CHAPTER FOUR

The Shifting Value Chain

The Television Industry in North America

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Locating global advantage in the television industry is a fascinating task, because it has shifted spatially and in production ownership terms, even while organizationally there has been far less change. As a physical product, a television resembles a personal computer (PC), and yet the organization of its value chain has greater similarity to the automobile industry. In spatial terms, the value chain has exhibited significant plasticity. The U.S. market is ideal for understanding the global forces affecting the industry, because it is the largest single market, and it has been the key competitive battleground for global manufacturers. It also was the first major Fordist industry to fall victim to global competition. This chapter utilizes North America as a case study to understand how the interaction between firm strategies, government actions, and consumer desires has affected the location of competitive advantage in the television industry.

While there can be little doubt that government policy, both Japanese and U.S., influenced the development of the television industry, the fates of the various national television industries were not determined by political initiatives, though location of factories was affected. Rather, these diverging fates rested upon corporate strategy and differing production systems. Still, the relationship between the government and firms also affected the structure of the market. U.S. government intervention in the television industry has a long history, beginning as a procompetition policy in reaction to RCA's use of its patents to stifle competition. Later, the government's major role would be to react to the demands by U.S. firms for protection. Among observers at the time, it was common to attribute Japanese success to clever Japanese and foolish U.S. policy (Prestowitz 1988).[1] This was a gross over-simplification.

There are three distinct segments of the television value chain: picture tube

production, other component production and assembly, and final assembly. Each exhibits different dynamics.[2] Each segment has different technical, physical, and personnel requirements: a feature allowing firms to develop complicated and changing spatial divisions of labor. The television industry, like many of the other industries in this book, has faced brutal price competition and, since 1980, constant overcapacity. In contrast to PCs, however, there has been no dramatic curve of improving functionality: there has been a constant increase in screen size for the same price. In response to these changes, firms continually adjusted and readjusted their divisions of labor, globally and regionally. Put differently, the value chain at any moment appeared fixed, but when seen dynamically, change was the rule.

When the television was introduced immediately after World War II, it was a leading edge, high-technology product. However, resembling other electronics products, each new model, even if it incorporated significant new technology, swiftly became a commodity. As the assembly process was routinized and simplified, the value of a television became increasingly embodied in a few components, particularly the picture tube, which is produced by a capital-intensive manufacturing production process.

The television industry was a harbinger of developments in other traditional assembly-intensive manufacturing industries. For example, as the chapter by Sturgeon and Florida indicates, the U.S. auto industry initially lost the low end of the market to the Japanese, but fortunately it regrouped before being annihilated; the television industry did not regroup, and it was annihilated. In this way, televisions were what Fine (1998) termed a "fruit fly" industry—that is, an early indicator of shifts that would affect more significant industries later.

Ultimately, production for the U.S. market was captured by Japanese and European firms producing in North America. The progression of the changing national ownership of the value chain is instructive. The U.S. industry first lost its component supplier industry, followed by the assembly operations, and later the tube industry. The most capital intensive activities were the last to experience a change in ownership and location.

The Television Industry

In 2003, the global television industry can be divided into six major markets: the United States, Europe, Japan, China, the rest of Asia, and the rest of the world. All the significant firms operate globally. The United States, Japanese, and Western European markets were largely saturated, and purchases were confined to replacement. By the late 1990s, the most important growth markets were in the developing countries of Asia, especially China and India, and they were becoming the locus of new investment. Europe remained a protected mar-

TABLE 4.1
The Ten Largest CTV Manufacturers in the World, 1978

	Company	Country	Number of sets produced (millions per year)
1.	Matsushita	Japan	3.60
2.	Philips	Netherlands	3.50
3.	RCA	USA	2.00
4.	Zenith	USA	1.97
5.	Sanyo	Japan	1.95
6.	Sony	Japan	1.70
7.	Toshiba	Japan	1.50
8.	Grundig[a]	Germany	1.40
9.	Hitachi	Japan	1.25
10.	Sylvania-GTE[b]	USA	1.20

Source: Ruottu (1998: 160)
[a] Grundig owned 25% by Philips
[b] Acquired by Philips in autumn 1980.

TABLE 4.2
The Ten Largest CTV Manufacturers in the World, 1987

	Company	Country	Number of sets produced (millions per year)
1.	Philips	Netherlands	8.60
2.	Thomson	France	6.80
3.	Matsushita	Japan	4.70
4.	Sony	Japan	3.80
5.	Toshiba	Japan	3.20
6.	Hitachi	Japan	3.10
7.	Samsung	South-Korea	2.50
8.	Zenith	USA	2.30
9.	Nokia	Finland	2.20
10.	Sanyo	Japan	1.80

Source: Ruottu (1998: 162).

ket served by the major European producers, Philips and Thomson, and the Japanese and Korean firms. Most recently, there have been shifts in Western European production, relocating to Eastern Europe. Finally, in Japan there is a continuing shift by Japanese firms of assembly and component production to Asian production sites.

During the last three decades, there have been significant changes in global leadership. As can be seen in Table 4.1, in 1978, U.S. producers were prominent among the top ten global producers. By 1987, Japanese firms were the leaders, but Zenith was still among the top 10 (Table 4.2). The two European producers, Thomson and Philips, had become the world's largest producers; the Finnish company Nokia joined the top 10; and Samsung had just entered the top 10. By 1997, the order had changed again, with the Japanese firms Sony and Mat-

TABLE 4.3
The Ten Largest CTV Manufacturers in the World, 1997

	Company	Country	Number of sets produced (millions per year)
1.	Sony	Japan	15.80
2.	Matsushita	Japan	12.70
3.	LG & Zenith	Korea	12.20
4.	Thomson	France	10.90
5.	Samsung	Korea	10.60
6.	Sharp	Japan	7.20
7.	Philips	Netherlands	7.00
8.	Daewoo	Korea	6.80
9.	Sanyo	Japan	6.90
10.	Toshiba	Japan	5.90

Source: Author's compilation from various sources.
Note: Chinese makers are unknown.

sushita becoming the leaders (Table 4.3). The two European firms lost ground, while the Korean firms Samsung, Daewoo, and Lucky Goldstar (LG) had become major competitors. In 1999, the sole remaining U.S. manufacturer, Zenith, was sold to LG. Since the Koreans entered the television industry in the 1970s, no other significant global players have emerged (though this might change, as some Chinese firms have begun exporting very inexpensive televisions). In the 1980s, it appeared that Taiwanese television producers, such as Tatung and Sampo, would become global players. However, in the mid-1980s Taiwan opened its consumer electronics market, and Japanese producers routed the local firms. This was not as problematic as it might first appear, as the Taiwanese electronics firms were already shifting to the personal computer industry—a movement that proved to be prescient for Taiwan (see Chapter 5).

The Fordist World of American Television Manufacturing

After World War II, B/W television sales commenced in earnest, and many new firms entered the industry in the United States, Europe, and Japan. From 1946 to 1948, there were approximately 500 firms assembling B/W televisions in the United States (Teitelman 1994: 52). In 1951, there were 97 B/W television assemblers remaining (*Television Factbook* 1951). By 1960, the number had declined to 27 firms (U.S. International Trade Commission 1977: A4). In 1968, there were 18 firms producing color televisions in 30 factories. The first nadir was reached in 1976, when there were only 12 firms left producing in 15 establishments (ibid.: 13). In 1989, this had increased to 17 establishments because of the Japanese transplants (Robert R. Nathan Associates 1989: 357). After that there would be a terminal decline in U.S. factories.

Since the 1960s the number of U.S. workers employed in SIC Code 3651,

which covers radio and television receivers, and SIC Code 3651, which covers vacuum tubes, has declined with only a few respites. For the manufacture of radio and television receivers, employment peaked in 1966 (the middle of the Vietnam War boom) at 130,000. During the next two decades, employment fell to 30,000 in 1987 and then remained relatively constant through 1994. In 2000, employment fell below 20,000 with no indication of recovery.

In the late 1940s, television manufacturing commenced in the U.S. Midwest. At that time, Fordism as practiced in the automobile industry was considered the essence of managerial excellence. Every ill that plagued the U.S. automobile industry surfaced in television production (MIT Commission on Industrial Productivity 1989). Labor relations and product quality were low. According to Porter (1983), between 1970 and 1979 Japanese television makers had between 9 and 26 field calls per 100 sets, whereas U.S. firms had between 100 and 200 field calls per 100 sets. In 1979, Baranson (1980) confirmed Porter's conclusions, finding that the defect rate for Japanese television sets was 0.4 percent, compared with 5 percent for U.S. sets. This greater quality provided important advantages: one of the most important was that when Japanese manufacturers entered the U.S. market, they did not have to establish a costly service network (U.S. International Trade Commission 1992: 4).

The U.S. and Japanese television industries diverged markedly in terms of labor-management relations. The U.S. employees (with the exception of those at Motorola) were represented by industrial unions, whereas in Japan they had enterprise unions (Kenney 1999b). American unionized factories were characterized by intricate job classifications, strict seniority, and bumping privileges; a lack of worker responsibility for inspection; quality control responsibility lodged with inspectors and management; a radical separation of blue- and white-collar workers; and arcane grievance procedures (Kenney and Tanaka 2003). From the 1950s through the early 1980s, the U.S. industry was plagued by strikes, both sanctioned and wildcat. Disruption and disagreement were common and necessitated the use of a just-in-case production system in which inventory was stockpiled in anticipation of difficulties.

Greater efficiency and automation have continuously reduced the labor input in television assembly. An MIT study undertaken in the late 1980s (MIT Commission on Industrial Productivity 1989: 16) stated that "in 1971 the cost breakdown for a 19" Zenith color television was approximately $18 for direct labor ($5 for component insertion), and $168 for materials, of which $70 was for the tube; the suggested retail price was $460. By 1984, offshore labor, automation, and component insertion had reduced direct labor costs approximately six-fold below levels of the early 1970s, making them nearly negligible." Despite the conclusion that labor costs were nearly negligible, there was a continual pressure to reduce costs further.

U.S. assemblers adopted automation reluctantly. One observer attributed this tardiness to a U.S. labor market organization that "inhibits the introduction of automation and other technological change for fear of irreplaceable job loss" (Developing World Industry and Technology, Inc. 1978: 18). In the late 1970s, Japanese firms used less than two hours to build a 21-inch color television, while U.S. and German firms used nearly four hours and the U.K. firm used nearly six hours (Office of Technology Assessment1983: 238). In 1997, one major Japanese producer had reduced the labor time used to assemble a 20-inch television to only twenty-seven minutes, while the more complicated 32-inch model took eighty-six minutes (Ohgai 1997). This decrease in per unit labor input was directly related to increased automation and component simplification.

Similar to the U.S. manufacturers, the parts and components suppliers also were reluctant to adopt automation. They had endemic quality problems, which adversely affected television reliability. For example, Juran (1978: 10) found that the causes of field service failures for televisions were design and development (20–40 percent), quality of components (40–65 percent), and final assembly (15–20 percent). Inadequate supplier quality had a direct impact on an assembler's quality, hence competitiveness.

The U.S. firms were late in understanding the importance of quality. It was only in the early 1970s that they invested in automatic test equipment, incoming parts inspection, and using burn-in tests for finished receivers (U.S. International Trade Commission 1977: A85). The greatest contribution to reliability was switching from tubes to transistors. Japanese manufacturers, drawing upon their experience with transistor radios, introduced all-transistor televisions in the mid-1960s. In contrast, it was not until the mid-1970s that U.S. manufacturers completely converted to the use of transistors, despite the fact that Fairchild had designed the first all-transistor television in 1962 and demonstrated it to all interested firms (Lecuyer 1999). It was not surprising that U.S. manufacturers garnered a reputation for lack of innovativeness and low quality that was difficult to change.

The Globalization of the Television Industry

The 1950s and Early 1960s—Licensing to Overseas Competitors and Component Imports

After World War I, the important radio and receiving tube patents were held by AT&T, GE, and Westinghouse. After complicated negotiations, a newly formed firm, RCA, emerged as the owner of their broadcasting patent portfolio. As a result of a 1930 antitrust indictment against RCA, GE, and Westinghouse, a consent agreement was signed in 1932 and RCA secured its indepen-

dence. The facilities RCA inherited from GE and Westinghouse made it not only the leading tube maker and radio assembler but also the chief source of research and development (R&D) for the entire U.S. broadcasting industry (Stokes 1982: 3).

From the 1920s onward, inventors and firms in a number of countries raced to perfect televisions. In the early 1930s, U.S. firms demonstrated viable B/W television transmitters and receivers. The onset of World War II interrupted these commercialization plans, but research continued. Moreover, the wartime need for display devices propelled the improvement of high-power vacuum tubes and accelerated the development of mass production techniques for cathode ray tubes. RCA's research laboratory played a central role in many of these innovations. To jump-start the television industry, in 1946 RCA announced that it would include B/W television licenses in the patent package it offered to other companies.

From its experience in radios and as the technical leader, RCA developed a strategy of licensing patents to increase its income, as it could earn greater profits from licensing and selling key components than from only manufacturing receivers (Chandler 2001). Typically, after developing and introducing an innovation RCA would have high market share and profits. It then licensed the technology, and, as new firms entered the market, prices dropped (Graham 1986). Through its licensing strategy, RCA made it uneconomical for the other consumer electronics firms to invest significant sums in research. Conversely, "for RCA, the effect was to make licensing fees the major payoff of its research activity" (ibid.: 41). The handsome profits from licensing and from its tube and component business made RCA successful, but created a potential vulnerability for the entire U.S. industry should RCA ever lag in innovation (Chandler 2001; Graham 1986).

In 1958, RCA's interest in overseas licensing was heightened after negotiating a consent decree with the U.S. Department of Justice requiring RCA to provide royalty-free licenses to U.S. producers. Government success in protecting U.S. producers from RCA had the unanticipated effect of accelerating RCA's efforts to find new licensing income to sustain its R&D operations (Chandler 2001). The decree did not prohibit RCA from charging high license fees to foreign companies. Seeking to expand after the war, Japanese electronics firms needed access to technology, and RCA's licensing strategy provided it. From 1960 to 1968, RCA granted 105 licenses for various radio and television inventions to Japanese firms (Collins 1970: 2924). Once these licensing relationships were established, there was every incentive for RCA to quickly license new innovations to its technology "customers" to ensure a continuing and even swelling cash flow. The result was a dramatic reduction in the lags one would expect in transnational technology transfer (on these lags, see Kogut and Zander 1993).

The licensing rate negotiated between RCA and the Electronics Industry Association of Japan (EIAJ) applied equally to all Japanese firms.[3] The rate on a per-product basis was 0.45 percent of the factory value for each AM radio, 0.9 percent for each FM radio, 1.75 percent for each B/W television set, and 2 percent for each color television set produced. From RCA's perspective the licensing scheme negotiated with the Japanese manufacturers had significant benefits because it was like a tax—profits grew as Japanese production expanded. It was in RCA's interest to encourage Japanese firms to produce as many units as possible. Due to this royalty structure, Japanese firms became the largest single foreign contributor to RCA's income (Bilby 1986: 222). In the late 1970s, RCA received more than $100 million per year in licensing fees from Japan (MIT Commission on Industrial Productivity 1989: 15). One method of increasing revenues was to show the Japanese how to produce. In the 1950s, Japanese personnel visited the United States to inspect RCA's television plants. This was important because Japanese visitors were able to see the production process. Another vehicle was the technology transfer engineering laboratory in Tokyo that RCA established in 1954 (Office of Technology Assessment 1983: 121ff).

From very early on, there were few incentives for U.S. television firms to expand sales globally. European and Japanese markets were small. So the U.S. television firms never evinced great interest in overseas markets, though they did open factories in Brazil and Mexico (Lowe and Kenney 1999). A Zenith executive explained his firm's indifference to overseas markets:

> It's hard to explain why a decision is made not to do something. There are a number of reasons behind it—including innate cautiousness. For one, we've always had our hands full with U.S. demand and we've always tended to stick with what appeared to be the biggest payoff and what we knew how to do best. For example, an additional two market share points in the Los Angeles area alone represents more sales volume than there is in most foreign markets. Also, we didn't feel we could compete with the local companies in those markets unless we were willing to sacrifice some of our margin, and we were unwilling to do that (Porter 1983: 487).

The one firm with global-class technology, RCA was not interested in entering other markets; it was content to license.

The licensing of technology and the transfer of know-how soon had competitive consequences. In the mid-1950s, independent Japanese parts suppliers began selling parts and components, such as tuners, deflection yokes, resistors, capacitors, and vacuum tubes in the United States (MIT Commission on Industrial Productivity 1989: 14). At the time Japanese parts were considered low quality, but U.S. assemblers were price conscious; some began purchasing them. In 1963, Admiral and Zenith, which had previously resisted using imported parts, started purchasing them from the Japanese (Takahashi 1993: 45). Many U.S. consumer electronics firms were not vertically integrated, therefore there

was little to prevent them from purchasing the high-quality, low-cost parts offered by Asian suppliers (Rowe 1970: 2883). The arm's-length relationship that the U.S. assemblers had developed with their U.S. suppliers meant that they were willing to purchase parts from the lowest bidder. The result was that the U.S. supplier infrastructure lost business and began to atrophy.

Japanese firms were not content, however, in the low end of the market. During this period, the Japanese government sponsored measures to improve the quality of electronics components. For example, in the early 1960s the government established a quality-testing program (Takahashi 1993). The major assemblers also extended technical assistance to their suppliers and would not purchase from unapproved suppliers. In the early 1960s, Japanese assemblers inspected all incoming parts. To improve reliability, in the mid-1960s Matsushita launched an effort to achieve 0.01 percent component defects. By the early 1970s, the improvements permitted Japanese assemblers to discontinue inspections. In the early 1970s, Matsushita raised its quality target to 0.001 percent defectives, then in 1985 it was raised to 0.0002 percent. In contrast, in 1972 RCA accepted 1.5 percent defects in the integrated circuits it purchased (Turner 1982: 57).

Using these inspection programs, major Japanese manufacturers began tracing defects to their source and demanding that the supplier remedy the causes (Nishiguchi 1994; Sako 1992). This active effort to manage the supplier chain steadily improved the Japanese supplier base. In contrast, U.S. suppliers had no such relationship with U.S. assemblers and were under price pressure but not quality-improvement pressure. This problem became manifest when U.S. assemblers discovered that imported parts were not only less expensive but also of higher quality. Gradually, they came to prefer Japanese parts.

In this period, U.S. firms, particularly RCA, taught Japanese firms how to become consumer electronics producers. The Japanese purchased and imported technology from the United States and, to a lesser degree, from Europe. In general, only the smaller, less technology intensive parts manufacturers in the United States experienced direct competition, but it did spread to higher value parts. Few finished televisions were being exported to the United States, and most U.S. consumer electronics firms were unconcerned: the B/W television market was growing rapidly, and they were switching to CTV production. However, there were warning clouds on the horizon.

The 1960s through the Early 1970s—Japanese Imports and Overseas Production

In the 1960s, the competitive environment changed. The rising imports of low-cost, and increasingly high-quality, Japanese components created serious problems for U.S. suppliers. Then Japanese firms began exporting B/W televi-

sions, and soon U.S. B/W television producers experienced extreme pressure (Curtis 1994: 109; Schiffer 1991). The U.S. firms' strategy of shifting to newer products became increasingly precarious as Japanese manufacturers immediately after capturing the lower end of the market migrated toward the high end.

Japanese entry into the U.S. television market was facilitated by the multiple-channel U.S. distribution system. The system was loosely coupled, and manufacturers, distributors, and retailers operated with changing partners. This was a stable, self-contained system until foreign manufacturers entered. These distributors were independent of the manufacturers, and thus would offer any brand capable of generating profits. They supplied radio/television shops and household appliance, furniture, and department stores. Yet another channel consisted of the house brands of general merchandisers, such as Sears & Roebuck, Montgomery Ward, and J. C. Penney. These merchandisers did not actually manufacture the products (Sears was an exception, as it had captive manufacturers); rather, they purchased products from original equipment manufacturers (OEMs) and placed their brand name on it. The general merchandiser offered the manufacturers large orders and, in return, demanded significant discounts (Prestowitz 1988; MIT Commission on Industrial Productivity 1989). They were continually searching for lower-cost producers. The OEM strategy was not universal among Japanese firms entering the U.S. market. Sony, for example, never sold through OEM channels (Morita 1986).

In 1964, through its Warwick subsidiary Sears received its first OEM color televisions (CTVs) from Toshiba. Sears had approached Toshiba, because RCA and Zenith declined to produce the TVs it required: they were already operating at full capacity because of the Vietnam War–era boom. To assist Toshiba, Sears provided Warwick designs. In 1965, Sears added Sharp as an OEM supplier. As the leading U.S. retailer, Sears's decision to purchase CTVs from Japanese firms confirmed their price competitiveness and quality. With the Sears contract, other retailers soon followed: after 1966, J. C. Penney bought, on an OEM basis, from Matsushita; Montgomery Ward commenced importing televisions from Sharp; and Sears switched from Sharp to Sanyo (Porter 1983: 468). The other smaller retailers also purchased from Japanese manufacturers.

Two critical factors for Japanese success were the favorable exchange rate of 360 yen to the U.S. dollar and low Japanese labor costs. This was significant, as television assembly was still labor intensive. The magnitude of the difference in 1968 can be seen in the hourly wage for production workers. In 1968, the Japanese hourly television factory wage was $.50 per hour, versus $2.72 in the United States. In 1970, the estimated total production costs for a television were about 20 percent lower in Japan than in the United States (Peck and Wilson 1991: 203).

Simultaneously, electronics parts imports increased because of overseas pro-

duction by U.S. parts makers and the greater use of foreign parts. U.S. assemblers were now dependent upon Japanese parts. These changes seriously affected employment in the U.S. consumer electronics components industry, which fell from the November 1966 peak of 179,000 to 122,000 in March 1970. In 1966, when the U.S. Customs Court ruled that duties on imported Japanese receiving tubes should be raised almost sixfold, U.S. assemblers lobbied Congress to rescind the increase (*Television Digest* 1966: vol. 6, no. 23, p. 7). The U.S. assemblers believed that their fate was separable from that of their U.S. suppliers. The importance and quality of Japanese components prompted *Television Digest* (1966: vol. 6, no. 38, p. 7) to conclude: "Busy Japan is a far cry from low-cost, high-labor content bargain basement of a decade ago. It is now an essential supply station for the U.S. electronics industry." Parts suppliers such as Murata and Toko, which began in the 1950s by innovating new parts for transistor radios, soon turned their attention to TV components (*Television Digest* 1965: vol. 5, no. 44, p. 6). In effect, Japanese parts makers had become integrated into the U.S. assemblers' value chain.

These developments were summed up later by Developing World Industry and Technology, Inc. (1978), which concluded that "it is [the Japanese] evolving capability that has enabled them to move progressively into increasingly complex and sophisticated production and to effectively utilize their widespread network of small-scale parts suppliers to progressively penetrate internationally competitive markets." Japanese TV manufacturers benefited from a supplier infrastructure that evolved with them to become world-class firms.

In the mid-1960s, the U.S. industry began relocating their operations offshore. The movement was propelled by two factors. The first factor, and the one we examine in greatest detail, was the increasing competition from low-priced Japanese imports. A second factor was the labor shortages arising from the fact that the U.S. economy was operating at full capacity servicing the Vietnam War and the Great Society. The first U.S. firms to move offshore were the parts suppliers that were under pricing pressure, because their customers were purchasing from Japanese suppliers. The two countries receiving the greatest investment were Taiwan and Mexico. Other U.S. firms, including assemblers seeking low-cost labor to produce labor-intensive components, soon followed (Moxon 1973; Lowe and Kenney 1999).

The savings from offshore production were only 5–10 percent. For example, in 1977 when Zenith decided to move a major part of its operations offshore and laid off 25 percent of its U.S. workforce, it expected to reduce costs by only $10 to $15 per color television receiver (Porter 1983: 497). And yet, a 5–10 percent reduction of costs could mean the difference between making a profit or suffering a loss. This was especially true in the smaller, less expensive sets that were often loss leaders.

Television subassembly imports increased in value from $23 million in 1971 to $176 million in 1976 (U.S. International Trade Commission 1977: A26–A28), while televisions entering under TSUS (Tariff Schedules of the United States) item 807.00 increased dramatically.[4] In 1971, 33 percent of the completed monochrome televisions sold in the United States were imported under TSUS 807; by 1975 this had reached 53 percent and continued to climb. For color televisions, imports grew from 2.5 percent to 5.8 percent. However, there was one other development—namely, the total percentage of TSUS parts exempted in televisions dropped, indicating that foreign parts were being substituted for exported U.S. parts. Moving offshore to decrease labor costs, U.S. firms discovered that inputs were also less expensive.

Taiwan was the largest Asian recipient of U.S. consumer electronics investment. In the 1960s the only attractant for U.S. firms to Taiwan was inexpensive labor and various government incentives, because there was no infrastructure for electronics production. And yet, U.S. investment grew rapidly. In 1962, the first major supplier to produce offshore, General Instrument Company, commenced operations to produce tuners and other parts in Taiwan with 500 employees. By 1969, it employed 7,200 and paid them an average hourly wage of 10 to 15 cents per hour. Simultaneously, General Instruments closed three factories in New England (Morganstern 1970: 2909). According to the president of a small firm supplying ferrite cores to General Instruments, when General Instruments decided to relocate to Taiwan, his firm's sales declined from $388,000 in 1966 to $240,000 in 1969 to less than $100,000 in 1970 (Stanwyck 1970: 3018).

Even as U.S. firms invested in Taiwan, Japanese firms also moved B/W television production offshore. As prices dropped from 1971 to 1973, virtually all assembly of Japanese B/W televisions relocated to other Asian sites, especially Taiwan (Gregory 1985: 13). Taiwan had an ideal situation because it received investment from the Japanese consumer electronics companies that were winning in global competition and from the U.S. firms that were trying to survive. This permitted Taiwan's infant electronics firms to form technological and marketing alliances with firms experiencing two different industrial logics. Through participation in joint ventures, local Taiwanese firms observed and learned new technologies, internalized new production processes, and participated in the rapidly changing international electronics industry (Zenger 1977). U.S. assemblers increased their parts purchasing from Taiwan's growing supplier base, further encouraging its development. The rising capabilities of Taiwanese suppliers corresponded with and accelerated the decline of the U.S. supplier industry.

The 1970s through 1987—The Television Transplants

This period was one during which the pillars of the U.S. television industry, including General Electric, RCA, Zenith, and Magnavox, experienced their

terminal decline because of Japanese competition (see Nevin [1978] for the Zenith perspective). Given the level of rhetoric and the amount of apparent activity in Washington, both on Capitol Hill and in the International Trade Commission, it seemed likely that significant fines, duties, or quotas would be placed on CTV imports. In 1977, the pressure by domestic manufacturers resulted in an agreement between the Japanese and the U.S. government to create a "voluntary" Orderly Marketing Arrangement (OMA) for three years. Under the terms of the agreement, Japan could export only 1.75 million color television sets (1.56 million completed and 190,000 unassembled) to the United States (Gregory 1985: 144). The OMA also restricted imports of nine basic parts, including color picture tubes (CPTs). According to Robert Strauss, the U.S. negotiator, the agreement was meant to encourage Japanese manufacturers to invest in the United States. Most certainly, it increased pressure on other Japanese manufacturers to follow the lead of Sony, Matsushita, and Sanyo, which had already established assembly facilities in the United States. A substantial portion of the financial benefit created by the OMA was captured by the Japanese assembly factories in the United States, thus negating most of the expected positive benefits for U.S. producers (Peck and Wilson 1991: 209f).

In 1971, the fixed dollar-yen exchange rate ended and the yen appreciated—thereby hampering the competitiveness of Japanese imports. Also, wages increased rapidly in Japan, further contributing to a shift in the economics of exporting to the United States. Still, with the exception of Sony, the Japanese firms were "reluctant multinationals" (Trevor 1988). Beginning in 1972, Japanese firms opened—or, in the case of Sanyo and Matsushita, acquired—a total of fourteen television assembly factories in the United States (See Table 4.4). Initially these factories were proverbial "screwdriver" factories utilizing production equipment and many components from Asia. For the most part, the CPTs were purchased from U.S. vendors.[5]

Almost immediately after the Japanese OMA was implemented, Taiwanese and Korean exports to the United States increased, and in 1979 those nations acquiesced to an OMA. The result was that Korean and Taiwanese imports were stabilized; however, Japanese firms, which had been especially active exporters from Taiwan, rather quickly relocated their low-end television production to Southeast Asia. This illustrates the difficulties of using bilateral Orderly Marketing Arrangements; the sanctions were applied to nations, but the exporters were multinational firms and were able to quickly shift assembly to other nations.

By the mid-1980s, few U.S. consumer electronics firms remained in Taiwan. Many U.S. assemblers had left the television business. Also, wages in Taiwan had

TABLE 4.4
The Status of Japanese Television Assembly Plants in the U.S. as of 1999

Company	Location	Start of operation	Type of operation	No. of employees, 1999	No. of employees, 1988	Products	Maquila	Operations
Sony[a]	San Diego, CA	1972	Startup	0	1,500	TVs, CTRs, monitors	Yes	TV assembly moved to maquila
Matsushita	Franklin Park, IL	1974	Acquisition	0	800	TVs & PTVs	Yes	Closed moved to maquila
Sanyo	Forrest City, AR	1976	Acquisition	400	400	TVs	Yes	Most production in maquila
Mitsubishi	Santa Anna, CA	1977	Startup	0	550	PTVs	Yes	Merged with Georgia factory
Toshiba	Lebanon, TN	1978	Startup	900	600	TVs & microwave ovens	Yes	Expanding maquila
Hitachi	Anaheim, CA	1979	Startup	0	900	TVs & VCRs	Yes	Closed moved to maquila
Sharp	Memphis, TN	1979	Startup	900	770	TVs & microwave ovens	No	Expanding maquila
JVC	Elmwood Park, NJ	1982	Startup	0	100	TVs	Yes	Closed moved to maquila
NEC	Mcdonough, GA	1985	Startup	0	400	TVs	No	Closed
Matsushita	Vancouver, WA	1986	Startup	250	200	VCR-TV Combo	Yes	Stable
Mitsubishi	Braselton, GA	1986	Startup	0	300	TVs & mobile telephones	Yes	Closed moved to maquila
Orion	Princeton, IN	1987	Startup	110	250	TVs	No	No
Pioneer	Chino, CA	1988	Startup	100	0	PTVs	No	No
Sony	Mount Pleasant, PA	1992	Startup	800	0	TVs & CRTs	Yes	Large screens only

Source: Electronics Industry Association 1989, Ohgai. 1997, and various sources.
[a] No longer assembling televisions; now producing CRTs and computer monitors and other items.

increased significantly and were soon comparable with those of Mexico. The U.S. television firms had by this time largely discontinued operations in Asia and expanded facilities in Mexico.

U.S. Assembly Moves to Mexico

By the 1990s, the price wars made it apparent to all assemblers, including the Japanese, that continued production in the United States would be difficult. So

even as Japanese and European firms expanded their CPT production in the United States they began relocating assembly to Mexico. During the 1990s, the number of televisions imported from Asia declined as Mexico's production increased. By the late 1990s, an entire production complex in northern Mexico had developed that was capable of producing nearly all the inputs for a television (including some CPTs). In the process, the number of televisions assembled in the United States declined.

The current dominance of Mexico as a site for television assembly was the result of a nonlinear, multicausal series of events. Mexico's Border Industrialization Program (BIP), initiated in 1965, provided financial incentives and freedom from import duties to foreign firms willing to locate factories (that would come to be called maquiladoras) in Mexico's low-wage border region on the condition that all production was exported. U.S. firms used U.S. tariff schedules 806/807 to avoid duties on the inputs exported from the United States. Under the BIP, cities along the U.S.-Mexican border, and later those in Mexico's interior, could establish free trade zones (Lowe and Kenney 1999).

These plants were located close to the U.S.-Mexican border because of the initial requirements of the Mexican law (Sklair 1993). Yet, even after the entire country was opened for investment, consumer electronics operations opted to stay close to the border. The reasons for this were superior access to U.S. suppliers and infrastructure, proximity to customers, and the firms' focus on the U.S. market. The U.S. consumer electronics firms used their Mexican production facilities to produce components (forty-three of forty-seven consumer electronics maquiladoras focused on components from 1966 to 1973). Four television assemblers, Warwick, GTE, Magnavox, and Teledyne, also joined this first wave of investment, but initially they undertook only subassembly (*Television Digest* 1974: vol. 14, p. 49).

Because of these investments, Mexico rapidly became an important parts supplier to the United States. Often these imports were entirely intrafirm—that is, a U.S. firm sent a set of parts to its maquiladora, where they were assembled and then shipped back to its U.S. factory. The dimensions of this trade were large. For example, from 1968 to 1977, Mexico was the largest source of television tuners. Similarly, in the early 1970s, Mexico was the number one exporter of tantalum capacitors to the United States (*Television Digest* 1971: vol. 11, no. 6, p. 4). Sears's Warwick subsidiary was one of the first television assemblers to aggressively exploit inexpensive Mexican labor. Warwick was partially owned by Sears, and its production was almost entirely dedicated to Sears and Roebuck. Despite the close relationship, Warwick faced constant price pressure because Sears purchased from other vendors (in this period, the other vendors were Japanese, and later they would be Korean).

In 1966, Warwick was the first U.S. manufacturer to open an assembly plant in Tijuana to produce for the U.S. market. In this factory Warwick assembled 12-inch B/W televisions (a product under severe competitive pressure from Asia). In 1968, it opened a second plant in Tijuana to produce television parts (ibid. 1969: vol. 9, no. 12, p. 7; Sklair 1993: 51). A third Warwick plant was opened in 1974 in Reynosa, Mexico (Sklair 1993: 51). Although Warwick had only 7 to 9 percent of the U.S. market share, it was the largest assembler in Mexico until the mid-1970s. With increasing costs in Taiwan, other important firms including General Instruments, Motorola, RCA, and Zenith opened plants in Mexico. And yet, until 1973, these new plants (the exception being Warwick) produced only components. For example, RCA opened a deflection yoke plant in Ciudad Juarez in 1969, and Zenith opened two parts plants in Matamoros in 1971.

Mexican production gradually shifted away from simple component assembly as many U.S. parts suppliers exited the industry. Also, the number of final assembly plants increased. By the late 1970s, Mexico's role had evolved from being a parts supplier and exporter of B/W televisions to assembling both the CTV chassis and television kits. Companies such as RCA, Sylvania, and Zenith had their Mexican plants assemble incomplete sets. This was determined partially by import restrictions requiring U.S. producers to assemble the final product in the United States to avoid high tariffs.

The U.S. and Mexican tariff regulations affected the spatial organization of production. In Mexico, U.S. firms could secure Japanese and Taiwanese parts duty-free, because of tariff laws written to protect U.S. firms assembling overseas. Higher tariffs were placed on many parts and components rather than preassembled or semiassembled televisions shipped into the United States. For example, the duty on a television tube was higher than on a finished television. Therefore, U.S. firms would purchase the tubes in Asia, assemble much of the television in Mexico, and do final assembly in the United States (Ohgai 1996). These purchases strengthened the Asian infrastructure. Trade rules that had been developed to protect high-value items, particularly the television tube, had the ultimate effect of accelerating the erosion of the U.S. parts infrastructure.

By the early 1980s, a new shift in the global television value chain was underway. For the most part, U.S. manufacturers had relocated television assembly from Asia to the Mexico-Texas border. For the remainder of the 1980s and into the 1990s, U.S. manufacturers (and those acquired by European firms) continued to move assembly operations into Mexico. During the 1980s, pricing pressure on Japanese manufacturers increased, as did trade friction. In response, the Japanese followed the American firms to Mexico.

Mexico was attractive to Japanese firms, also. Most obviously, Mexico of-

fered inexpensive labor coupled with free trade zone status. There were other benefits, such as a fairly lax taxation system, and less stringent environmental, health, and safety regulations. For the Japanese, Tijuana had significant advantages over the Texas border, where the U.S. firms had clustered. First and foremost, it was close to the Pacific Ocean shipping lanes, allowing easy access for many parts imported from Asia. These parts landed in Los Angeles or Long Beach, where duties were paid (or not paid and trans-shipped) and then re-exported to Mexico. Moreover, the Southern California area already hosted Sony, Hitachi, and Mitsubishi Electric. Also, San Diego was a much more desirable domicile for the Japanese expatriates who would establish and manage the maquiladoras. Still, at that time, Tijuana's industrial infrastructure was poor, and there were few trained workers—but the advantages outweighed the disadvantages. Curiously, Warwick had been operating chassis assembly factories in Tijuana since 1966, but the operations were closed in 1977, when Warwick was purchased by Sanyo (Kenney and Florida 1994; Lowe and Kenney 1999). So, in 1980 there was little electronics production in northwestern Mexico.

In 1980, Matsushita opened a small chassis assembly operation in Tijuana that would be the seed of what evolved into the largest cluster of television assembly operations in the world. In the early 1980s, Sony, which had a television assembly and CPT factory in San Diego, used a subcontractor in Tijuana to undertake labor-intensive activities. The initial activities in Tijuana involved low technology and were labor intensive. And yet, the Tijuana factories were not static; they would evolve. During this period, often, there was a division of labor between the United States and the Mexican factories known as the "twin plant" arrangement. However, twin plant proved to be a misnomer, because the overwhelming tendency was for the U.S. plants to shrink while the maquiladoras grew. Frequently this resulted in the closure of the U.S. factory in favor of its Mexican counterpart, though that was not always the case. For example, the Sony San Diego factory began by assembling televisions, then gradually transferred its various assembly operations, first to its Tijuana facilities and later also to Mexicali. Sony San Diego graduated to cathode ray tube (CRT) production, R&D, and the assembly of various other Sony products.

The Japanese assemblers were not the only firms to relocate. After their abortive attempts to begin assembling televisions in the United States, the Korean assemblers, driven by rising wages in Korea, the rising value of the won, and ferocious competition in the U.S. market, also opened factories in northern Mexico (Choi and Kenney 1997). In these factories the Korean firms assembled televisions on an OEM basis for various U.S. retailers and also supplied smaller televisions to their Japanese and European competitors.

The Japanese and Korean assembly plants opened in Tijuana with only a few

accompanying suppliers. Their operations were geared to receive components, either from Asia or the United States, assemble them, and then ship them to their U.S. counterpart plants for final assembly. But given the labor cost advantages and continuing trade friction with Asia, the transplants deepened their production, and in the process offered opportunities for Japanese or Korean suppliers to relocate to Mexico to supply them.

The first foreign assemblers to leave the United States were the Taiwanese. For the Taiwanese, this marked their abandonment of the global television business. Korean firms followed the U.S. and Japanese manufacturers and established assembly factories in Mexico. While Japanese firms established Mexican factories, they tenaciously tried to retain their U.S. factories. But by the early 1990s, most Japanese firms concluded that television assembly in the United States would never become profitable; they closed their U.S. factories and transferred the remaining production to their Mexican factories.

Zenith, the final U.S. manufacturer, succumbed to competition in 1998, when the Korean firm LG (Lucky-Goldstar Electronics) increased its ownership to a majority position. But even this investment was insufficient, and Zenith filed for bankruptcy in late 1998. LG absorbed the remainder of Zenith and closed its manufacturing facilities in the United States and in Mexico, with the exception of one Mexican assembly operation. The Zenith closing cost approximately 2,000 U.S. jobs (Wolinsky 1998; Zenith Electronics 1998).

The two major European producers, Thomson and Philips, had large U.S. operations. Thomson Electronics of France had the largest North American market share, as the result of its 1987 acquisition of GE's television operations (GE had purchased RCA's operations in 1985). The acquisition was meant to build sufficient scale to compete with the Japanese.[6] This scale was reached, but both the newly purchased GE operations and Thomson's European operations continued to lose money and market share. During the 1990s, to offset these losses, the French government repeatedly provided subsidies to Thomson. In 1996, wearying of the seemingly endless subsidies, the French government accepted a bid from Daewoo and the French defense contractor Lagerdere. This bid intended to split Thomson's profitable defense electronics operations from the money-losing consumer electronics division. In order to accomplish this the defense operations would be merged with Lagerdere and the consumer electronics division would be absorbed by Daewoo. Because of French public pressure and union concerns, which centered upon the threat that Daewoo would lay off French workers, the proposed sale was blocked and Thomson remained French.

In 1998, in an effort to lower costs, Thomson closed the former RCA television assembly factory in Bloomington, Indiana, which was once the world's

TABLE 4.5
Television Assembly Plants in U.S., by Location, Product and Employment, 1999

Firm	Location	Products	Employment
GC Capital	Knoxville, TN	All sizes	800
Matsushita Kotobuki	Vancouver, WA	TV/VCR Combo	500
Orion	Princeton, IN	All sizes	110
Sanyo	Forrest City, AR	All sizes	300
Sharp	Memphis, TN	All sizes	900
Sony	Mount Vernon, PA	Projection televisions	300
Toshiba	Lebanon, TN	All sizes	900

Source: Author's compilation.

largest color television factory, and where mass production of the color television first began. The closure cost 1,100 jobs (Nickell 1997), and came despite the fact that Thomson controlled approximately 20 percent of the U.S. market. After 1999, all Thomson televisions sold in the North American market were assembled in Mexico. Finally, in 2001, Thomson's television operations returned to profitability on the basis of its large share of the U.S. market and global cost cutting.

Philips's U.S. operations were the result of its purchases of Magnavox in 1974 and GTE/Sylvania in 1980. Through these purchases, Philips acquired assembly facilities and a CPT factory in Ottawa, Ohio. With the purchase of Magnavox, Philips inherited a large assembly complex in Ciudad Juarez and a complex of factories in Chattanooga. In the late 1990s, Philips also fell victim to the difficult environment. Curiously, its response differed from that of most firms: rather than closing its U.S. facilities, it spun them off to their managers and provided them with medium-term contracts. These factories no longer produce televisions, and Philips production is now all in Mexico.

By 2002, only seven U.S. assembly factories remained in operation. Of these only three were large facilities (see Table 4.5). The Sanyo facility in Arkansas had shrunk to a minimum economic size, and remained open at the insistence of Sanyo's most important customer, Wal-Mart. With the exception of the Sony large-screen television factory in Westmoreland County, Pennsylvania, serving the East Coast, all the remaining U.S. factories had sister plants in Mexico. Given the difficult competitive environment, the U.S. factories' survival seems dubious, particularly because the Mexican plants were profitable and could draw upon a growing transplant supplier base.

The 1990s were difficult for CTV manufacturers. Low-cost imports from Southeast Asia and Korea were joined by imports from rapidly expanding Mexican factories, driving prices down. This was exacerbated by the increasing importance of electronics superstores, such as Circuit City and The Good Guys,

and retailers, such as Wal-Mart and Target that demanded large discounts in exchange for large volume. High wages and benefits made the U.S. factories uncompetitive, and these factories relocated to Mexico to take advantage of the maquiladora program.

Suppliers

With little support from either the government or U.S. assemblers, U.S. suppliers collapsed. In contrast, Asian and especially Japanese suppliers captured increasing market share as they supplied Asian and U.S. assemblers. Only a few of the Asian suppliers followed their customers to North America, preferring to ship parts from Asia. However, a continuing increase in the value of Asian currencies made labor costs in Mexico ever more attractive. Also, the assemblers demanded cost savings and rapid responses to demand. Thus as Mexican television assembly increased, Japanese suppliers began relocating to Mexico.

With a few exceptions, Japanese parts suppliers had not made extensive investments in the United States. For those that had U.S. factories, they were often not unprofitable. The initial response was to subsidize the U.S. operations, but as the assemblers relocated to Mexico it was pointless to remain, so all activities were consolidated into the maquiladoras. For example, a plastic parts maker, Kyowa Electric, had operated a factory in Anaheim, California, since 1986 to supply local Hitachi and Mitsubishi plants, but in 1994 it felt compelled to open a factory in Tijuana, Mexico. In 1998 it closed its Anaheim factory and moved its remaining operations to Mexico, and then opened a branch factory in Mexicali. In another case, a Japanese plastic molder had established a factory in Dalton, Georgia, to supply Mitsubishi in Georgia and Thomson in Indiana. When these factories announced their closure, the plastic molder also closed and moved to Tijuana. Other Japanese suppliers repeated this pattern as they followed their customers.

Suppliers' locational decisions are always contingent upon a variety of factors. However, all factors being equal, proximity to customers is beneficial. For the most part, the U.S. television maquiladoras in the Ciudad Juarez area operated integrated facilities, so suppliers were not as significant. In contrast, Asian producers were far more dependent upon their suppliers. In other words, U.S. manufacturers did not mind operating internal parts operations. Japanese firms, on the other hand, were more comfortable outsourcing such activities. The initial Japanese assembly operations did not attract parts suppliers; however, in 1986 a new wave of Japanese assemblers relocated operations to Tijuana, and Matsushita upgraded its chassis production (i.e., stuffing a printed circuit board) to full television assembly. Chassis production does not require local suppliers, because the components are small and can simply be delivered in bulk. However, the television assembly has different logistical requirements. For

example, plastic and wood cabinets are bulky but relatively low value-added, meaning that transportation costs can be prohibitive. Fortunately, a factory for their production is relatively inexpensive ($5 million). In contrast, other components such as the CPT are not only bulky but are also high value-added and must be produced in capital- and scale-intensive facilities. CPT production benefits from economies of scale, and, unlike cabinet production, the capital investment for a new factory is high.

In 1987, the initial wave of independent Japanese parts suppliers arrived in Tijuana. The cabinetmakers were in this group; often they relocated because of encouragement and even pressure from the assemblers. Wire harness producers also began operations, as their production is extremely simple but labor intensive. Even a Japanese firm producing the shaped styrene foam used in packaging televisions began operations. The first wave of supplier investment created a rudimentary division of labor.

The difference between Tijuana and Ciudad Juarez was striking. Ciudad Juarez received far less supplier investment, either American or Asian. In 1987, Murata Electric established a maquiladora to manufacture deflection yokes replacing U.S. and Asian imports. In 1988, Taisho Electric built a factory in Ciudad Juarez to build television coils, and in 1989, TDK established a factory to build coil components for autos and televisions; few other suppliers arrived, however, and they were in insufficient numbers to create the synergistic clustering effects that would be experienced along the California border.

An important deepening of the Tijuana parts infrastructure occurred in the early 1990s, when two of the largest television component manufacturers in the world, Sanyo Industrial Components and Matsushita Industrial Components, established operations in Tijuana. They produced deflection yokes, flyback transformers, and many other television-related parts, not only for their own assembly operations but also to supply other television assemblers. They would soon be joined by another global giant, Samsung. These operations did not displace U.S. production, which was already minimal, but rather replaced Asian imports.

The Korean assemblers arrived in the late 1980s and began their operations using parts imported from Korea. In the early 1990s, they began purchasing some components locally from Japanese suppliers, even as they established their internal component-making operations and encouraged their Korean suppliers to relocate to Mexico. Almost paralleling a process that Japanese assemblers had begun five years earlier, the Koreans began warning their suppliers that production would be moved out of Korea, and it would no longer be economically feasible to use components imported from Korea.

In 1991, the rudiments of an industrial cluster were apparent in Tijuana; however, it proved to be only the beginning, as the number of televisions pro-

duced increased further. The 1994 ratification of NAFTA accelerated a general relocation to North America, because it stipulated that all televisions must contain 62 percent North American content to be accepted for duty-free status. NAFTA also had a clause effective in 2002 discontinuing the Mexican policy of allowing the import of CPTs duty-free provided they were then re-exported in a television. These requirements pressured Asian television firms to increase their North American content. For the Japanese firms, this was not so difficult because they already had begun producing CPTs in the United States and were purchasing other CPTs from Thomson and Philips. For the Korean firms, which were importing many parts from their Asian factories, NAFTA's passage required more dramatic action, if they did not want either to pay high import duties or purchase parts from their competitors.

The Korean response was to deepen their operations by building CPT factories in Mexico. Each Korean firm established an integrated production complex producing all the television components except for sophisticated integrated circuitry. This strategy meant that the Korean firms made investments an order of magnitude larger than they had in their initial assembly facilities. Samsung invested over $500 million in its Tijuana television production complex, which now manufactures CPTs and components and assembles televisions. LG invested $300 million and Daewoo invested $260 million so they could also produce CPTs, components, and televisions.

During the 1990s, the number of Japanese and Korean television parts suppliers swelled. Soon they began establishing operations in Mexicali because of the lack of new factory space and increasing wages in Tijuana. In 1999, there were at least twenty-one Japanese and eight Korean television parts suppliers in Tijuana, and twelve Japanese and nine Korean television parts suppliers in Mexicali. The suppliers were not the only firms to relocate operations to Mexico. When Matsushita closed its Chicago facility (which it had purchased from Motorola) in 1995, a U.S. plastic parts firm, Mulay Plastics, also moved to Tijuana.[7]

Employment in the consumer electronics maquiladoras can only be estimated, because growth has been rapid and there is no single reliable source for employment. However, in 1998, Thomson, Philips, and Toshiba employed approximately 22,000 Mexicans in their factories along the Texas border. The Japanese and Korean firms employed another 30,000, mostly along the California border. In total, the consumer electronics assembly maquiladoras employed approximately 52,000 Mexicans. Another significant source of employment were the no less than sixty-seven parts suppliers that, with a conservative estimate of 200 employees each, hired another approximately 13,400 persons for a total of more than 65,000 employees.

Television assembly in North America shifted to Mexico, while imports from

Asia continue to decline. In 2001, Mexico produced more TVs than the United States; however, the average cost of the televisions produced in the United States was higher (in large part, because they were larger). Similar statistics by tube size were not available for other years. However, in 1997, North American television demand was for 27.2 million units; of these 21.4 million were produced in Mexico, 3.8 million in the United States, and 2 million in Asia (BANCOMEXT 1999). With the 1998 closure of the Mitsubishi factory another 700,000 mostly large-screen televisions shifted to Mexico. The 1998 opening of a Sharp television factory in the Tijuana area further shifted production to Mexico, though the Mexican factory has not led to the closure of the Sharp factory in Memphis, Tennessee.

In 2000, it was possible to purchase nearly all the components needed for assembling a television in northwestern Mexico. Moreover, for most components there were multiple sources. In other words, the environment became richer and more complex, thereby increasing its attractiveness. The only components not available locally were the sophisticated digital signals processing chips and some CPTs, but the situation for CPTs was changing. In other words, the region had become the center of television assembly in North America, and it has developed many of the agglomeration economies associated with an industrial cluster.

Color Picture Tubes

The single most critical and highest value-added component in a color television is the CPT, which is also the last tube left in the television—and as Murtha et al. argue in Chapter 7, will be phased out over the next decade. The location of CPT facilities is determined by a matrix of the following considerations: proximity to glass production, TV assembly plants, and transportation nodes; availability of skilled labor; and decent utilities. Global-class CPT factories were concentrated in Europe (France, Holland, and the UK), North Asia (Japan, Korea, Taiwan, and China), Southeast Asia (Singapore, Malaysia, and Thailand), and North America (U.S. Midwest and northeastern Mexico). There were two concentrations of CPT production in North America, one in the Midwest and another in northwestern Mexico. The concentration of operations in Ohio and Pennsylvania was the remnants of the U.S. television industry, which had been clustered in the Midwest. Increasingly, as in the case of televisions, CPTs were no longer being transported between continents, even while trade between countries in the same macro-region increased.

The capital investment in a CPT factory was determined by a number of variables including size, the number of production lines, the type of tube (di-

rect view or projection), and the size of the tubes produced. Smaller tube sizes, in general, required less expensive factories. The initial investment for larger screen televisions (25-inch and greater) was between $200 and $300 million, and a typical factory employed between 500 and 1,000 persons. For example, in 1988 it cost Matsushita $150 million to build its Troy, Ohio, factory with an annual capacity of 2 million tubes. In 1986, Toshiba spent $220 million to refurbish and expand the Horseheads, New York, CPT factory (Khurana 1994: 89). To be viable, the operational capacity of a new plant should be more than 1.5 million tubes per year. The most expensive lines were required for tubes larger than 30 inches and with rectangular screens (16 x 9 aspect ratio) and ultraflat face panels. The larger CPTs are more difficult to produce because there is a greater defect probability. As in any capital-intensive process, high yields are the key to profitability.

Corporate strategy regarding the building of new CRT production facilities is complicated by the seemingly inexorable erosion of market share by Flat Panel Displays. The FPD will eventually make the CRT obsolete, and likely in the process will result in a shift of that production to Asia. Thus these U.S. factories are probably doomed to closure in the next decade.

In contrast to television assembly, CPT production is automated, capital intensive, and requires a skilled labor force including significant numbers of technicians and engineers. Because of the large capital investment and required technical capabilities, there were fewer firms producing CPTs than assembling televisions. The picture tube was an important part of the total cost of a television. Through time this percentage has increased because the tubes were being improved to have flatter faces, more nearly perfect rectangular shapes, and shorter necks, while most of the other components declined in price. Profitability for the smaller tubes was low, because they were easier to make and there was price competition; gradually, Japanese and European manufacturers abandoned those segments.

The CPT production geography differed from that of television assembly. In contrast to the large number of television assembly plants globally, in 2001 there were only twenty-three companies producing CPTs of any kind, and only ten producers were significant. In total, there were approximately fifty major CPT production facilities globally. With the exception of Southeast Asia, Taiwan, Korea, and, most recently, China, there were no leading-edge CPT production facilities in developing countries, though in the late 1990s Korean manufacturers and Mitsubishi had begun operations in northwestern Mexico. Globally, of the currently operating factories, more than 60 percent were owned by Japanese companies, an increase from 10 percent in 1970 (ibid.: 67), though by 2001 Japanese firms were abandoning production facilities on account of Korean com-

petition. In 1985 there were more than twenty CPT factories in the United States (ibid.: 66), compared with only eight in 1999; the sole factory in Canada closed in 1998.

In the 1970s prior to foreign producers' entry into the United States, RCA, GTE-Sylvania, Zenith, and National Video Corporation controlled the U.S. color tube market (MIT Commission on Industrial Productivity 1989: 48). U.S. CPT industry employment peaked in 1967 with total employment of 27,600. In 1999, U.S. CPT factories employed approximately 11,000 persons—a significant decline from the 13,000 employed in 1997. The most recent losses were due to the 1998 closure of the Zenith factory. In March 2002, Hitachi announced that it would end CPT production in its Greenville, South Carolina, factory (Landers 2002). Total employment will continue to decrease, because no new CPT factories will be built in the United States, and older ones will close as consumption shifts to FPDs.

In the last twenty years, there has been a significant shift in the world's leading television tube-makers that has mirrored the changes in television assembly (see Table 4.6). In 1981 three U.S. makers and five Japanese makers were in the top ten. By 1995 the rankings had changed dramatically, as there were no longer any U.S. firms in the top ten, and the Japanese maker Mitsubishi had fallen out of that group. During the last three decades, some U.S. factories have closed, and foreign firms acquired the others. The most notable development has been the growth of Korean manufacturers (Kenney 1999a).

The three Korean tube producers Samsung, LG, and Daewoo are also television assemblers, and they did not cross-source tubes, though they all supplied non-Korean firms. Taiwanese firms entered the television tube market in the 1970s, but with the exception of Chungwha (a company related to Tatung) dropped out or switched to computer monitor production in the mid-1980s. So entry into CPT production has been limited. Korea was successful because its companies had access to massive low-interest government loans and captive in-house television assembly operations that guaranteed a market for a portion of the capacity. Finally, their most significant competitor, Japan, was hobbled in the low end of the market because of rising labor costs and an appreciating yen. These conditions permitted Korean firms to capture market share and expand operations (ibid.).

In the late 1990s, a number of CPT factories were opened in northwestern Mexico. These were an important deepening of the Mexican television production infrastructure. Samsung's aims were particularly ambitious: it built the largest CPT factory in the world in Tijuana. Further, a joint venture of Corning, Samsung, and Asahi Glass established a glass bulb and faceplate factory in Tijuana. Also, NEG, the largest Japanese producer of television tube glass, built a

TABLE 4.6
World's Largest Television CPT Producers in Units, 1981 and 1995

1981 Rank	Company	1995 Rank	Company	1995 Production in million units
1	Philips (Neth)	1	Samsung (K)	30.5
2	RCA (U.S.)	2	Philips (Neth)	19.5
3	Hitachi (J)	3	Toshiba (J)	17
4	Toshiba (J)	4	Thomson (F)	14.7
5	Zenith (U.S.)	5	Sony (J)	11.9
6	Matsushita (J)	6	Orion (K)	11.8
7	Sony (J)	7	Chunghwa (T)	10.4
8	Mitsubishi (J)	8	LG (K)	9.6[a]
9	ITT (U.S.)	9	Matsushita (J)	8.8
10	Videocolor (F)	10	Hitachi (J)	6.9

Sources: Turner 1982; Fukushi 1995.
Note: Countries omitted included CIS, India and Poland
[a]LG purchased 60 percent of Zenith that had production of 4.4 million tubes

neck, funnel, and faceplate factory in Mexicali to serve Mitsubishi, LG, and Daewoo's CPT factories. The investments in these factories are in the range of $200 to $300 million. These glass factories increase the richness of the Mexican infrastructure.

If the past is prologue, the current electronics investment in northwestern Mexico will create a deeper and more powerful infrastructure as the existing firms expand and relocate even more production from Asia and the United States to Mexico. The number of TV imports to North America from Asia (2 million in 1997) should either decline or remain stagnant. Mexico, which already assembles nearly 20 percent of the world's televisions, should continue to increase its exports (BANCOMEXT 1999).

Tube Components and Glass

The television tube glass industry makes the glass neck, funnel, and faceplate that are joined together at the tube factory. The glass industry was globally oligopolized, and there were only a few exits and even fewer entries over the past two decades. The three major independent glass producers were Corning Glassworks, Nippon Electric Glass (NEG), and Asahi Glass. European CPT glass production was integrated within the large television producers, Philips and Thomson. The two major Japanese producers developed their technology through long-standing technical relationships with U.S. glass producers.

In 1980, there were three major U.S. producers, Corning, Owens-Illinois, and Lancaster Glass, supplying glass picture tube bulbs and panels. RCA operated its own tube glass production, though it also purchased from external vendors

(Levy 1981: 107). The U.S. industry was concentrated in Ohio, Pennsylvania, and New York. The history of Japanese glassmakers was nearly the inverse of that of the U.S. firms. After World War II there were no major Japanese tube glass manufacturers. In response to the necessity of importing the glass, the entire tube, or the glass blanks from abroad, Japanese companies entered the growing market for homegrown tube makers. Toshiba (with Westinghouse technology) and Matsushita (with Philips Technology) began producing glass internally. As in the United States, Japan quickly realized that glassmaking was quite different from electronics, and the independent glassmakers displaced the in-house glassmaking operations of CPT and television makers, such as Toshiba, NEC, Matsushita, and Mitsubishi Electric. The two dominant Japanese producers would be Asahi Glass and NEG. Asahi imported technology from Corning Glass. NEG, utilizing technical assistance agreements with Owens Illinois, began production of B/W CPT funnels and panels in 1965. In 1968, with technical assistance from OI, NEG began production of color bulbs and panels (NEG n.d.).

Asahi and NEG had quite different strategies for responding to the movement offshore of Japanese television assembly and then later CPT production. In 1988, Corning and Asahi formed a U.S. joint venture, Corning Asahi Video Products Company, to produce CPT bulbs and panels (Asahi Glass 1992: 26). For this joint venture, Corning contributed its CPT glass facility in College Station, Pennsylvania (Mathew 1993: 11). However, in April 2003 Corning announced it would increase production of CPT glass in North America. In 1995, Asahi, Sony, and Corning created a joint venture to produce glass for Sony's Pittsburgh area television tube facility. In 1988, NEG concluded an agreement with OI to create a 50–50 joint venture, called Techneglass, to manufacture CPT bulbs and panels in the United States. Then in 1993, NEG purchased OI's share of the joint venture, making it a wholly owned subsidiary (NEG 1995). After purchasing OI, NEG embarked on a major investment program to improve the quality and capabilities of its acquired plants, all of which were in Ohio. In 1996, Techneglass supplied glass for nearly 70 percent of North American televisions (Salmon 1996).

There are no statistics available regarding employment in TV tube glass production, and the companies do not provide information. Employment is difficult to calculate because of Corning's secrecy. In 1996, there were approximately 1,600 employees at the NEG Columbus plant, 1,400 of which were union members and the rest salaried (ibid.), though in Ocober 2002, the number had decreased to 750 because of the closure of one production line (Newpott 2002). Total U.S. factory employment in the CPT glass industry has declined during the last forty years. The proportion of the decrease related to imports and that

related to technological change is uncertain. However, there must have been some displacement of U.S. tube glass production, because of the foreign-made tubes imported either in unassembled form or as part of finished televisions. Even though U.S. firms may have decreased CRT production, the total volume of glass processed probably increased in the 1990s as Japanese manufacturers began CPT production and imports dropped. Also, television screen sizes increased, requiring larger bulbs and thus more glass.

Conclusion

The U.S. television industry is often pointed to as an example of the catastrophic consequences of globalization. The reasons for the collapse of the U.S. television industry and then the relocation of the foreign firms out of the United States are complicated. The structure of the U.S. industry with its arm's length relationships with suppliers and loose relationships between manufacturers and retailers is often portrayed as the Achilles heel that permitted Japanese manufacturers to enter the market. This is undoubtedly correct, and when Japanese firms were able to offer less expensive products, both components and completed televisions, U.S. retailers and consumers were willing to purchase them. Whether correctly or incorrectly, the U.S. response was to retreat to higher value-added areas. The difficulty with this strategy was that it meant that improvement in terms of functionality, quality, and production efficiency was mandatory. However, U.S. firms failed in all three improvement areas.

U.S. government protectionism was unable to save the U.S. manufacturers. Protectionism did encourage Japanese firms to establish or purchase factories in the United States. However, the difficult competitive environment meant that Japanese transplants also found it impossible to retain their competitiveness and relocated their assembly factories to Mexico. The attraction of proximity to the assembly plants and the general competition facilitated by a constantly ongoing process of production routinization encouraged the establishment of tube factories and other higher valued-added component production in the United States. However, tube production also gradually relocated to Mexico. By 2000 the locus of the North American television assembly, tube, and component production had shifted to northern Mexico.

For the larger understandings of globalization, the television industry provided interesting insights. As we demonstrated, despite their apparent stability at any given moment, the spatial location of various nodes in the value chain was constantly in flux, though the organizational structure was invariant. Interestingly, the United States never had a clear television or consumer electronics cluster; rather it was dispersed from the East Coast through Chicago. Orga-

nizational competitive advantage continued to be located in the integrated firms, because of their control over branding and distribution channels. In contrast to the PC industry, the television never became a modular product produced by a disintegrated value chain.

Although the television has some resemblance to the PC in terms of components, it does not experience the same pressures of obsolescence. In this respect, television assembly has greater resemblance to the automobile. The production process never was as disintegrated, and there was never an open market for components, despite the fact that television assembly is almost as modularized as PC assembly. The most important threat to the current global configuration of television production is the possible replacement of CPT by the FPD as the viewing device of choice. As the Murtha, Lenway, and Hart chapter indicates, the FPD is rapidly declining in cost and appears to be on a trajectory to replace the CPT. This technology shift could alter the geography of television production, because at this time substantially all FPD production is in Asia—and there is no guarantee that FPDs will ever be produced in North America. It is possible that this architectural shift will transfer substantially all television production to Asia.

Notes

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1. For another version of this shibboleth, see Murtha et al. in this volume.
2. For a discussion of value chains, see Porter (1985). For the commodity chains formulation, see Gereffi and Korzeniewicz (1994).
3. Traditional wisdom says that the EIAJ and MITI bargained on behalf of the Japanese industry, and therefore was able to achieve a much lower price. However, this arrangement was also convenient for RCA, as the EIAJ and MITI policed the agreement and ensured that the fees were paid, thereby simplifying the collection process.
4. TSUS 807 is the customs category permitting U.S. parts to be exported overseas for assembly and then be reimported with duty paid only on the value-added incurred overseas.
5. These CPTs continued to have quality problems even in the late 1980s.
6. "Overnight, Thomson Has the Stuff to Take on the Titans." *Business Week* (August 10, 1987): 36–37.
7. Mulay Plastics is interesting because it also supplies the Sanyo television factory in Forrest City, Arkansas. The relationship with Sanyo can be traced back to Warwick, which was a subsidiary of Sears, based in Chicago. Similarly, Motorola was based in Chicago and sold its television operations to Matsushita.