitions by both organizations and individuals. Simultaneously, adoption of more open computer networks picked up, increasingly reliant on the Internet, largely starting in 1995 (see table 7.12). This tripling of adoption meant Japan's global share of Internet hosts expanded from 2.9 percent to 3.8 percent in that critical period of takeoff.[153] Table 7.13 documents applications of both private and Internet-based networks by organizations, supplying evidence that the evolution in usage mimicked global patterns. Use of networks expanded across almost all industries, with participation ranging from 45/50 percent to 60/65 percent of firms and agencies.[154]

We are too close to the events of the 1990s to understand with confidence if the lag in adoption of such forms of computing as PCs and the Internet were due to adoption cultures described by Anchordoguy, Fransman, and myself, or to the harsh economic realities faced by the Japanese. But clearly, customers of IT slowed their acquisitions, both at institutional and individual levels. One study on activities in 1995 looking at global adoption rates of PCs documented Japan's rate per 1,000 people, ranking it eleventh in the world (United States first, Australia second, and Canada third). Yet, it also noted that sales had been rising in the previous several years.[155] That slower pattern can be largely explained by the fact that Japan embraced PC-based applications later than other countries and had an expensive telecommunications market making online computing less affordable than in many other countries in the late 1980s and early 1990s. The lag of roughly 2 years in adoption of the Internet in Japan during the first half of the decade reflected those realities. It was not for

Table 7.12 NUMBER OF INTERNET HOSTS IN JAPAN, 1995–1996

November 1995	225,000
May 1996	400,000
November 1996	700,000

Source: JPNIC.

Table 7.13 APPLICATIONS OF JAPANESE NETWORKS, CIRCA MID-1990S

Within Inter-firm Networks
Ordering systems
Reservation systems
Technology information management
Distribution applications
Financial transactions
Across Intra-firm Networks
Production control
Sales and inventory control
Accounting
Human resource management
Customer information management

lack of trying.[156] Internet usage essentially arrived in Japan in 1993, followed by the establishment of hundreds of Internet access providers, most small enterprises, which continued to grow in numbers and revenue during the decade.

There were structural supply side problems with telecommunications, however, that influenced extensively events in Japan and that mimicked many of the behaviors and issues evident in the 1960s–1970s with computing in the country. During the 1980s and 1990s Japan maintained a telecommunications environment that served as a drag on IT adoptions, a situation made obvious by what happened in so many other countries where telecommunications were modernized and reorganized to make access better and more affordable, as in South Korea, North America, and Western Europe. NTT, the prime supplier of telecommunications access in Japan, maintained very high costs, slowing development of ICT infrastructures, including new goods and services, a pattern evident in the United States with AT&T, for example, prior to its breakup in the early 1980s. NTT also embraced technical standards which constrained further use of the Internet in the 1990s. Selecting the wrong technologies, rigidity of management practices, and inadequate efforts by government to restructure the telecommunications industries were all

sources of problems that in hindsight are increasingly becoming obvious.[157] The Japanese only began addressing these problems in the late 1990s, after a few half measures in the 1970s and 1980s failed to have significant positive effects.[158] As one Japanese expert wrote in 2006, not until the end of the prior century had it become "clear to all that Japan's domestic telecom sector was well behind cutting-edge developments in information technology," and that "the government was becoming increasingly aware that the existing regulatory structure and institutional environment hindered firms from using new technologies and pursuing new business strategies." This problem cost "Japanese firms dearly in global markets," particularly in the fast moving growth market for wireless phones accessing the Internet.[159] After changes were made, utilization of the Internet surged, making it more evident that computing and all forms of communications were now moving into what possibly was the dawn of Wave Two IT.[160]

With those telecommunications issues in mind, we can better understand what market data from the first half of the 1990s indicate. It begins to shed light on how users (institutions and individuals) were applying computers by tracking what they purchased. Table 7.14 shows that the percent of expenditures devoted to traditional mainframe computing versus smaller, more distributed (indeed in many instances network dependent computing) grew incrementally. Large enterprises began to use distributed processing by creating networks over which they could fax documents, supported by national packet-switching networks. As early as 1984, a survey of some 1,700 firms determined that a third already used digital networks linked to computers and other companies. Firms could also conduct teleconferences that year for the first time among sites located in Tokyo, Osaka, Kobe, and Nagoya, continuing the diffusion of information about digital possibilities in yet new ways.[161] The trends are obvious and predictable. Users began moving work from mainframes to distributed processing in increasing amounts at the same time as consumers were entering the market for digital products. To be sure, the demand for computing declined as the recession extended, from a high of $42 billion in 1991 to a low of $34 billion in 1994, before increasing incrementally again during the second half of the decade.[162]

Future discussions about who used computers and for what purposes during the 1990s and beyond will have to take into account the role of individual users, as is now the case when discussing the role of IT in North America and elsewhere. Table 7.15 demonstrates that by 1994, consumers were entering the IT world as individuals, a sign that Japan was moving from predominantly Wave One computing into the initial phase of Wave Two. These data suggest cell phones had become ubiquitous within a decade of their availability and that PC ownership had leveled off.[163] By the early 2000s, many functions available before only via a PC were now accessible using cell phones, including banking transactions, e-mail, and games. The evidence also suggests

Table 7.14 PERCENT OF MARKET SHIFTS FOR VARIOUS CLASSES OF JAPANESE COMPUTING, 1991–1996 (EACH YEAR TOTALS 100 PERCENT)

Year	Mainframes	Minis	Office Computers	Workstations	PCs
1991	51.0	3.7	14.8	8.7	21.8
1992	48.1	4.2	13.8	9.2	24.7
1993	45.0	4.0	11.9	10.9	28.2
1994	39.2	3.6	9.9	10.9	36.3
1995	32.9	3.1	9.0	11.0	44.0
1996	29.1	2.9	8.9	11.9	47.2

Source: Data extracted from Norris Parker Smith, "Computing in Japan: From Cocoon to Competition," *Computer* (March 1997): 30.

Table 7.15 OWNERSHIP OF DIGITAL PRODUCTS BY JAPANESE HOUSEHOLDS, SAMPLE YEARS 1995–2004 (PERCENT OF HOUSEHOLDS)

Year	Personal Computers	Cellular Phones
1995	16.3	10.6
1997	28.8	46.0
1999	37.7	64.2
2001	58.0	75.6
2003	78.2	93.9
2004	77.5	91.1

Source: Information and Communications Policy Bureau, Japanese Ministry of Internal Affairs and Communications.

that the relative cost of computing had declined sufficiently to make it affordable to consumers, despite the persistence of economic recession.[164]

While events in the 2000s lie outside the scope of our study, because they represent increasingly Wave Two activities, they cannot be ignored entirely as they built on behavior evident in the 1980s and 1990s. Most specifically there was the Internet, so we must discuss this issue further, describing the arc of its adoption into the 2000s. Table 7.16 shows diffusion of Internet use in Japan. While starting later than in the United States, its growth rates were high in households, enterprises, and other establishments even during difficult economic times.[165] Over 60 percent of households and establishments of all types used the Internet by 2001 in one way or another, ranking Japan second after the United States in raw number of users and, interestingly, followed by China at third with 33.70 million users.[166] By mid-decade (2005) just over 68.5 percent

Table 7.16 INTERNET ADOPTION IN JAPAN, 1997–2010

Year	Number of Users (millions)	Population (percent)	Penetration of Households (percent)
1997	1.55	9.2	6.4
1998	16.94	13.6	11.0
1999	27.06	21.4	19.1
2000	47.08	37.1	34.0
2001	55.93	44.0	60.5
2005	75.05	60.9	n/a
2007	87.54	68.0	n/a
2009	95.98	73.8	n/a
2010	99.14	78.2	n/a

Source: Ministry of Public Management, Home Affairs, Posts and Telecommunications, Japan, *Stirring of the IT-Prevent Society* (Tokyo: General Policy Division, Information and Communications Policy Bureau, Ministry of Public Management, Home Affairs, Posts and Telecommunications, Japan, 2002): 5; "Internet World Stats," http://www.internetworldstats.com/asia/jp/htm (last accessed 7/31/2010).

of the population had access to the Internet, accounting for 87.5 million people.[167] In short, Japan had become a densely ICT-networked society, or, to use the words of two witnesses, "the country is now a sea of video games, computers, instant messaging, and camera phones."[168] While historians will eventually present reasons for extended use of the Internet in Japan, one can point to several pieces evidence: expanded and affordable high-speed broadband, adoption of state-of-the-art mobile phones and other digital consumer products, and declining costs of all technologies, collectively making use of IT relatively more affordable to people than in the 1980s and early 1990s.[169] Finally, we must acknowledge that technological innovations in the Internet's base technologies spurred demand, such as the availability of web browsers by the mid-1990s and the expanding supply of content over the web that has continued to the present, including online games which are so popular in Japan.[170]

PATTERNS IN DIFFUSION OF IT IN JAPAN BY THE NUMBERS,1950S–1990S

The use of information technology in Japan demonstrates a pattern of diffusion similar to those of other industrialized nations: first came the vendors along with government initiatives to support their efforts, next early adoption by the largest firms and agencies, and then as the technologies improved, dropping in cost, and enhanced with software applications, seeped further into society. An educated workforce employed in industries that increasingly used IT themselves became advocates and users of additional computing, first at work, then in their private lives. We have argued

in this book that the most discernable forensic evidence at the scene of the action documenting diffusion is the trail of computer installations, in particular, mainframes, but later such distributed processors as personal computers during Wave One, and in private life cell phones and other digital products in late Wave One and early Wave Two. Japan, like other nations, left a trail of spreading installations of computers across its economy.

The pattern of additions was a familiar one. A handful of systems were built and used in the 1950s, followed by a spike as second generation mainframes came into use in the early 1960s. The big spurt began after third generation hardware became available, driving all the computer population numbers up sharply in the 1960s. The spike extended into the 1970s. By the 1980s tracking populations of installed systems became increasingly difficult since computing had spread to so many formats: mainframes, distributed processors, minicomputers, personal computers, other IT embedded in consumer and industrial equipment, even in automobiles and all other modes of motorized transportation. Table 7.17, however, suggests the rate of diffusion at takeoff of diffusion. Various inventories were kept through the 1950s–1980s with only slightly differing "nose" counts for how many were installed.[171] The great takeoff in installations which began in the mid-1960s can also be seen by the amount of money spent on these. Net domestic consumption of computing cost $359 million in 1967 and increased each year to where it reached $2.21 billion in 1974.[172] These data demonstrated that the nation invested extensively and rapidly in the technology.

Industry observers commented about adoptions in the 1970s and 1980s that confirmed a long term pattern of adoption had remained relatively intact, despite difficulties along the way. This adoption validated comments made by Anchordoguy, Fransman, and others, about the enduring IT ecosystem right into the recessionary period of the 1990s. For example, an Arthur D. Little

Table 7.17 NUMBER OF COMPUTERS INSTALLED IN JAPAN, 1959–1973, SELECT YEARS

1959	50
1961	130
1963	300
1965	581
1967	1004
1969	2057
1971	3787
1973	5025

Source: Various lists prepared by MITI and JECC, including Japan Productivity Center, *Computer Utilization Management in Japan* (Tokyo: Japan Productivity Center, July 1969): 11, CBI 32, Box 471, folder 3; Japan Electronic Computer Co., *Progress of Computer Industry in Japan* (Tokyo: JECC, 1974): 4, CBI 32, Box 631, folder 22, both at Charles Babbage Institute, University of Minnesota, Minneapolis.

commentator wrote in 1978 that the market was being influenced by "the continuing enhancement of technologies and the resulting improved economies," citing recent product announcements by IBM that once again "forced a reaction by the Japanese domestic manufacturers" to lower their prices to domestic customers. The same analyst acknowledged that the uncertain economic conditions faced by Japan in the late 1970s might dampen investments (we now know it did but only momentarily).[173] The Japanese computer market grew to $4.3 billion in revenues in 1981, and expanded to over $6 billion in mid-decade. By the early 1980s, the domestic market had expanded to become the second-largest single national one after that of the United States and just less than half the total size of all Western Europe's; in short, it had expanded rapidly.[174] At the other extreme of mainframes—PCs—by 1989 the Japanese had just over 5 million scattered across their economy, representing an investment of nearly $19.8 million.[175] Put into an international perspective, diffusion of this class of computing remained relatively low when compared to such other nations as the United States, United Kingdom, and Germany, comparable to that of France and South Korea, and ahead of Italy in the 1990s, yet always less than the average for the 27 OECD nations in that decade.[176]

The economic crisis that began in 1989–1990 signaled the start of a slowdown in the diffusion of IT in Japan, but not a profound pause. In the mid-1990s, the economy rebounded slightly, leading to several years of extended IT expenditures in Japan, before deteriorating at the dawn of the new century as happened across the entire pan-Atlantic community as well.[177] The ICT community—industry and its users—however, remained important elements of the Japanese economy in the 1990s. In fact, the ICT industry contributed 7 percent of the nation's GDP in 1990 and grew to 7.3 in 1997.[178] By the end of the decade, some 80 percent of large companies were using the Internet in one fashion or another, 70 percent of all government agencies, but only about a third of small companies. Consumers, as noted earlier, had become very active; in the same year (1997) they frequented nearly 12,500 retail outlets for Internet-related products and services, a 20 percent growth in retail outlets since the partial economic recovery in 1995–96.[179] IT investments and uses picked up again after 2002, driven this time, largely by Wave Two considerations, most notably demand for broadband, a story for a future historian to tell.[180]

ECONOMIC EFFECTS OF IT DIFFUSION

As observable in other nations that relied extensively on the use of IT since at least the 1970s, measurable results suggest extent of diffusion and speed of adoption of computing, contributing further to our understanding of patterns of behavior. Japan proved no exception *in general*; indeed, while particular facts vary from one nation to another, the broad patterns of Japanese

economic effects generated by IT mirror those of the pan-Atlantic community, including, in particular, the United States, with some local variations, such as lower labor productivity than the Americans. As in the pan-Atlantic community, Japan's experience has no similarity to the Comecon experience in Eastern Europe. In subsequent chapters, we compare Japan's experience to those of other Asian economies. The economic data on Japan's use of IT in the 1950s and 1960s is virtually non-existent largely because the role of computing was, to put it bluntly, miniscule, despite the quick ramp up in investments in IT during the 1960s. In large part, this is due to the fact that at a national level it takes 10 to 20 years from the start of such investments before results are large enough to document substantially in economic statistics dealing with such measures as labor productivity and effects on GDP. Although, one can discern and catalog results in exports and the value of national currencies as they occur almost immediately. As we do with other nations, exploring the economic impact of IT offers insights also on the shape of adoption of computing, leaving to economists to debate methods of data collection and various effects—a dialogue underway regarding Japan since the 1990s. The long recession in Japan intensified interest in the economic impact of IT on its economy, and it is from that literature one can draw some lessons for the history of Japanese uses of computing.

Yen investments in ICT—computing and telecommunications—grew steadily from 1970 to 2005, with a noticeable flattening, beginning in the early 1990s, but with some subsequent growth. For the entire period 1970–2005, the annual rate of growth in investment averaged 8.6 percent. Clearly the amount of investments made in the period to the end of the 1980s turned out to be less than the volume of expenditures since 1995, as measured in 2000 constant prices. Put in more precise language, the Japanese invested more in ICT between 1996 and 2005 than in the years from 1970 to the mid-1990s. The amount spent on communications, while rising in the late 1990s was not appreciably significant; the growth came in computer hardware and software. In 2005, ICT expenditures accounted for 18 percent of all investments made by Japan. In that year this class of ICT (computers) accounted for just over half the total investments in ICT, much as in the previous several years.[181] During the mid-1990s investments remained flat, now down over prior years. These picked up quickly during the second half of the 1990s at rates comparable to those in other industrialized economies.[182]

The influence attributable to ICT on economic productivity has been sizeable and the subject of considerable discussion among economists. Its effects were similar to those seen in other Wave One economies, such as those comprising the G-7 countries within OECD. These ranged between 0.1 and 0.4 of 1 percent per year during the 1980s and early 1990s. Japan's investments, hence participation of ICT in its economy, proved lower than that of the United States, but comparable to France, Germany and Italy, caused by less IT

installed and used in the economy than to some other factor.[183] Economist Dale W. Jorgenson, in looking at the same issues concluded that "during the 1980s productivity played a minor role as a source of growth for the G7 countries except Japan," but proved more important for G7 countries after 1995, except for Germany and Italy. Japan's investment in various forms of ICT led it to have some of the highest per capita economic output of most industrialized nations with the exception of the period beginning after the mid-1990s, when its economic malaise was on full display in results gained from use of ICT. Japan lagged while all other G7 nations enjoyed growth in ICT-driven productivity, beginning in 1995. Jorgenson noted that Japan's quality of investments in ICT lagged those of other G7 nations over the entire period with the exception of the 1980s, when it did well. Although its per capita investment in IT went from being the fourth highest of the G7 in 1980—an impressive amount—it dropped to third highest in 2001. It invested substantially in the 1970s and 1980s, making it often the leader in growth rates, but again the process slowed during the recessionary years 1989–1995. Jorgenson's observation about the contribution of capital investments in IT could not be clearer, its "contribution of IT capital comparable to that of the US during the 1980s, followed by a decline in contribution from 1989–1995, reflecting the sharp downturn in Japanese economic growth."[184] Non-IT investments rose in the recessionary years having greater influence on overall performance of the economy.

However, he also observed, as in the United States, that the portion of the economy producing IT products and services generally made a positive contribution economically from 1980 through 2001. But it was not enough:

> For Japan the dramatic upward leap in the impact of IT investment after 1995 was insufficient to overcome downward pressures from deficient growth in aggregate demand. This manifests itself in declining contributions of Non-IT capital and labor inputs.[185]

In other words, as in France, Germany, and Great Britain, IT alone could not stir the national economy into growth and prosperity. As for the other G7 nations, investments in such tangible assets as IT was one of the most important sources of growth for these nations from 1980 to the end of the century. In fact, about two-thirds of Japan's output growth since 1995 to 2003 was a result of IT production (supply side of the economy) from both hardware and software. That data reflected consequences of accumulated and substantial investments made in IT over many years, a rebound that stood in sharp contrast to the decline in output of the first half of the 1990s. In other words, the influence of IT on Japan's economy continued to expand in general over the entire period 1970 to the early 2000s, despite the slowdown in the early 1990s.[186]

In the same period, Japanese observers complained that slow management decision-making and *keiretsu*-style practices were holding back use of IT, most notably "more open, downsized computer network systems." With a clearly 1990s twist, one student of the process described the situation this way: "With the traditional Japanese management philosophies that emphasized rich communications among geographically concentrated, closed groups of individuals and firms, open computer networks are neither necessary nor useful." In the 1980s and beyond even "PCs were irrelevant." "Enclosing customers" remained in force in the 1990s as it had in earlier decades.[187] So leaping to conclusions that Wave Two was unfolding with Wave One now in the past must await stronger evidence since Japan was enmeshed in a transitory period, moving from the pre-recession era to as yet new one in the processing of emerging.

Based on both the evidence presented in this chapter, combined with what economists observed, it appears that changes in diffusion of IT and influence on the economy had led to changes by late 1980s or early 1990s. Furthermore, between the mid-1990s and the early 2000s, investments in IT obviously increased, as in the United States, but, unlike in the United States, labor and total factor productivity (TFP) did not improve in Japan. The closer one approaches the present, the more unclear even that kind of data becomes. For example, for much of the second half of the twentieth century, users of IT were large enterprises, as in other countries. There is now a tiny, yet growing body of evidence suggesting that as IT came in less expensive units that ever smaller enterprises embraced them, as occurred in the United States and in various parts of Western Europe, such as in Italy. Recall that Japan's economy in a way it mimicked Italy's, because it consisted overwhelmingly of small and medium-sized companies, in fact well over 90 percent of all enterprises. Leaving aside definitions of small and medium-sized enterprises, they clearly were not in the same league as NTT, Sony, Hitachi, or Nissan.

The always present issue of exports enters the discussion here and for clarity we have the excellent analysis done by Adam S. Posen who got to the heart of its role and relationship to IT: "the bulk of the Japanese economy, in fact practically the entire economy outside of the export-oriented manufacturing sectors, is beset by very low productivity, extreme inflexibility, and long-term stagnation," except, of course, where government stepped in with economic stimulative programs. Armed with a raft of data, Posen concluded that "there has been a complete lack of diffusion of either technical progress or labor productivity from the high-tech sector to the rest of the Japanese economy in the last forty years."[188] While his last statement may have to be moderated somewhat, as our evidence suggests, he is, nonetheless, correct that when comparing Japanese results to those in so many other countries, it came up shorter on results. Yet to give the Japanese their due, Posen

also concluded that when they changed (improved) products, they did this very well, with a deep bow of respect to the contributions made to those technologies with which they proved so successful in foreign trade. Nearly a decade later, Japanese economists looking at productivity levels of the 1980s and 1990s reached similar, if less harsh, conclusions. IT had not stimulated productivity to the extent it had in other countries, despite the highly evident increased adoption of IT across the economy in the 1990s. In the tactful language so many Japanese scholars used when discussing the problem, they argue, "our results suggest that Japan's comparative advantage in areas such as production technology and management techniques may have been sharply eroded by advances in IT," which became rapidly available all over the world, from PCs and new software to deployment of quality management practices.[189]

But, of course, at the time users did not know to what extent they would affect national productivity and GDP by their individual decisions. They continued to do in the 1990s what they felt appropriate in the best interests of their organizations. In a survey conducted in 1998 with over 5,000 participants across major Japanese industries, researchers observed that firms of all sizes were using IT: 23 percent with 4 or less employees, 58 percent with 5 to 19 employees, 86 percent with 20 to 49 employees, and over 93 percent by firms with more than 50 employees (97 percent those with 100 or more). The same survey reported firms using IT also produced more innovative goods and services than those that did not. Additionally, companies using IT were more profitable than those which did not, suggesting greater flexibility in creating products, services, and business models among users, or at least more creative management in these firms. More precisely, over 30 percent of the users were profitable as against only 15 percent of non-users. The surveyors did not explain why profitability was so low overall, although small firms were more likely to be profitable and users of IT than medium-sized companies.[190]

Japanese economists have documented the increased expenditures and use of IT since the 1990s along two tracks: supply side (that is to say, by IT manufacturing and service vendors) and on the demand side by users of their products. The combination of the two played an important role in improving productivity in Japan in the 2000s. But to be more precise, "the IT-using sector has relatively slow growth in the 2000s, compared to the IT producing sector, because the recent cyclical expansions have been mainly driven not by an increase in domestic demand but by an increase in exports abroad." This brings us back to an issue that has masked the extent of IT diffusion in Japan since the 1960s: the role of foreign trade in driving production of IT products, hence in causing economic statistics to make Japan appear a greater and more productive user of computing than it was.[191] Additionally, resurgence in product innovations and investments in R&D in

this period, often supported by government programs, proved essential to the process.

Japanese economists recognize, as do their American and European counterparts, that while IT producing industries appear quickly in the national statistics, productivity increases as a result of investments in IT by user industries lag by many years, in Japan's case by 10 years or more. Japanese economists, therefore, did not expect to see significant effects in the post-1995 pickup in investments in IT until closer to 2003–2005. The delay in the evidence would become apparent later because about two-thirds of all capital investments made by users of information technologies in all manner of capital went into IT since 2000. As two Japanese economists noted in 2008, "the post-2000 resurgence (in Japan's economy, my comment) in technology has been an IT-centered story, with increases in the rate of technology change for both IT-producing and IT-using sectors."[192] One has to question whether this was good news. Just a few years earlier a thoughtful team of business professors examining events in Japan concluded that investments in IT alone were not enough to improve the nation's economy: "Japanese targeting did not work. Government policy should instead focus on removing constraints to productivity."[193] In other words, the institutional infrastructure described at the start of this chapter continued to put a brake on what otherwise was the implementation of IT in ways evident in other countries.

JAPAN'S IT DIFFUSIONARY ROLE IN ASIA

All through the history of IT's diffusion around the world one encountered Japan. In the pan-Atlantic community it established alliances with local firms to sell its products, beginning in the 1970s. It exported manufactured goods made at home and in other countries to the area. The same occurred in the United States and Canada and, of course, across Asia. Export economics has been a global half century long Japanese strategy for economic development, cutting across many industries, not just IT producing ones. Given its geographic, historic, and cultural ties to Asia, what patterns were evident that we can expect to encounter in subsequent chapters on the region? In a word, they were similar. Exports began with such relatively high-tech items as refrigerators, radios, and television sets, but soon extended to transistors, semiconductors, and other electronic components, and in time to such higher order products as telecommunications and computer machines. However, Asian markets were not as developed in the 1950s and 1960s in a way suitable enough to have customers afford such IT items to the extent in the United States and in Western Europe. As these nearby economies evolved and became more prosperous, Japan's products proved more relevant to them.

Producing in other Asian countries preceded selling IT to these neighbors. As demand for semiconductors, for example, increased worldwide, Japanese electronics firms found labor costs lower in other parts of Asia and so began investing in productive capacities there. The rising value of the yen in the 1970s and 1980s provided additional incentive to move work to less expensive countries. These actions drove down production costs while creating additional capacity to keep up with growing global demand in the 1970s and 1980s. Hitachi made foreign direct investments (FDI) in semiconductors in Malaysia in 1973, NEC in Singapore and Malaysia in 1976, Toshiba in Malaysia in 1975 but in South Korea as early as 1969; a decade later Matsushita did the same in Singapore, and Tokyo Sanyo in South Korea in 1973 and Taiwan the next year.[194] These same companies also invested in semiconductor manufacturing in the pan-Atlantic community, such as NEC in the United States in 1978, Hitachi in West Germany in 1980, Toshiba in the United States in 1980. In the case of Asia, all investments went into nations that were rapidly developing into industrialized economies.

Our narrative should be balanced with an acknowledgment of circumstances that also slowed the process of manufacturing overseas because of how production took place in Japan. Let a student of the process explain:

> The just-in-time delivery system, and their close relations with subcontractors did not lend itself to overseas production. Also, Japanese productivity was based in significant measure on the close working relation between engineering and the constant improvement developed on the line. This depended on attitudes and work habits of Japanese labor and were not easily developed abroad.[195]

The Japanese overcame these impediments, exporting their manufacturing practices, as we saw earlier to the United States, initially through the automotive industry but later to all manner of production practices. By the early 1990s, only about nine percent of Japan's manufacturing capabilities across all industries were located outside the country, so the process described below was slow.[196] That percentage still represented a large volume of transactions, because the overall size of the Japanese economy was so extensive that even a statistically small amount of activity was large within the context of many other Asian economies.

By the late 1970s, buying and selling of ICs in Asia had become important elements of Japan's high-technology import/export business. It's most important Asian trading partners were South Korea, Taiwan, Hong Kong, Philippines, Thailand, Singapore, and Malaysia. Table 7.18 catalogs this trade. Note that where imports were small or nonexistent, Japanese investments were essentially to leverage lower labor costs and often products manufactured in such economies were shipped on to customer in the pan-Atlantic markets.

Table 7.18 TRADE IN INTEGRATED CIRCUITS BETWEEN JAPAN AND ASIA, 1978 (MILLIONS OF U.S. DOLLARS)

	Imports into Japan	Exports out of Japan
South Korea	$20.0	$20.00
Taiwan	0.5	33.00
Hong Kong	0.00	33.00
Philippines	13.0	0.00
Thailand	0.30	0.00
Malaysia	9.00	0.00

In the case of Singapore, trade was funneled to it through South Korea, Philippines, Thailand and Malaysia.
Source: Gene Gregory, *Japanese Electronics Technology: Enterprise and Innovation* (Tokyo: The Japan Times, Inc., 1985): 402–404.

As in the case of the United States, Japanese electronics manufacturers concentrated their Asian manufacturing facilities primarily in Taiwan, South Korea, and Singapore in the 1970s, expanding these as local skilled labor and world demand grew in the 1980s.

Japan did not implement such import/export strategies on its own. In each instance, Asian national governments welcomed Japanese investments and subsequent trade, a key point to keep in mind as one explores the broader question of how computing and other electronics became such a rapidly defining feature of so many Asian economies by the 1990s. These governments had concluded economic development required active leadership of private enterprises and just as the Japanese had borrowed and learned about technologies from the United States in the 1950s–70s, so too they would from Japan, beginning in the 1960s. They liberalized trade, welcomed Japanese and American investors, and learned from them. This strategy worked for them as it had for Japan in propelling diffusion of IT into their economies. In the process IT raised their per capita GDP during the last three decades of the century.

This process was not small. Just between 1960 and the end of 1979, for instance, Japanese companies established 208 wholly-owned or joint ventures in Asia covering many electronic components and products, including IT.[197] An observer of the process in the 1980s described the emerged ecosystem as "an intricately interactive system" of three tiers of countries, Japan, the four most industrializing Asian nations (see table 7.18) and another four developing economies, such as the Philippines and Malaysia. Each complimented the other in the global market: "As comparative advantage shifts within the region, export-oriented manufacturers have no alternative but to rapidly abandon production which is no longer competitive abroad, developing new products and technology suitable to the changing

costs of production."[198] The increasingly expensive economies in turn became consumers of IT products. The system was dynamic and worked fast enough to be globally competitive. Japan sat squarely in the middle of this cycle of activity in the years 1960-late 1980s, bringing in technology, know-how, investments, and in the process created demand for its products and both directly and indirectly, diffusion of IT in the region.[199] This strategy worked well with components for mainframes, but in the 1980s and later even better for PCs because its manufacture and sale optimized manufacturing and sales more globally than mainframes. The latter's manufacture optimized more frequently at the nation level, which is why Japanese production of larger products stayed at home than smaller devices, such as peripherals and PCs.[200] In time the process caused the emergence of local IT companies that could stand on their own, competing against the Japanese and the pan-Atlantic community, beginning in the 1980s and in full flower in the 1990s.[201]

Asian results were impressive. By the mid-1990s, Japan was only one of many computer users of all types in Asia. Relying on the measure of number of installed computers per 1000 residents in 1995 as an indicator of diffusion and use, the United States was at 365 systems per 1,000, Japan 145, Singapore already at 189 and Hong Kong at 171. Countries with larger populations across diverse income levels and industries were also doing well: Taiwan at 98 and South Korea at 78. Growth rates in investments in IT between 1985 and 1995 reaffirm the momentum that had developed: South Korea with growth rates in its investments at 17.8 percent, followed in descending order of investments Hong Kong at 17.1 percent, Singapore at 12.2 percent, and Taiwan at 8.3 percent. Both Japan and the United States actually invested at slower rates, 9.5 and 9.6 percent, respectively, which we can account for by the fact that each had already invested substantially prior to 1985 while the other states were playing catch-up.[202]

Japan stuck to its combined foreign investment/export strategies through the 1990s, despite difficult economic times at home. As late as 1998, worldwide Japan controlled 1,274 manufacturing facilities producing all manner of electronics, with more than two-thirds of these situated in Asia, twenty percent of the global total in China.[203] By 2010, its foreign manufacturing had only climbed to 30 percent of its national capacity across all industries, but its exports around the region were affected by another round of growing strength of the yen in the face of Chinese and other Asian competition now fully capable of taking on the Japanese at their own export game. Yet all Japanese industries had foreign factories that were productive and competent, allowing Japanese firms to continue competing around the world, while their domestic firms declined in productivity and skills, in the words of *The Economist*, "great for Japanese firms but troubling for Japan."[204]

CONCLUSIONS

Japan was the largest and earliest user of information technologies in Asia between the 1950s and the mid-1990s. It was also the most influential source of diffusion of all manner of digital devices across Asia, a role it continued to play into the next century. Just as it was necessary to understand the role of the United States in the diffusion of IT in Western Europe, so too was it essential to appreciate Japan's actions to begin the process of comprehending the role of computing around the Pacific Rim. Since events in the diffusion of IT in both the United States and Western Europe were tied to activities in Japan, and Japan's embrace of computing to diffusionary actions in the United States, additional linkages have to be made to begin building a global-wide view of both the extent and nature of the diffusion of IT. This also had to be done to explain the speed with which this happened. Every nation had a role, but some more important parts to play. If one had to rank in importance the national players, clearly on the short list of a handful of nations, we would have to include Japan. More than the rationale for why I wrote such a long chapter about Japan, this nation's role was, simply put, extensive for over one hundred million Japanese and for over one billion Asians. As argued in this chapter, Japan's way of embracing computing, when combined with its export strategies, became consequential and a model for many Asian countries.

The story told is that Japan relied on a nationally endowed collection of skills and firms in the electronics and telecommunications industries which combined served as the core delivery mechanism for injecting computing into its society. Coordinated, tightly linked public policies to these companies created the economic, political, and disciplined actions that made diffusion possible within the context of Japanese culture and the economic realities it faced across the half century. Regardless of the assessments of various experts about the speed and effectiveness of diffusion, and peculiarities of Japanese business practices or culture, by the 1990s Japan had become an extensive user of computing and influenced measurably by it. A feature distinguishing Japan's experience from that of the United States was the relatively disciplined, indeed effective, collaboration between the private and public sectors, providing protection for the home team but also room for competition. It was the national champion strategy applied effectively, the effort West Europeans failed to deploy as well as the Japanese. The Japanese approach kept Schumpeterian realities at bay, while in the United States government created the environment for success and early investments, then let the market work its will. Eastern Europe's and China's experiences stood in such contrast to that of the West and East that attempting comparisons may not be a useful exercise, particularly since the experiences of one had little influence on those of the others.

Japan stayed in the early phases of Wave One far longer than it should have, wedded to mainframe-styled computing in both what it made and used when the rest of those countries also using IT were moving rapidly into new forms of computing. This resulted in Japan having to play another round of catch-up with the West, beginning in the late 1980s and extending through the 1990s as it embraced distributed processing and the Internet. This constituted a process still underway while this chapter was being written. The evidence presented supports the notion that Japan's *keiretsu*-style communitarianism played a profound role in determining the rate of diffusion into many industries. It reminds us that in every nation diffusion of IT was shaped and influenced by local national culture. I mean that statement in its broadest form: language, education, way of thinking, forms of government, how public administration is done, existing institutions, companies, personalities of individuals, and geographic and demographic realities. Conversely, on a more homogeneous note, the Japanese had access to all the same technical knowledge as any of the most "advanced" economies of the world and again, here the statement is also meant in its broadest form: knowledge about all components of a technology, the underpinning science, manufacturing expertise, entry to distribution channels, legal access to patents and copyrights, and insights on innovation.

Japan's experiences with information technologies were also situated within an economic and business context that it could not choose to opt out of, or to escape if trapped in it, despite heroic efforts to do so. This economic/political context was the environment Schumpeterian rules which described how economies, industries, and firms operated. The economy of any nation, industry, and firm was affected by all the elements of our generalizations made above. All were profoundly influenced by these global activities during the entire second half of the twentieth century. This behavior can be characterized as capitalist-centric, influencing the actions of the pan-Atlantic community, certainly even Communist European countries coupled to political and military vagaries of Cold War. Increasingly in the 1990s and early 2000s, managers and public officials came to realize that many of the behaviors of an increasingly techno-scientifically influenced set of global commercial markets were those described initially by Joseph Schumpeter in the 1930s and 1940s. The Japanese attempted to avoid the churn he described as essential to capitalism's vitality. MITI and other Japanese institutions blunted some of the harshest effects he said were essential, and which manifested themselves in many economies, including those of neighbors in the Pacific Rim. Their blunting efforts proved insufficient to stop the "gales of creative destruction" he is so best known for. This insufficiency cost the Japanese precious time in a moment in history when industries and economies were rapidly becoming linked up to a far greater extent than had been the case since before World War I. Future historians will decide if its being out of phase with the world's economic evolution disadvantaged the nation's welfare. I believe it did.

Our generalization about the role of local cultures in the context of international economic and political actions also applies to a shared ethos about technology. Recall how Japanese electronics firms went to the Americans to learn about technology at AT&T, Bell Labs, and RCA. Those experiences at a personal level influenced the values Japanese engineers applied at home in the development of transistors, semiconductors, computers, and, yes, the humble transistorized radio at Sony. More than the Europeans, who also learned from the Americans, the Japanese more than others embraced viscerally notions of innovation as essential—indeed core—to their success in both product development and manufacture.[205] The subject of the extent of Japan's acceptance or rejection of a managerial and technological value system evident in other countries will remain a subject of debate among historians. But, the message to them cannot be any clearer: Japan was an active participant in the flow of information about the "what," "how," and "why" concerning all aspects of the story of IT's diffusion. It never operated in isolation, and when it attempted to (as in its repeated attempts to cordon off its domestic economy from foreign competitors) it did it overtly. We are too close to many of the events discussed in this chapter; but, it appears that whenever it isolated itself, it paid a high price, repeating a pattern of prior attempts to distance the nation from the World's events in earlier centuries.

Before leaving Japan, one final, brief view of how much this nation invested in IT helps put its IT adoption activities into the context of what so many other nations did. The OECD tracked such investments, providing snapshots as of 1980, 1990, and 2001 across select nations, all of which are discussed in one form or another in this book. In the arcane language of the economists, as a percentage of non-residential gross fixed-capital formation, in 1980 Japan was investing more in IT than most nations, outpaced only by Canada, Netherlands, and the United States at annual rates of about 7–8 percent of total capital expenditures. By 1990, its rate of investments had climbed to a range hovering around 9 percent per annum, outpaced only by Denmark, Australia, Sweden (just slightly), Canada, Great Britain, and the United States, with the United States leading by spending over 20 percent per annum. So, Japan started quickly—reflecting the catch-up phenomenon of the 1970s and early 1980s at work—but manifestly slowed in the second half of the decade with other nations spending higher percentages on IT and in some cases significantly greater proportions, such as firms in the United States. The snapshot for 2001 demonstrates that in the late 1990s like so many other nations, Japan dramatically ramped up its investments (another catch-up at work), with annual expenditures now over 17 percent. The number of countries outinvesting Japan in IT had climbed to nine, although 8 were investing just slightly more than the Japanese, while the United States remained the wide leader over all others with rates approaching 28–30 percent. The major global trend between 1990 and 2001 was that all nations surveyed by OECD had

stepped up their expenditures as a percent of total capital investments, and quite dramatically over rates of the 1980s. In short, "everyone" was deploying IT in ever greater amounts and faster, with Japan more or less in the middle of the pack.[206]

Having situated Japan in the broader story of global diffusion of IT, we have now entered the vast area called Asia, which for our purposes may also and, more precisely, be termed the Pacific Rim. It is to this large area of the world we turn, a region that entered Wave One later than Japan and the pan-Atlantic community, but which seems to have simultaneously journeyed through it even faster than Japan, entered through some doorways into Wave Two piecemeal, and yet clearly not left the first wave behind it. It is to its experience to which we now turn our attention.

213. Srholec, "Global Production Systems and Technological Catching-Up: Thinking Twice About High-Tech Industries in Emerging Countries," 57–78.
214. Ibid., 92.
215. Quoted in Wilson P. Dizard and S. Blake Swensrud, *Gorbachev's Information Revolution: Controlling Glasnot in a New Electronic Era* (Washington, D.C.: Center for Strategic and International Studies, 1987): 80–81.
216. Quoted in Simon Shuster, "Russia Plans a Silicon Valley," *Time*, April 19, 2010, p. Global 2.
217. Loren R. Graham, *What Have We Learned About Science and Technology from the Russian Experience?* (Stanford, Cal.: Stanford University Press, 1998): 36.
218. Ibid.
219. Ibid., 39.
220. OECD, *OECD Information Technology Outlook, 2008* (Paris: OECD, 2008), www.oecd.org/sti/ito (last accessed 4/18/2010).
221. Deniz Eylem Yoruk and Nick von Tunzelmann, "Knowledge Accumulation, Networks and Information and Communication Technologies: Evidence from Traditional Industries in Central and Eastern Europe," in Piech and Radosevic, *The Knowledge-based Economy in Central and Eastern Europe*, 124.
222. Hardy, *Poland's New Capitalism*, 93–94.

CHAPTER 7

1. Shohei Kurita, "Computer Use in Japan," paper presented at 1973 National Computer Conference, New York, N.Y., June 4–8, 1973, Record Group 62, Box 17, folder 16, Charles Babbage Institute, University of Minnesota, Minneapolis.
2. G.C. Allen, *A Short Economic History of Modern Japan* (London: Allen & Unwin, 1981): 187–230; Masataka Kosaka, *A History of Postwar Japan* (Tokyo: Kodansha International, 1972): 200–224.
3. Tom Forester, *Silicon Samurai: How Japan Conquered the World's I.T. Industry* (Cambridge, Mass.: Blackwell, 1993): ix.
4. Ikujiro Nonaka and Hirotaka Takeuchi, *The Knowledge-Creating Company: How Japanese Companies Create the Dynamics of Innovation* (New York: Oxford University Press, 1995), first quote, p. 16; second quote, p. 246.
5. Key themes well articulated and documented by Michael E. Porter, Hirotaka Takeuchi and Mariko Sakakibara, *Can Japan Compete?* (Cambridge, Mass.: Perseus, 2000) and Marie Anchordguy, *Reprogramming Japan: The High Tech Crisis under Communitarian Capitalism* (Ithaca, N.Y.: Cornell University Press, 2005).
6. William K. Tabb, *The Postwar Japanese System: Cultural Economy and Economic Transformation* (New York: Oxford University Press, 1995): 225–254.
7. Japan was finally knocked out of its long standing second position by China for the first time during 2010, stirring a flurry of commentary about the decline of the nation, the rise of China and the "New Asia"; "China's March Towards World's No. 2 Economy," *CNNMoney.Com*, August 16, 2010, http://www/CNNMoney.com (last accessed 9/2/2010).
8. The scope of the literature on these issues has yet to be defined, but for a start, there is Dawn E. Talbot, *Japan's High Technology: An Annotated Guide to English-Language Information Sources* (Phoenix, AZ: Oryx Press, 1991) and the non-annotated, yet detailed bibliography, Fransman, *Japan's Computer and Communications Industry*, 511–525; for bibliography that includes Japanese titles, Kazunori Minetaki and Kiyohiko G. Nishimura, *Information Technology Innovation and the Japanese Economy* (Stanford, Cal.: Stanford University Press, 2010): 218–223.

9. Gene Gregory, *Japanese Electronics Technology: Enterprise and Innovation* (Tokyo: The Japan Times, 1985): 7.
10. T.F.M. Adams and N. Kobayashi, *The World of Japanese Business: An Authoritative Analysis* (Tokyo: Kodansha International, 1969); on European views about Japanese practices, see William R. Nester, *European Power and the Japanese Challenge* (New York: New York University Press, 1993): 195–198, and for Japanese perspectives, 198–201. There were also more balanced reviews, such as by John Nathan, *Japan Unbounded: A Volatile Nation's Quest for Pride and Purpose* (Boston, Mass.: Houghton Mifflin, 2004); and even earlier during the near hysteria evident in the West, Rodney Clark, *The Japanese Company* (New Haven, Conn.: Yale University Press, 1979); Richard E. Caves and Masu Uekusa, *Industrial Organization in Japan* (Washington, D.C.: Brookings Institution, 1976).
11. I used the word partial because every personal experience is unique. Comparison of memoirs of startup firms illustrates the point. In addition to the Japanese memoirs cited elsewhere in this chapter, see Akio Morita with Edwin M. Reingold and Mitsuko Shimomura, *Made in Japan: Akio Morita and SONY* (New York: E.P. Dutton, 1986) and Takeo Miyauchi, *The Flame from Japan: A Story of Success in the Microcomputer Industry* (Tokyo: Sord Computer Corporation, 1982), then compare their sense of uniqueness to those in the West, such as those written by Konrad Zuse, *The Computer—My Life* (New York: Springer-Verlag, 1993) and Thomas J. Watson Jr. and Peter Petre, *Father Son & Co.: My Life at IBM and Beyond* (New York: Batam, 1990).
12. Ezra F. Vogel, *Japan As Number One: Lessons for America* (Cambridge, Mass.: Harvard University Press, 1979): ix.
13. On Japan's educational system, Brian M. Murphy, *The International Politics of New Information Technology* (New York: St. Martin's Press, 1986): 226–229. Most Japanese programmers learned their trade on the job; formal education on computer science at universities was quite limited in the twentieth century. Entrepreneurial initiatives by individuals skilled in IT remained low, in part because of social disapproval of risk and potential failure, and software was not treated as important as hardware; but also due to attractiveness of life-time employment practices by the largest firms, Anchordoguy, *Reprogramming Japan*, 140–143.
14. William Chapman, *Inventing Japan: The Making of a Postwar Civilization* (New York: Prentice-Hall Press, 1991): 94.
15. Patents are traditionally used as a surrogate measure of innovation in an industry or economy, and if we leave aside the fact that what constitutes a patent in the USA versus Japan, for the moment, the evidence suggests in general that by the late 1980s, of the top ten corporate recipients of patents in the IT communication, four were Japanese (1987): Canon, Hitachi (normally with the largest number), Toshiba, and Mitsubishi Electric and if one looks at the number per unit of sales, again the Japanese did well in the late 1980s-early 1990s, particularly Canon and Toshiba, Fransman, *Japan's Computer and Communications Industry*, 431–436.
16. Koji Kobayashi, *The Rise of NEC: How the World's Greatest C&C Company Is Managed* (Oxford: Blackwell, 1991): 62–75.
17. Makoto Ohtsu and Tomio Imanari, *Inside Japanese Business: A Narrative History, 1960–2000* (Armonk, N.Y.: M.E. Sharpe, 2002): 17–43; but see also for origins of consumer electronics, Gene Gregory, *Japanese Electronics Technology*, 141–191; Alfred D. Chandler, Jr., *Inventing the Electronic Century: The Epic Story of the*

Consumer Electronics and Computer Industry (Cambridge, Mass.: Harvard University Press, 2005): 217–220.

18. These various models emerged from such global influences as political alignments of nations with Communism, hence Communist economies, and Third World or "non-aligned" models which embraced socialism, or quasi-managed economic models; in short, not all advanced economies using IT were neo-classical cases of practicing capitalism. I argue that these varying models of economic organization influenced profoundly the adoption and use of IT all through the second half of the century.
19. Angus Maddison, *Monitoring the World Economy, 1820–1992* (Paris: OECD, 1995): 107.
20. Japan Government, www.stat.go.jp (last accessed 9/10/2010).
21. Mario Polèse, *The Wealth and Poverty of Regions: Why Cities Matter* (Chicago, Ill.: University of Chicago Press, 2009): 110; and impact cities have that continues, Richard Florida, *The Great Reset: How New Ways of Living and Working Drive Post-Crash Prosperity* (New York: Harper, 2010): 117–120.
22. T.F.M. Adams and Iwao Hoshii, *A Financial History of the New Japan* (Tokyo: Kodansha International, 1972): 64.
23. Thomas F. Cargill and Takayuki Sakamoto, *Japan Since 1980* (Cambridge: Cambridge University Press, 2008): 1–8.
24. MITI's name changed its name to Ministry of Economy, Trade and Industry (METI) in 2001.
25. The most detailed study about IBM in Japan was conducted by Robert Sobel, *IBM vs. Japan: The Struggle for the Future* (New York: Stein and Day, 1986): 143–190; but see also Martin Fransman, *Japan's Computer and Communications Industry: The Evolution of Industrial Giants and Global Competitiveness* (Oxford: Oxford University Press, 1995): 147–156, 165–166; Anchordguy, *Reprogramming Japan*, 126–136, 160–163, 187–188.
26. Leon Hollerman (ed.), *Japan and the United States: Economic and Political Adversaries* (Boulder, Col.: Westview Press, 1979); United States-Japan Trade Council, *Yearbook of U.S.-Japan Economic Relations* (Washington, D.C.: U.S.-Japan Trade Council, 1979-annual); Nester, *European Power and the Japanese Challenge*, 191–258.
27. Cargill and Sakamoto, *Japan Since 1980*, 27–100; Hiroshi Yoshikawa, *Japan's Lost Decade* (Tokyo: LTCB International, 2002): 4–5, 29–32, 135–139; Shahid Yusuf and Kaoru Nabeshima, "Japan's Changing Industrial Landscape," World Bank WPS3758, 2004, *www-wds.worldbank.org/servlet/. . ./WDSP/IB/. . ./wps3758.txt*-Cached (ast accessed 3/8/2012).
28. Cargill and Sakamoto, *Japan Since 1980*, 3.
29. Considerable attention was given to the issue by influential organizations, especially in the United States, National Research Council, Computer Technology Resources Panel, *The Computer Industry in Japan and Its Meaning for the United States* (Washington, D.C.: National Research Council, 1973); U.S. Congress, Committee on Science and Technology, *Background Reading on Science, Technology, and Energy R&D in Japan and China* (Washington, D.C.: U.S. Government Printing Office, 1981); U.S. Congress, Joint Economic Committee, *International Competition in Advanced Industrial Sectors: Trade and Development in the Semiconductor Industry* (Washington, D.C.: U.S. Government Printing Office, 1982); U.S. Congress, Office of Technology Assessment, *U.S. Industrial Competitiveness* (Washington, D.C.: U.S. Government Printing Office, July 1981), but most damning is U.S. International

Trade Commission, *Foreign Industrial Targeting and Its Effects on U.S. Industries, Phase I: Japan*, Publication 1437 (Washington, D.C.:U.S. Government Printing Office, October 1983).

30. Nester, *European Power and the Japanese Challenge*, 128–161.
31. Because the body of literature is so large, it is described more thoroughly in the bibliographic essay at the back of this book.
32. Fransman, *Visions of Innovation*, 167–197.
33. Exports represented a major portion of the business of key industries. For example, in 1950 exports comprised only 2.3 percent of Japan's total GDP, but jumped to 7.9 percent in 1973, and by the end of 1992, to 12.4 percent, actually less than for other Asian countries, Maddison, *Monitoring the World Economy*, 38. However, just a few industries routinely dominated Japan's export business. Using early 1990s, motor vehicles and consumer electronics led Japan's exports, over 48 percent of Japan's export business, while integrated circuits amounted to 2.63 percent in 1991–92, Fransman, *Japan's Computer and Communication Industry*, 8–9.
34. Anchordguy, *Reprogramming Japan*, 6.
35. Ibid.
36. Although increasingly over time, firms hired fewer permanent workers, made possible by automating working, outsourcing it to less expensive labor markets in Asia, and by hiring contract (temporary) workers in Japan. Almost all Western writers like to point out, however, that this policy institutionalized retention of employees who were not so productive, adding a drag on the cost of doing business, particularly in large enterprises. I used the word *increasingly* in the narrative to point out that in aggregate management sought for its total workforce to be more productive, an objective hardly met when measured at the national level, and discussed later within the context of economic effects of the use of IT.
37. Ibid., 13.
38. Ibid.
39. Anchordoguy, *Reprogramming Japan*, 50–54 and passim; William K. Tabb, *The Postwar Japanese System: Cultural Economy and Economic Transformation* (New York: Oxford University Press, 1995): 37, 41–43, Porter, Takeuchi and Sakakibara, *Can Japan Compete?*, 74, 151–152, 165.
40. Chalmers Johnson, *MITI and the Japanese Miracle: The Growth of Industrial Policy, 1925–1975* (Stanford, Cal.: Stanford University Press, 1982); Scott Callon, *Divided Sun: MITI and the Breakdown of Japanese High-Tech Industrial Policy, 1975–1993* (Stanford, Cal.: Stanford University Press, 1995): 182–207; Martin Fransman, *Japan's Computer and Communications Industry: The Evolution of Industrial Giants and Global Competitiveness* (New York: Oxford University Press, 1995); Porter, Takeuchi and Sakakibara, *Can Japan Compete?*, 1–68.
41. Anchordguy, *Reprogramming Japan*, 10.
42. Sobel, *IBM vs, Japan*, 150–154; Marie Anchordoguy, *Computers Inc: Japan's Challenge to IBM* (Cambridge, Mass.: Harvard Council on East Asian Studies, 1989): 22–24.
43. Anchordguy, *Reprogramming Japan*, 96–146; Tabb, *The Postwar Japanese System*, 43–44.
44. The issue of time-based competition in industries undergoing rapid change is a complicated story but crucial to ours, W. Mark Fruin, "Competing in the Old-Fashioned Way: Localizing and Integrating Knowledge Resources in Fast-to-Market Competition," in Jeffrey K. Liker, John E. Ettlie and John C. Campbell (eds.),

Engineered in Japan: Japanese Technology-Management Practices (New York: Oxford University Press, 1995): 217–233.

45. Nester, *European Power and the Japanese Challenge*, 110–112, 121–127.
46. Laura D'Andrea Tyson and David B. Yoffie, "Semiconductors: From Manipulated to Managed Trade," in David B. Yoffie (ed.), *Beyond Free Trade: Firms, Governments, and Global Competition* (Boston, Mass.: Harvard Business School Press, 1993): 37.
47. Chandler, *Inventing the Electronic Century*, 6–7, 64–65, 79–80; Anchordoguy, *Reprogramming Japan*, 144–146, 164–166, 219–222; Martin Fransman, *Visions of Innovation: The Firm and Japan* (Oxford: Oxford University Press, 1999): 93–96. A founder of Sony, Akio Morito, wrote a highly informed, well written memoir/history of the firm, *Made in Japan* (New York: Dutton, 1986).
48. Cargill and Sakamoto, *Japan Since 1980*, 83–98.
49. Cargill and Sakamoto, *Japan Since 1980*, 13–15.
50. Fransman, *Visions of Innovation*, 8.
51. Ibid., 74–75.
52. Tabb, *The Postwar Japanese System*, 257.
53. Ryota Suekane, "Early History of Computing in Japan," in N. Metropolis et al. (eds), *A History of Computing in the Twentieth Century* (New York: Academic Press, 1980): 575–578; Sigeru Takashashi, "Early Transistor Computers in Japan," *Annals of the History of Computing* 8, no. 2 (April 1986): 144–154; Hidstosi Takahasi, "Some Important Computers of Japanese Design," Ibid., 2, no. 4 (October 1980): 330–337; Sigeru Takahashi, "A Brief History of the Japanese Computer Industry Before 1985," Ibid., 18, no. 1 (1996): 76–79.
54. Fuido Kricks, "A Brief Overview of the History of the Japanese Computer Industry," November 3, 1982, pp. 2–7, Charles Babbage Institute, University of Minnesota, Minneapolis; Kenneth Flamm, *Creating the Computer: Government, Industry, and High Technology* (Washington, D.C.: Brookings Institution, 1988): 172–179; Martin Fransman, *The Market and Beyond: Information Technology in Japan* (Cambridge: Cambridge University Press, 1990): 13–56.
55. Japan Electronic Development Association, *J.E.I.D.A. and Its Computer Center* (Tokyo: JEIDA, undated [circa 1959], CBI 32, Box 714, folder 5, Charles Babbage Institute, University of Minnesota, Minneapolis.
56. Everett S. Calhoun, "New Electronic Computer Developments in Japan and Europe," February 21, 1957, Blachman Papers, Box 217, Smithsonian Institution, Washington, D.C. but see also Nelson M. Blachman, March 9, 1953, Box 216.
57. Kent E. Calder, *Strategic Capitalism: Private Business and Public Purpose in Japanese Finance* (Princeton, N.J.: Princeton University Press, 1993): 116–117.
58. Fransman, *Japan's Computer and Communications Industry*, 134–136.
59. Described well by NEC's chairman, Koji Kobayashi, *Computers and Communications: A Vision of C&C* (Cambridge, Mass.: MIT Press, 1986): 61–76 and *The Rise of NEC: How the World's Greatest C&C Company Is Managed* (Cambridge, Mass.: Blackwell, 1991): 112–169; NEC Corporation, *NEC Corporation, 1899–1999* (Tokyo: NEC Corporation, 2002): 194–200, 237–279.
60. Fransman, *Japan's Computer and Communications Industry*, 136–138; Chandler, *Inventing the Electronic Century*, 194–211.
61. Kricks, "A Brief History of the History of the Japanese Computer Industry," 5–6.
62. Flamm, *Creating the Computer*, 178.
63. Quoted in Fransman, *Japan's Computer and Communications Industry*, 138.
64. Ken. W. Sayers, "History of IBM's International Operations, 1911–2006," (2006), pp. 273–275, IBM Corporate Archives, Somers, New York.

65. James W. Birkenstock, "Pioneering: On the Frontier of Electronic Data Processing, A Personal Memoir," *IEEE Annals of the History of Computing* 22, no. 1 (January–March 2000): 36; for further details, see Fransman, *Japan's Computer and Communications Industry*, 137–139.
66. Report by Ulric Weil to A.L. Harmon, December 19, 1967, World Trade Corporation Legal Records, Country Files, Japan, Box 61, folder 4, IBM Corporate Archives. The same records document IBM's frustrations with Japanese officials and activities of government agencies toward the firm in the 1960s with the most useful a detailed description of government policies by Richard W. Rubinowitz to William T. Ketcham, December 24, 1965, World Trade Corporation Legal Records, Country Files, Japan, Box 63, folder 7, IBM Corporate Archives. It documents Japanese policy in these years with insights about the difficulty of describing specifics: "the policy announced by the MITI official with whom we have been dealing is nowhere embodied in any provision of law or administrative regulation of which we are aware. Nor has there even been, to the best of our knowledge, any public disclosure of this policy."
67. Flamm, *Creating the Computer*, 184–185.
68. Ibid., 186–188; Fransman, *Japan's Computer and Communications Industry*, 140–141; Chandler, *Inventing the Electronic Century*, 191–192; Anchordoguy, *Reprogramming Japan*, 125–140.
69. Chandler, *Inventing the Electronic Century*, 192.
70. Fransman, *Japan's Computer and Communications Industry*, 139–141; Sobel, *IBM vs. Japan*, 157–173.
71. "JCM & IPS Status in Japan & U.S.," November 20, 1979, unpaginated, Record Group 5, "Business Planning CMC/Meeting Material, 1979-11/20," Box 46, folder 3/4, IBM Corporate Archives, Somers, N.Y.
72. Ibid.
73. Ibid.
74. Chandler, *Inventing the Electronic Century*, 190–210; reviewed in greatest detail by Nester, *European Power and the Japanese Challenge*.
75. Scott Callon, *Divided Sun: MITI and the Breakdown of Japanese High-Tech Industrial Policy, 1975–1993* (Stanford, Cal.: Stanford University Press, 1995): 166–181; Forester, *Silicon Samurai*, 194–201.
76. Anchordoguy, *Reprogramming Japan*, 146.
77. Taiyu Kobayashi, *Fortune Favors the Brave: Fujitsu: Thirty Years in Computers* (Tokyo: Keizai Shinposha, 1983): 77–110. The author was chairman of the board at this company during the crucial years when it committed itself to computers. He should not be confused with another Japanese chairman with the same name, Koji Kobayashi, who led NEC, both of whom overlapped in time their leadership of their respective firms.
78. For examples of contemporary discussions, see Hugh Patrick and Larry Meissner (eds.), *Japan's High Technology Industries: Lessons and Limitations of Industrial Policy* (Seattle, Wash.: University of Washington Press and Tokyo: University of Tokyo Press, 1986) and for more contemporary presentations, William H. Davidson, *The Amazing Race: Winning the Technorivalry with Japan* (New York: Wiley & Sons, 1984); Christopher Wood, *The End of Japan Inc. And How the New Japan Will Look* (New York: Simon & Schuster, 1994). For Japanese perspectives, see Naoto Sasaki, *Management and Industrial Structure in Japan* (Oxford: Pergamon, 1981); Michio Morishima, *Why Has Japan "Succeeded"?* (Cambridge: Cambridge University Press, 1981). For a more current retrospective, see Makoto Ohtsu, *Inside*

Japanese Business: A Narrative History, 1960–2000 (Armonk, N.Y.: M.E. Sharpe, 2002): 17–41.

79. Sheridan Tatsuno, *The Technolopis Strategy: Japan, High Technology, and the Control of the Twenty-first Century* (New York: Prentice Hall, 1986): 23–31; Y.W. Liu and I.R. Marchant, *The Japanese-American Struggle For Supremacy in the Computer Industry*, Occasional Paper No. 9 (Singapore: EPS Publishers for University of Western Australia, Centre for East Asian Studies undated [circa 1982–83]).
80. For the clearest and most compelling discussion of the issue, see Porter, Takeuchi and Sakakibara, *Can Japan Compete?*, 1–68.
81. Chandler, *Inventing the Electronic Century*, 209–210.
82. A central point made by Martin Fransman in all his books on Japan, see for example, *The Market and Beyond, Japan's Computer and Communications Industry* and more recently, *Visions of Innovation*.
83. Anchordguy, *Reprogramming Japan*, 127–129.
84. Paul Fannon, *Trojan Horses and National Champions: The Crisis in Europe's Computing and Telecommunications Industry* (London: Apt-Amatic Books, 1997): 187–195; Vogel, *Japan As Number One*; Fransman, *The Market and Beyond*, 9; Nester, *European Power and the Japanese Challenge*, 97–258.
85. Anchordoguy, *Reprogramming Japan*, 177–205.
86. Ibid., 187–188.
87. Gannon, *Trojan Horses and National Champions*, 195.
88. Richard Florida and Martin Kenney, "High-Technology Restructuring in the USA and Japan," *Environment and Planning* 22 (1990): 233–252, but see also their *Beyond Mass Production*, 50–55, which takes the story of Japanese dominance story to the end of the period of prosperity before the economy began declining in 1989–1990.
89. Yui Kimura, *The Japanese Semiconductor Industry: Structure, Competitive Strategies and Performance* (Greenwich, Conn.: JAI Press, 1988): 51.
90. Ibid. 52.
91. Ibid., 54–55.
92. Ibid., 56.
93. Ibid., 57.
94. Fransman, *Japan's Computer and Communications Industry*, 273–274.
95. Ibid., 276.
96. Chandler, *Inventing the Electronic Century*, 210–212; Jason Dedrick and Kenneth L. Kraemer, *Asia's Computer Challenge: Threat or Opportunity for the United States and the World?* (New York: Oxford University Press, 1998): 78–84. On the language problem see Kobayashi, *Computers and Communications*, 80–82.
97. For examples of these various perspectives, see Yasunori Baba, Shinji Takai, and Yuji Mizuta, "The User Driven Evolution of the Japanese Software Industry: The Case of Customized Software for Mainframes," in David Mowery (ed.), *The International Computer Software Industry: A Comparative Study of Industry Evolution and Structure* (New York: Oxford University Press, 1996): 104–130; Fransman, *Japan's Computers and Communications Industry*; and the perspective I most adhere to, Achordoguy, *Reprogramming Japan*, 147–176.
98. OECD, *Information Technology Outlook* (Paris: OECD, 2008): 118.
99. Achordoguy presents much of the evidence from multiple sources in a useful graph, *Reprogramming Japan*, 149.
100. Ibid., 150.
101. Fransman, *Japan's Computer and Communications Industry*, 186–187, 191.

102. Subject of much discussion in the West, Michael Cusumano, *Japan's Software Factories: A Challenge to U.S. Management* (New York: Oxford University Press, 1991); Yoshihiro Matsumoto and Yutaka Ohno, *Japanese Perspectives in Software Engineering* (Singapore: Addison-Wesley, 1989): 3–18; Kenney and Florida, *Beyond Mass Production*, 81–85.
103. Achordoguy, *Reprogramming Japan*, 155–157; Fransman, *Visions of Innovation*, 160–165.
104. Achordoguy, *Reprogramming Japan*, 159; Marie Anchordoguy, *Computers Inc.: Japan's Challenge to IBM* (Cambridge, Mass.: Harvard Council on East Asian Studies, 1989): 149–150.
105. Ibid., 162.
106. Ibid., 163.
107. The standard work consulted in the 1990s on FMS was by B. Joseph Pine II, *Mass Customization: The New Frontier in Business Competition* (Boston, Mass.: Harvard Business School Press, 1993).
108. Gregory, *Japanese Electronics Technology*, 300–301.
109. Ibid., 287–309.
110. Jon Sigurdson, *Industry and State Partnership in Japan: The Very Large Scale Integrated Circuits (VLSI)* (Lund: Research Policy Institute, 1986); Edward A. Feigenbaum and Pamela McCorduck, *The Fifth Generation: Artificial Intelligence and Japan's Computer Challenge to the World* (Reading, Mass.: Addison-Wesley, 1983): 99–148; Fransman, *The Market and Beyond*, 193–242.
111. Anchordoguy, *Reprogramming Japan*, 163–166.
112. Martin Campbell-Kelly, *From Airline Reservations to Sonic the Hedgehog: A History of the Software Industry* (Cambridge, Mass.: MIT Press, 2003): 284–285.
113. Ibid., 288.
114. Anchordoguy, *Reprogramming Japan*, 164.
115. Chandler, *Inventing the Electronic Century*, 70–71; Gregory, *Japanese Electronics Technology*, 96–99. Digital watches had a similar effect as video games, beginning in the 1970s.
116. For a definition of robotics from the perspective of manufacturers and users: "a reprogrammable, multifunctional manipulator designed to move material, parts, tools, or specialized devices through variable programmed motions for the performance of a variety of tasks," *RIA Robotics Glossary* (Dearborn, Mich.: Robots Institute of America, 1984): 28. See also a Japanese catalog of various types of robots, "Japan Industrial Standards (JIS) Classification of Robots," reprinted in Frederick L. Schodt, *Inside the Robot Kingdom: Japan, Mechatronics, and the Coming Robotopia* (Tokyo: Kodansha International, 1988, 1990): 45.
117. Schodt, *Inside the Robot Kingdom*, 39. On uses, Shimony Nof (ed.), *Handbook of Industrial Robotics* (New Yorlk: John Wiley & Sons, 1985).
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CHAPTER 8

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