## Chapter 8

# Electronics

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# Electronics

## SUMMARY

As in the auto industry, government policies have shaped growth, development, and foreign investment in Mexican electronics. By controlling access to its domestic market, Mexico has attracted foreign-owned multinationals who have set up local manufacturing plants. Low-wage labor and preferential tariff treatment have also helped Mexico attract many *maquiladora* plants producing electrical equipment and electronic products such as TVs and telephones. In 1990, *maquiladora* factories sent 4.4 million color television sets to the United States—more than any other producing nation and half of all U.S. imports of color TVs. Growth in Mexican TV production has gone hand in hand with a continuing shift of production out of the United States in search of lower labor costs. In 1991, Zenith, the only remaining U.S.-owned TV maker, began moving its remaining U.S. assembly operations to Mexico.

Limitations in technology, worker skills, and infrastructure will, however, limit development of a more robust electronics industry in Mexico. Electronics fins, particularly those producing computers, telecommunications equipment, and process control systems for business and industry, compete on technological excellence, as do producers of some advanced consumer products like videocassette recorders (VCRs) and projection TVS. These businesses depend on skilled labor, along with design, development, and marketing.

Responsiveness to rapidly changing market demand is also essential in electronics. Production facilities belong near design and marketing teams so that new ideas can be quickly incorporated into products that are often specialized or customized. Mexico's proximity to the United States gives it some advantages over Asian competitors in this respect, but limited skills and research capacity detract from that advantage.

Better technical and managerial capabilities would enable Mexico to move up the development ladder over time. The Mexican university and technical training systems are producing large numbers of graduates, but relatively few can find jobs that provide the kind of experience needed for Mexico to improve its industrial competence. Furthermore, the Mexican Government has all but eliminated incentives for multinationals to produce sophisticated electronics products locally, which promises to slow the pace of development.

In the near term, Mexico will continue to attract mostly labor-intensive electronics production, such as TVs and other standardized consumer electronics products, telephones, and answering machines. There are still many of these kinds of jobs in the United States. U.S. plants employ about 230,000 electrical and electronics assemblers and over 150,000 precision assemblers. The Bureau of Labor Statistics (BLS) estimates that more than 40 percent of these jobs could disappear by the turn of the century. The jobs are at risk from automation and other forms of productivity improvement, including redesigned products that require less labor, as well as transfers of production to low-wage offshore plants. Production of many more-or-less standardized products has already moved out of the United States to the Pacific Rim, Mexico, and the Caribbean. A North American Free Trade Agreement (NAFTA) might accelerate movement of jobs to Mexico somewhat, but Mexico has been pursuing policies to attract labor-intensive production for years; a NAFTA would have only a limited effect on the dynamics in this sector.

## MEXICO'S ELECTRONICS INDUSTRY: DEVELOPMENT AND CAPABILITIES

The electronics industries in the United States and Mexico are becoming increasingly interrelated through trade and investment. U.S. electronics firms have invested in Mexico to take advantage of cheap

[1] This section draws in many places on "NAFTA and the Electronics Industry in Mexico, " report prepared for OTA under contract No. H3-7200 by Patricia Wilson, February 1992. The Wilson report is based on surveys of *maquiladoras* and interviews covering the period 1988 until late 1991, and recent interviews at non-*maquila* electronics plants. This section also draws on "Japanese-Owned Maquiladoras in Mexico, " report prepared for OTA under contract No. H3-7145 by Martin Kenney and Richard Florida, April 1992, which reports on site visits and interviews with Japanese-owned electronics firms in Mexico, both end-product manufacturers and component suppliers, and on interviews in Japan with high-level executives of electronics firms.

**Table 8-l-Government Policies Affecting Electronics Production in Mexico**

| Sector | Policy tools | outcome |
|---|---|---|
| Consumer Electronics. . . . . | • Import substitution through trade barriers, later liberalized.<br>• *Maquiladoras.* | Export-oriented assembly industry dominated by foreign-owned multinational corporations (MNCs). Limited use of local suppliers. Limited domestic sales. |
| Computers. . . . . | • Targeting through informal computer decrees in 1981 and 1987, which created a protected market for MNCs willing to invest in local manufacture. | Production within Mexico by companies including IBM and Hewlett-Packard. Limited integration of local component suppliers. Export of production in excess of Mexican demand, coupled with imports of products not locally produced. |
| Telecommunications. . . . . | • State ownership of TelMex, the national t telecommunications company, accompanied by "buy national" policies.<br>• Market protection through tariff and non-tariff barriers, | Local production by two foreign-owned MNCs, Ericsson and Indetel, with limited imports and exports of finished products. |
| Electrical Equipment. . . . . | • *Maquildadoras.* | Export-oriented firms supplying U.S.-based manufacturers. |
| Suppliers. . . . . | Local content provisions in computer decrees. | Extremely limited supplier network. |

SOURCE: Office of Technology Assessment, 1992.

labor and gain access to a market that was heavily protected until recently. In 1989, the United States was Mexico's leading trading partner in electronics products; Mexico was the sixth largest trading partner of the United States, behind Japan and a number of other Asian countries, but ahead of Canada.[2] In 1991, the sum of U.S. electronics imports from Mexico and U.S. electronics exports to Mexico totaled $12.5 billion, with the United States posting a $1.0 billion deficit.

Electronics generates about 3 percent of Mexico's gross domestic product. There has been a good deal of foreign direct investment (FDI), especially in telecommunications, computers, consumer electronics, and electrical equipment. Factory shipments totaled $6.5 billion in 1989, and employment topped 250,000 workers.[3] But the Mexican industry is dwarfed by that of the United States, which had domestic shipments of over $190 billion in 1989 and employed more than 2 million workers. While employment in U.S. electronics is 8 times that in Mexico, U.S. output is almost 30 times greater, indicating much higher productivity, for reasons that range from higher levels of automation to differences in the types of products manufactured in the two countries.

## *Government Policies*

The Mexican Government has long considered electronics a key industry for the nation's overall economic development and created programs to attract investment. Unlike the auto industry (ch. 7), there was no single comprehensive policy. Instead, the government implemented a shifting mix of policies tailored to different segments of the industry and ranging from strict import substitution to the promotion of exports (table 8-l).

Government efforts to build a domestic industry by simple import substitution were generally ineffective. In consumer electronics, for instance, Mexico found itself with 10 small companies competing to sell components to domestically-oriented TV manufacturers. Total demand could have been supplied by a single producer. With the removal of

[2] *The Likely Impact on the United States of a Free Trade Agreement with Mexico*, USITC Publication 2353 (Washington, DC: U.S. International Trade Commission, February 1991), p. 4-27.

[3] Ibid., p. 4-26.

trade barriers in 1987, imported components flooded in. The percentage of locally manufactured components used by domestically-oriented TV manufacturers dropped from almost 90 percent during the mid-1980s to 10 percent in 1988.[4]

More effective were Mexico's computer programs which used restrictions on local sales in combination with import barriers to attract foreign investment (box 8-A). A number of U.S. companies established facilities in Mexico to gain access to the growing Mexican market-which would otherwise have been denied them-and to other Latin American countries with which Mexico had favorable trade agreements. Major U.S. computer manufacturers, including IBM, Hewlett-Packard, Digital Equipment Corp., and Tandem, established plants in Mexico.

In telecommunications, the government pursued its ends through state ownership, until 1990, of TelMex, the sole provider of telephone service. TelMex limited its purchases of switching and terminal equipment to domestic producers. Together with high trade barriers, this policy attracted investments by Ericsson and Indetel, the first based in Sweden, the second owned by the French company Alcatel.

In keeping with Mexico's overall transition away from an import substitution strategy, trade barriers in electronics have been reduced significantly in recent years. The market for computers has been opened to imports, TelMex has been privatized, tariffs have been lowered to a maximum of 20 percent, and import licensing requirements have been eliminated on many goods, These changes promise to enhance U.S. access to Mexico's markets for electronic products.

Mexico's export-oriented policies-notably the special treatment afforded *maquiladoras—also* attracted FDI in electronics. Many U.S. companies, in particular, invested in *maquila* operations to assemble standardized, labor-intensive products including TVs, transformers, and power supplies. Japanese TV manufacturers have done the same. Because the *maquiladora* program did not include provisions on local content, the sector developed in almost total isolation from Mexican suppliers.

### *The Mexican Industry Today*

Largely as a result of these policies, Mexico's electronics industry consists of two groups of firms with quite different business objectives and capabilities. Both groups are dominated by foreign capital and technology. One produces goods such as computers and telecommunications equipment primarily for the Mexican market (although some computers are exported to meet trade-balancing requirements). The other group produces in *maquiladora* plants almost exclusively for export to the United States. *Non-maquiladora* electronics producers pose relatively little threat to U.S. jobs because they are inefficient, limited in skills, and/or focused on the Mexican market. They produce goods that might, but for the past policies of Mexico's government, be shipped in from the United States. Mexico's domestically oriented consumer electronics industry illustrates this point. As figure 8-1 shows, it is very small, with insignificant exports and considerable imports.[5]

Mexico's production and exports of computers have grown rapidly since 1985, but from a tiny base, so that the industry remains small and many products must still be imported (figure 8-2). Most of the multinational corporations (MNCs) operating in Mexico produce state-of-the-art products (the IBM PS/2, for example), but Mexican manufacturing tends to be limited to routine assembly of final products with components brought in from the United States and the Far East. While Mexico's computer decrees required foreign firms to transfer technology to Mexican suppliers, local content rules were necessarily loose enough to permit imports of critical components. Mexican suppliers provide simple, low-technology parts-housings, printed circuit boards, metal and plastic mechanical parts, cable harnesses, some power supplies, and some discrete electronic components.

The Mexican components industry is small-only about 50 firms, employing some 7,000 people. Local manufacture of semiconductors is limited to discrete

[4]Wilson Perez Nuñez, *Foreign Direct Investment and Industrial Development* in *Mexico* (Paris: Organization for Economic Cooperation and Development, 1990), pp. 92-93.

[5] Tariffs on imported consumer electronic goods were reduced dramatically in 1987. By the middle of 1988, Mexico had stopped producing car radios, audio turntables, and tape decks; speaker production had declined 92 percent. Gray Newman, "Industries vs. Imports: The Gloves are Off," *Business Mexico,* March 1989, pp. 14-19.

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### *Box 8-A—Mexico's Computer Programs*

**In 1981, following a near doubling of computer imports between 1979 and 1980,** Mexico's government issued **a set of unofficial guidelines intended to draw in foreign investments to the computer industry.** Modified in **1987, these "computer decrees" helped** Mexico **attract foreign manufacturers of computers and peripherals.**[1] **The goals included:**

- **domestic production of computers sufficient to meet 70 percent of demand within 5 years;**
- **a greater number of domestically-owned component suppliers;**
- **promotion of exports to achieve economies of scale and generate foreign exchange; and**
- increased **spending on** R&D.

Firms wishing to participate in the Mexican market were required to begin manufacturing in Mexico, meeting specified targets for employment, local content, and trade balancing, and to establish job training programs. Prices were limited to 15 percent above those charged in the firm's home country to prevent manufacturers from taking advantage of the protected market.[2] Microcomputer manufacturers could enter only through minority ownership in joint ventures with Mexican firms. (Apple refused to participate for fear of losing control over its proprietary Macintosh technology in a country with weak intellectual property protection.) The government permitted full foreign ownership of minicomputer operations so long as export requirements were met. Companies could import large computers provided they maintained local production of smaller machines. In return for their investments, companies were protected from import competition through tariffs and import licensing requirements. They also benefited from investment tax credits, low-interest loans, and subsidized utility rates.

Partly in response to pressure by IBM, the government relaxed some of its rules in 1985, codifying the changes in the 1987 decree. Foreign firms were permitted to establish wholly owned affiliates in Mexico for producing microcomputers, provided they complied with foreign exchange, export performance, training, and local content requirements. Import licensing requirements on some components and subassemblies were eased. Later changes eliminated many incentives, while permitting firms operating outside the plan to bring in larger numbers of assembly kits.

In April 1990, the Mexican Government effectively dismantled its previous computer decrees, replacing them with a "program for the Modernization of the Computer Industry' scheduled to run through March 1993. Under the new program, Mexico will move in stages toward an open market. Import licensing requirements will be further eased, tariffs reduced to 20 percent on assembled computers and 5 to 10 percent on parts, and trade balancing requirements removed Manufacturers with plants in Mexico will be allowed to import computers and components duty free up to a limit determined by the level of local content in their Mexican production and their level of investment in fixed assets and R&D.[3] Companies must maintain at least 30 percent local content by value and perform some R&D in Mexico.

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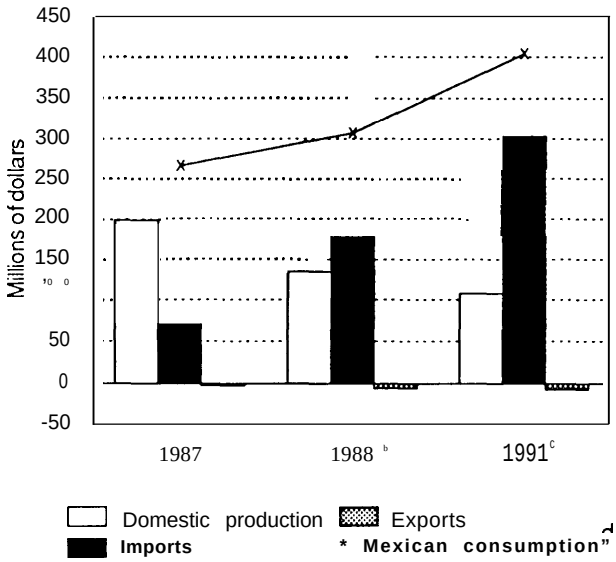
1"The Program for Promoting the Manufacturing of Electronic Computer Systems, Their Main Modules and Their Peripheral Equipment" was never formally adopted by the Mexican government, but administrative authorities followed its guidelines, often modifying thereon a case-by-case basis. *See Economic and Social Progress in Latin America: 1988 Report* (Washington, *DC:* Inter-American Development Bank, 1988), p. 166. Also, Susan Walsh Sanderson and Ricardo Zermeño-Gonzales, "Trade Liberalization in Mexico's Electronics Industry," *Strategic Sectors in Ma"can-U.S. Free Trade,* M. Delal Baer and Guy F. Erb, eds. (Washington, DC: Center for Strategic and International Studies, 1991), p. 72.

2In OTA interviews, some firms stated that they can produce computers at somewhat lower cost in Mexico than in the United States. For others, however, higher prices for locally purchased components lead to increased manufacturing costs. See Wilson Perez Nuñez, *Foreign Direct Investment and Industrial Development in Mexico (Paris:* Organization for Economic Cooperation and Development, 1990), pp. 92-93.

3For instance, companies with local manufacturing facilities established under the old decrees can now import computer equipment and components duty-free up to 80 percent of the level of value added in their Mexican plants. ***Review of Trade and Investment Liberalization Measures by Mexico and Prospects for Future United States-Mexican Relations,*** USITC Publication 2275 (Washington, DC: U.S. International Trade Commission, April 1990), p. 4-8.

components such as transistors and diodes (not integrated circuits) and occurs in *maquiladoras* for export back to the United States. While Mexican-owned firms make parts for locally produced radios, TVs, and other consumer goods, they generally cannot meet requirements for close tolerances and high stability laid down by MNCs for industrial applications. Lack of experienced engineers and

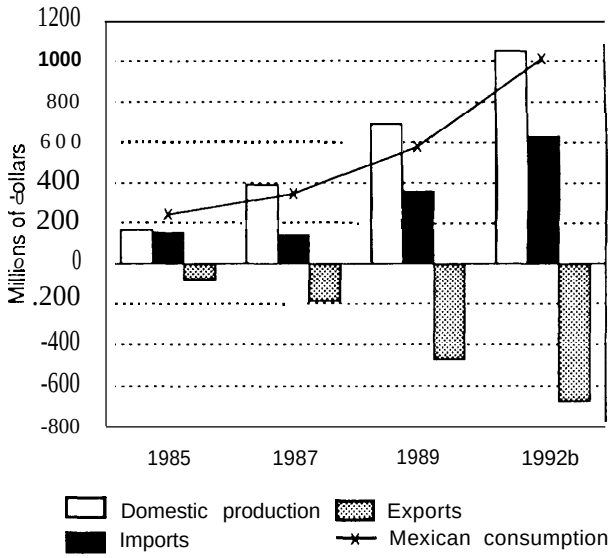
**Figure 8-l—Production and Trade in Mexico's Consumer Electronics Sector[a]**




[a]Excluding *maquiladoras*. [b]Estimated.
[c]Projected.
[d]production plus imports minus exports.

**SOURCE: Edith Houston, "Mexico: Electronic Consumer Goods Market Assessment," U.S. Department of Commerce, International Trade Administration, 1988.**

**Figure 8-2—Production and Trade in Mexico's Computer Sector[a]**




[a]Including peripherals,
[b]Projected.
[c]Production plus imports minus exports.

**SOURCE: "Trade and Event Research: Mexico—Computers, Peripherals, Software, and Services," U.S. Department of Commerce, International Trade Administration, August 1990.**

technicians will limit expansion into more sophisticated components, and indeed into more sophisticated electronics products of all types. Mexican suppliers currently provide one-third to one-half of the quantity of computer parts, but this corresponds to only about one-quarter by value (table 8-2).[6] Color monitors, disk drives, and most power supplies are imported from Asia. Integrated circuits come from the United States or Asia.

Few Mexican-owned firms have established themselves in the computer industry. U.S.-based companies, for example, account for about 80 percent of the personal computers (PCs) made in Mexico. While a few Mexican companies (Printaforma, for one) have designed PCs around components available on the open market, they are not exported. Companies producing peripherals have been somewhat more successful, but they typically produce simple assemblies such as keyboards, power supplies, and displays; in 1991, these three items comprised nearly all of Mexico's total exports of peripherals to the United States, with keyboards alone totaling 82 percent (table 8-3). U.S. imports from Japan and newly industrializing countries (NICs) in Asia, in contrast, center on more sophisticated peripherals such as disk drives and laser printers.

Computer production in Mexico poses little threat to U.S. jobs. If Mexico's economy grows, domestic production will be needed to serve the growing local

**Table 8-2—Value-Added by Country for Personal Computer Production in Mexico**

| | Value (percent) |
|---|---|
| **Components:** | |
| From Mexico | 30%[a] |
| From the United States[b] | 30 |
| From Asia | 30 |
| **In-plant value added (Mexico)** | 10 |

[a]Overstated because many subassemblies purchased in Mexico indude parts imported from the United States and Asia.
[b]Includes all internal production of components by the computer manufacturer in countries other than Mexico,

**SOURCE: Harley Shaiken, *Mexico in the Global Economy: High Technology* and *Work Organization in Export Industries (La* Jolla, CA: University of California, San Diego, Center for U.S.-Mexican Studies, 1990), p. 112.**

6 Wilson, ''NAFTA and the Electronics Industry in Mexico, ' op. cit., foomote 1, p. 7; Susan Walsh Sanderson and Ricardo Zermeño-Gonzales, "Trade Liberalization in Mexico's Electronics Industry, " *Strategic Sectors in Mexican-U.S. Free Trade,* M. Delal Baer and Guy F. Erb, eds. (Washington DC: Center for Strategic and international Studies, 1991), p. 79.

**Table 8-3—U.S. Imports of Computer Peripherals and Subassemblies by Country, 1991**

| | Mexico | Taiwan | Singapore | Japan |
|---|---|---|---|---|
| | (thousands of units) | | | |
| Hard disk drives. . . | 4 | 90 | 7,460 | 4,080 |
| Floppy disk drives. . | 1 | 410 | 210 | 12,960 |
| Printers. . . . . | 8 | 10 | 290 | 6,140 |
| Displays. . . . . | 146 | 4,550 | 300 | 3,000 |
| Power supplies. . . . | 370 | 1,870 | 670 | 450 |
| Keyboards, . . . . . | 2,450 | 3,630 | 510 | 1,280 |

SOURCE: Office of Technology Assessment, 1992, based on official statistics of the U.S. Department of Commerce.

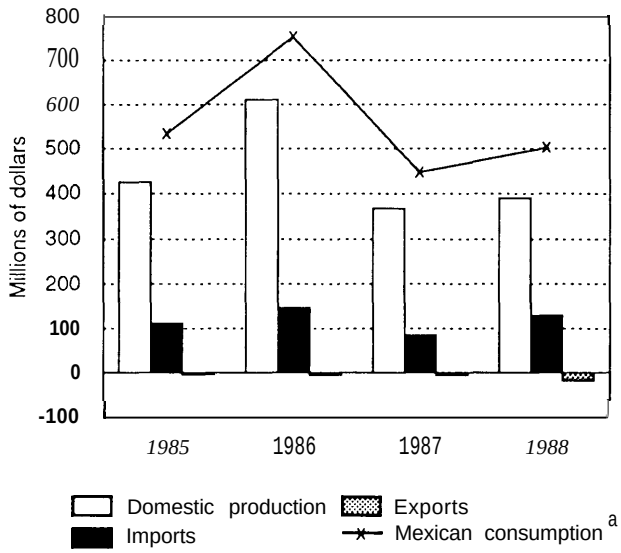
market. Imports from the United States and Asia will supply demand for products not locally produced. U.S. computer manufacturers have little incentive to establish additional manufacturing facilities in Mexico; they have already established production facilities primarily to serve the Mexican market. A NAFTA would not change this pattern.

In telecommunications, Mexico is nearly self-sufficient, due to local production by two large European-owned manufacturers, Ericsson and Indetel (figure 8-3). Other multinationals, including Siemens, Philips, and NEC sell some products including transmission equipment (e.g., cables) to TelMex. With Mexico investing heavily in its telephone network, imports have increased because local producers cannot expand rapidly enough. Little telecommunications hardware has been exported, with the exception of terminal equipment made in *maquiladoras, in* part because Mexican production has not offered economies of scale.

Telecommunications manufacturers in Mexico buy about one-third of their inputs locally, typically housings, low-end passive components, transformers, circuit boards, connectors, and relays for customer premises equipment. In recent years, both Ericsson and Indetel have established joint ventures with Mexican firms to produce printed circuit boards, connectors, and power equipment. One of Indetel's joint ventures makes advanced circuit boards using surface-mount technology. While Mexican firms export some of these components, volumes are small and sales have been mostly in Latin America.

Mexican telecommunications producers will probably continue to concentrate on domestic demand, which is expected to grow rapidly during the next decade. Mexico now has only about 6.3 telephone

**Figure 8-3-Production and Trade in Mexico's Telecommunications Equipment Sector**




[a]Production plus imports minus exports.

SOURCE: "Market Research Summary: The Mexican Market for Telecommunications Equipment," U.S. Department of Commerce, International Trade Administration, 1990.

lines per 100 inhabitants, compared with 50 to 60 lines per 100 in the United States. Over the next 5 years, TelMex expects to spend $10 billion to $14 billion to expand its telephone network (box 8-B), a task that will absorb most local production and also require increased imports.

### *Maquiladora Electronics*

Electronics represents the largest sector of the *maquiladora* industry. In 1990, over 500 electronics *maquiladoras* produced goods valued at $6.1 billion, accounting for 44 percent of *maquiladora* output and 37 percent of employment (table 8-4). This is the segment of Mexico's electronics industry that presents the greatest threat to U.S. jobs, particularly in the manufacture of standardized, labor-intensive goods.

Unlike investments in Mexico's domestic-oriented electronics industry that were dictated by restrictions on market access, expansion in the *maquila* sector has been driven by cost considerations. U.S. companies have sought to reduce production costs and fend off competition from overseas rivals, particularly those in the Far East, by investing in Mexico or contracting with existing *maquilas.* Hourly wages in electronics *maquiladoras* averaged about $1.10 for direct laborers in 1991, approxi-

### *Box 8-B—Upgrading Telecommunications in Mexico*

As part of the privatization agreement, the new owners of TelMex must expand and improve the Mexican telecommunications system. For example, by 1994, TelMex must:

- provide long distance service to all towns with over 500 inhabitants, 10,000 of which have no service at present;
- improve reliability and provide faster repairs; and
- answer all operator-assisted calls within 10 seconds (only 70 percent meet that mark at present).

TelMex is committed to increase network line density to 10 lines per 100 people by 1994, and 20 per 100 by 2000. This will require installation of about 800,000 new lines per year through 1994, rising to 1.6 million lines per year afterwards, New telephones (as opposed to lines) wilI go in at a rate of 3.3 million per year, to reach a level of 25 million installed phones by 1994. Much of the expansion will consist of digital systems.

mately one-seventh to one-tenth their level in the United States and half the typical level in the Asian NICs.[7] Over 99 percent of the components used in these *maquiladoras are* imported from abroad.

Electronics *maquiladoras* rely heavily on low-skilled workers (box 8-C), which limits production to two types of assembly: finished products with high labor content and low profit margins, and labor intensive components or subassemblies to be shipped to the United States for incorporation into final products. The first category includes consumer goods such as telephones and small- to medium-sized TVs, along with electrical equipment such as transformers and power supplies; the second includes circuit boards and other subassemblies for large-screen TVs and for telecommunications switches. Such products can be assembled by unskilled or semiskilled workers with little or no sacrifice in product quality.

Thus, *maquiiadora* electronics firms can be viewed as competing directly with both U.S. and Asian workers. They are more representative of the cost-driven investments likely to be *seen in* Mexico in the wake of a NAFTA than the investments that have taken place in computers or telecommunications.

**Table *8-4--Maquiladora* Electronics Production**

| | 1982 | 1984 | 1986 | 1988 | 1990 |
|---|---|---|---|---|---|
| Number of plants. . . . . | 223 | 244 | 302 | 411 | 519 |
| Employment (thousands). . . . | 74 | 109 | 113 | 153 | 170 |
| Output (billions of dollars). . . . . | $1.7 | $2.6 | $2.6 | $4.6 | $6.1 |
| Value added (billions of dollars). . . . . | $0.44 | $0.57 | $0.58 | $0.97 | $1.36 |
| Share of electronics in all *rnaquila* production (by value). . . . . | 620/. | 53% | 47% | 45%. | 440/o |

SOURCE: *Maquiladora Industry Analysis,* CIEMEX-WEFA Mexican Service, September 1991, pp. 68-73.

## THE U.S. ELECTRONICS INDUSTRY

While the United States still has the largest electronics industry in the world in terms of output and employment, growth has been slower than in Japan and a number of Asian NICs. Competition has increased in all segments of the industry, but it is in commodity goods that the United States has fallen behind.

In the analysis that follows, OTA divides U.S. electronics into seven sectors:

1. consumer electronics, including household audio and TV equipment (Standard Industrial Classification (SIC) code 365 1);
2. computers and peripherals (SIC 357);
3. semiconductors (SIC 3674);
4. electronic components other than semiconductors, including capacitors, resistors, and connectors (SICs 3671, 3672, 3675, 3676, 3677, 3678, and 3679);
5. telephone and telegraph equipment, including central office (CO) switches, private branch exchange (PBX) equipment, and customer premises equipment such as telephone sets and answering machines (SIC 3661);
6. radio communication and navigation equipment, including radio and television broadcasting and cellular telephone equipment (SICs 3663, 3669, and 3812); and

7 *Maquiladora Industry Analysis,* CIEMEX-WEFA Mexican Service, September 1991, pp. 75-78. In South Korea, Taiwan, and Singapore, production workers in electronics averaged $3-$3.25 per hour (including benefits).

### Box 8-C—Workers in Electronics Maquiladoras[1]

Because of the high labor turnover rate in border area maquilas, itself a consequence of low wages and generally poor working conditions, managers are continuously hiring new workers and putting them on the production line. In Ciudad Juarez, a city with a high concentration of electronics production, maquiladoras report monthly turnover rates of 7 to 8 percent. Managers report that workers will leave a job for as little as 20 more pesos a week (there are about 3,000 pesos to a dollar). Workers object to the pace of assembly and to the continual pressure to increase output; managers claim that workers lack the discipline needed for industrial production. In the densely packed maquiladora parks in Juarez, plants actively solicit new employees. Many have large banners outside advertising that they are hiring. Others send sound trucks to rival maquiladoras during breaks to solicit workers, although in some parks managers have agreed to halt such practices.

Today, the typical maquila worker has little or no industrial experience beyond jobs in other maquiladora plants. Education levels are low (ch. 5), in part because maquiladoras in electronics tend to hire a large percentage of women, most of whom have little formal education. Direct production labor accounts for nearly 80 percent of employment, a figure that has declined only slightly in recent years. This is a much higher fraction than is typical in the United States, where production workers account for only 38 percent of employment in computers and peripherals and 68 percent in consumer electronics.[2]

Given low skills and high turnover, companies sometimes de-automate or otherwise modify tasks for Mexican workers, reducing productivity, often harming quality, and slowing production changeovers. Others have looked to automation as a means of coping with turnover, paying higher wages to retain a core of skilled workers able to keep the machines running while accepting high turnover in the rest of their workforce. In this way, one TV plant in Juarez reduced its workforce from 6,000 in 1974 to 3,800 in 1991.

Even in plants with automated equipment, most new workers get only a day or two of training. In OTA interviews, a manager in a maquila making transformers stated that production methods had been simplified compared to U.S. operations to accommodate workers lacking basic skills so that half the workforce needed only manual dexterity and good hand-eye coordination to do their jobs. Other workers did need skills such as soldering or tracking production statistics. The plant manager noted that it had taken 3 years to get the plant operating properly.

So far, these patterns have kept maquiladoras from moving into more complex forms of production. But with time and experience, the capabilities of the maquiladora labor force will improve. According to the manager of a TV plant, production skills and industrial discipline are now beginning to be passed down through families, so that young people entering the labor force have abetter idea of what to expect. Willingness to pay higher wages would enable maquilas to reduce turnover and upgrade their workforces more rapidly. If they did so, they might begin attracting more demanding production, thereby putting Mexican workers in head-to-head competition with a larger number of U.S. electronics workers.

[1]Based on OTA interviews and "The Auto and Electronics Sectors in U.S.-Mexico Trade and Investment," report prepared for OTA under contract 13-1815 by Harley Shaiken, May 1992.

[2]*U.S. Industrial Outlook* '92 (Washington, DC: Department of Commerce, January 1991), pp. 27-1, 37-14.

7. electrical equipment such as transformers, electric lighting equipment, motors, and generators (SICs 361, 362, and 364).

## Competitive Status

### Import Pressure

Since 1981, U.S. imports of electronic goods have increased from about $20 billion to $80 billion. U.S. exports, while increasing, have not kept pace, and since 1983, the United States has run a trade deficit in electronics.[8] In 1991, the deficit totaled over $11 billion, with consumer electronics leading the way (table 8-5). Only two segments of the industry recorded a surplus in 1991-components, which sends most if its exports to Mexico, Canada, and Asia to support offshore assembly operations, and radio communication and navigation equipment, much of which is defense-related.

Import penetration has been particularly high in standardized, labor-intensive products. As shown in table 8-6, the U.S. computer industry posted a trade deficit only in peripherals, for which direct labor constitutes up to 50 percent of production costs; the

[8]1991 *Electronic Market Data Book* (Washington DC: Electronic Industries Association 1991), p. 104.

**Table 8-5-U.S. Electronics Trade, 1991**

| Sector | Shipments | Imports | Exports | Balance* |
|---|---|---|---|---|
| | (billions of dollars) | | | |
| Computers | $58.5 | $25.6 | $24.0 | ($ 1.6) |
| Radio communication and navigation equipment[b] | 57,5 | 3.8 | 6.5 | 2.7 |
| Electronic components | 34.5 | 5.9 | 6.0 | |
| Semiconductors | 27.9 | 12.3 | 11.8 | (0.6) |
| Electrical equipment[c] | 22.3 | 3.9 | 3.5 | (0.5) |
| Telephone and telegraph | 15.2 | 4.3 | 2.5 | (1 .9) |
| Consumer electronics | 7.7 | 12.3 | 2.1 | (10.1) |
| Total | $223.6 | $68.1 | $56.3 | ($11.9) |

[a]Parentheses denote negative balance (imports greater than exports).
[b]Industry shipment data estimated from product shipment data for 1991.
[c]Trade figures estimated from 1990 data.

NOTE: Totals may not add because of rounding.

SOURCE: Office of Technology Assessment, 1992, based on official statistics of the U.S. Department of Commerce.

**Table 8-6--U.S. Trade in Computers and Telecommunications Equipment, 1991**

| | Imports | Exports | Balance[a] |
|---|---|---|---|
| | (billions of dollars) | | |
| **Computer equipment** | | | |
| Computers | $4.0 | *$7.6* | $3.6 |
| Peripherals | 13.6 | *6.7* | (6.9) |
| Parts and accessories | 8.0 | *9.7* | |
| | $25.6 | *$24.0* | ($1.6) |
| **Telephone and telegraph** | | | |
| Network and transmission | $0.5 | 1.9 | 1.4 |
| Customer premises equipment | 3.5 | 0.8 | (2.7) |
| Parts | 0.5 | 0.7 | 0.2 |
| | $2.1 | $1.4 | ($1.2) |

[a]Parentheses denotes negative balance (imports greater than exports).

NOTE: Totals may not add because of rounding.

SOURCE: Office of Technology Assessment, 1992, based on official statistics of the U.S. Department of Commerce.

computers and parts segments posted surpluses in 1991. Similarly, the deficit in telecommunications resulted from imports of customer premises equipment (telephones, FAX machines, and the like), of which little production exists in the United States, and for which direct labor is approximately 30 percent of production costs. For these products, competition hinges on costs, and low-wage Mexican labor can help improve the competitiveness of U.S. manufacturers. In capital goods such as large computers or CO switches, technological capability counts for more than manufacturing costs. Successful firms must continually develop new hardware and software. Because of its underdeveloped R&D base, Mexico offers little to U.S. manufacturers of capital goods and will compete only marginally with U.S. workers in these sectors.

Competition from low-wage nations has hurt U.S. manufacturers of standardized electronics products. For example, of 27 U.S.-owned companies that made TVs in 1960, only Zenith survives. The others have vanished or been purchased by Japanese and other foreign fins. Zenith has 16 percent of the U.S. television market, but, unlike its primary competitors, does not compete on a world scale. As of 1990, nine Japanese corporations assembled color TVs in the United States; four of these companies produced picture tubes here as well. Most of the TV manufacturers that sell in the United States assemble some of their sets in Mexico, and bring in circuit boards and other subassemblies from *maquiladoras* for those assembled in the United States.

In the computer industry, U.S. firms have managed to maintain their primacy, but competition has intensified as the industry has fragmented into submarkets for machines ranging from notebooks and laptops to workstations to supercomputers. Price competition for PCs has become almost as intense as for home entertainment products, with Asian and some U.S. firms seeking to undercut U.S.-based product leaders by offering competitive, but less sophisticated, machines. Low-cost clones have further segmented the PC market into a lower end, that can be satisfied with readily available technology and is thus less responsive to brand names, and an upper end that demands sophisticated technologies, such as active matrix liquid crystal displays, where brand names still help differentiate products.

Competitive pressures in end-product markets have been transferred to U.S.-based suppliers of electronic components and electrical equipment,

driving down prices and profit margins. Faced with rising capital investments required to keep up in new technologies, many manufacturers sought merger partners or simply exited. In the recession year of 1991, more than two dozen manufacturers of circuit boards left the industry or went bankrupt, while Japanese firms bought out three large component producers. Nearly all component imports once originated in the offshore plants of U.S. fins, but now more than half come from foreign-owned companies.

### U.S. Government Policies

U.S. electronics markets are considerably more open than foreign markets, including the European Community and Japan. The United States has led the world in deregulating telecommunications, for example. Other countries have been slow to follow, with governments reluctant to stop sheltering their manufacturers and service providers.[9] Foreign firms have captured over half the U.S. market for CO switches (in essence huge special-purpose computers, many of which sell for tens of millions of dollars) and PBXs, while U.S. telecommunications manufacturers have not done nearly as well abroad.

Deregulation and divestiture have had equally profound effects on household telephone equipment. As a monopoly, AT&T leased telephones to its customers. But, once customers could buy their own telephones, answering machines, and so on, many chose cheaper products from abroad. AT&T produced 14 million phones in 1982, less than 2 million in 1984. All telephones for home use, cordless phones, and answering machines sold in the United States—and almost all FAX machines (some are made here by foreign-owned "transplants' ')--are now imported, most from Asia and some from Mexico. Some office telephones are still made in the United States.

U.S. trade policies have preserved some domestic jobs in television production. After a long series of complaints alleging dumping and other "unfair" trade practices, U.S. officials negotiated Orderly Marketing Agreements (OMAs) in the late 1970s to limit imports. Japanese firms responded by investing in U.S. plants for assembling TVs, preserving some U.S. jobs in an otherwise declining industry.[10] The structure of U.S. import duties also encourages domestic production of the picture tubes. Completed TVs are subject to a 5 percent tariff; picture tubes are subject to a 15 percent tariff. But picture tubes—the most costly component in a TV, representing some 40 percent of component costs-can be produced in the United States, shipped to a Mexican *maquiladora*, and then re-enter as part of an assembled TV with only a 5-percent tariff on the value added in Mexico, thus helping U.S. picture tube plants compete with Asian plants.

**Table 8-7—Employment in the U.S. Electronics Industry, 1991**

| | Total employment (thousands) | Production workers (thousands) | Production workers (percent) |
|---|---|---|---|
| Electrical equipment | 430 | 300 | 70% |
| Electronic components | 320 | 220 | 69 |
| Consumer electronics | 60 | 40 | 65 |
| Telephone and telegraph | 120 | 70 | 54 |
| Semiconductors | 230 | 90 | 40 |
| Radio communication and navigation | 390 | 140 | 37 |
| Computers | 420 | 130 | 32 |
| Total | 1,970 | 1,000 | *51%* |

NOTE: Totals and percentages may not compute because of rounding.

SOURCE: Office of Technology Assessment, 1992, based on figures from *Employment* and *Earnings,* March 1992.

## *The Labor Market in Electronics*

### Jobs, Wages, and Displacement

The U.S. electronics industry employed nearly 2 million people in 1991, about 1 million of them classified as production workers (table 8-7). In computers, semiconductors, and radio communications and navigation equipment, production workers make up less than 40 percent of total employment. In electrical equipment, components, and consumer electronics, production workers represent 65 to 70 percent of employment.

Generally speaking, parts of the industry producing high-technology equipment in low to moderate volumes have the smallest percentages of production workers. Examples include military electronics and mainframe computers, where large numbers of engineers, software specialists, and skilled techni-

9 After the AT&T breakup, the United States opened its equipment market mom-or-less unilaterally to foreign manufacturers, losing leverage that might have helped U.S. firms gain access to foreign markets. See *International Competition in Services* (Washington, DC: Office of Technology Assessment, July 1987), ch. 9.

IO *International* competitiveness in *Electronics* (Washington, DC: Office of Technology Assessment, November 1983), pp. 446-447.

cians are needed to design and develop new products. Companies in these businesses sometimes move labor-intensive operations offshore, as do mass producers of semiconductor chips.[11] The sectors with high percentages of production workers tend to have lower rates of technological change and manufacture mature consumer products in large volumes or engage in customized assembly of standardized components (e.g., small-volume production of specialized power supplies). High-volume assembly is more footloose because so much production is controlled by MNCs that operate globally. Smaller U.S. companies producing specialized electronic equipment often depend on a core of experienced employees, from production workers and technicians to engineers and salespersons, working under one roof. Proximity to one another and to customers is important in this part of the industry.

U.S. electronics employment peaked in 1984. Since then, jobs have been disappearing more or less uniformly across the industry. In the five segments for which continuous data are available from the Labor Department, employment declined 16 to 19 percent over the period 1984 to 1991, for a total of 307,000 jobs (table 8-8). Production workers have suffered a disproportionate share of the decline. Employment in all of U.S. electronics was nearly the same in 1991 as in 1978, having risen before falling. But, with the exception of the highly diversified components industry, the labor-intensive segments of the industry have been shrinking since the late 1970s. Between 1978 and 1991, 194,000 production worker jobs were lost, 145,000 of these in consumer electronics and electrical equipment alone.

At the same time, employment in service industries related to electronics-notably computer and data processing services (SIC 737)—has been on the rise. BLS forecasts that employment in computer and data processing services will grow faster than in any other major industry, reaching 1.2 million jobs by the year 2000 compared with 224,000 in 1978.[12] Growth in software and computer services firms could create more jobs than are lost in electronics manufacturing over the next decade, but few people who lose production jobs in electronics are likely to find new work in computer services without considerable retraining.

**Table 8-8—Employment Trends in U.S. Electronics**

| Sector | Number of employees (in thousands) and percentage of production workers | | | | | |
|---|---|---|---|---|---|---|
| | 1978 | | 1984 | | 1991 | |
| Electrical equipment | 570 | 73% | 520 | 71% | 430 | 700/o |
| Electronic components | 280 | 73 | 380 | 72 | 320 | 69 |
| Consumer electronics | 90 | 73 | 70 | 69 | 60 | 65 |
| Semiconductors | 170 | 47 | 270 | 43 | 230 | 40 |
| Computers | 340 | 45 | 520 | 40 | 420 | 32 |
| Total | 1,450 | 64% | 1,770 | 58% | 1,460 | 54% |

NOTE: Totals may not add because of rounding.

SOURCE: Office of Technology Assessment, 1992, based on data from *Employment* and *Earnings,* March 1992; and *Employment, Hours, and Earnings, United States, 1909-1990,* vol. 1, BLS Bulletin 2370, (Washington, DC: Department of Labor, Bureau of Labor Statistics, March 1991).

Real wages have been relatively stable in electronics as a whole over the past 15 years (table 8-9). But in consumer electronics and electrical equipment, the two sectors with the longest history of job losses, wages have fallen by 7 to 10 percent since the mid-1980s. For most of the post-World War II period, unions represented workers at many large companies in these labor-intensive parts of the industry. Over time, the movement of production offshore and to nonunion plants in the United States diminished union influence on wages. To keep some jobs in the United States, unions have been willing

11 Semiconductor firms employ many engineers in the design of new products, and more complex manufacturing during front-end wafer fabrication has increased the need for technicians. Much of the labor-intensive assembly required to package "commodity' semiconductors such as memory chips moved offshore beginning in the late 1960s. Unlike consumer electronics firms, which went to Asia and Mexico in efforts to match the costs of foreign firms, U.S. semiconductor firms shifted assembly operations to Asia at a time when they had little meaningful competition. Competitive forces within the U.S. industry drove these transfers of production, as firms sought to cut their costs in order to gain market share and move down learning curves ahead of their domestic rivals. *International Competitiveness in Electronics,* ibid., pp. 192-193. Design and production of application-specific integrated circuits (ASICs) has remained in the United States because these products must be tailored more closely to the needs of individual customers.

12 Many more software specialists work in other parts of the economy, including the computer manufacturing sector and other durable goods industries. BLS expects employment of software professionals to increase by over 400,000, to 1.4 million by the end of the decade. George Silvestri and John Lukasiewicz, "Projects of Occupational Employment, 1988 -2000," *Monthly Labor Review,* November 1989, pp. 42-65.

**Table 8-9--Hourly Wages in the U.S. Electronics industry and in Mexican *Maquiladoras***

| | 1978 | 1984 | 1988 | 1990 | 1991 |
|---|---|---|---|---|---|
| | (1991 dollars) | | | | |
| Electrical equipment[a] | $11.54 | $11.55 | $11.03 | $10.51 | $10.39 |
| Electronic components | 9.42 | 9.72 | 9.68 | 9.51 | 9.51 |
| Consumer electronics | 10.95 | 12.16 | 11.35 | 10.58 | 10.97 |
| Telephone and telegraph[b] | NA | NA | 13.25 | 12.09 | 12.20 |
| Semiconductors | 10.93 | 12,21 | 12.74 | 12.74 | 12.78 |
| Radio communications and navigation[b] | NA | NA | 13.82 | 13.53 | 13.38 |
| Computers | 11.29 | 11.90 | 12.19 | 11.97 | 12.16 |
| Average, U.S. manufacturing | $12.39 | $12.24 | $11.67 | $11.26 | $11.18 |
| Average, electronics *maquiladoras*[c] | NA | $1.06 | $0.87 | $0.92 | $1.09 |

NA = Not available.

[a]Hourly wage data for electrical machinery (SIC 362) are not reported for 1978-1987. Wage estimates for this sector are therefore based upon wages in SIC 3621, motors and generators, which comprises 50-60 percent of production worker employment in SIC 362.

[b]Due to changes in SIC categories, wage data for telephone and telegraph and radio communications and navigation prior to 1987 is not comparable with that after 1987, and thus are not included in this table.

[c]Data not available for 1978. Data for 1991 forecast by CIEMEX-WEFA.

SOURCE: *Employment and Earnings,* March 1992; *Employment, Hours, and Earnings, United States, 1909-%1, vol. 1,* BLS Bulletin 2370 (Washington, DC: Department of Labor, Bureau of Labor Statistics, March 1991). Base wages in Mexican maquiladoras estimated from data in *Maquiladora Industry Analysis,* CIEMEX-WEFA Mexican Service, September 1991, p. 75.

to accept wage reductions.[13] Members of the International Brotherhood of Electrical Workers (IBEW) at the Zenith plant in Springfield, Missouri, for example, agreed to an 8-percent wage cut and a 5-year wage freeze in order to dissuade the company from moving operations out of the United States. Nonetheless, the Springfield plant's production later went to Mexico.

Rates and impacts of displacement due to plant closings or other permanent layoffs reflect the variations in sectoral labor and product markets. On average, electronics workers lost jobs less often, found new jobs faster, and experienced smaller and less frequent wage losses between 1979 and 1989 than did workers in other durable goods industries. Workers in the labor-intensive portion of electronics (electrical equipment, consumer electronics, and components) fared slightly better than those in other durable goods industries, while workers in other electronics sectors fared significantly better (see ch. 4, table 4-3). For example, in electronic machinery, equipment, and supplies, an average of 3.7 percent of workers were displaced each year over the 1979 to 1989 period, a rate about 10 percent below the average for durable goods manufacturing. About 28 percent of these workers experienced periods of unemployment greater than 6 months. Of those that had found new jobs by the time of the displaced worker survey, almost one-half earned their previous wage or higher (in nominal terms).

## Mexico and NAFTA

The IBEW estimates that 25,000 of its members lost their jobs between 1985 and 1989 because of transfers of production to Mexico.[14] Electronics *maquiladoras* now employ more than 160,000 Mexican workers. But it is difficult to assess the true impact of Mexican production on U.S. electronics employment. In many cases, the only alternatives for electronics firms that moved manufacturing to Mexico were to shut down or move production to Asia. Moving production to Mexico has less impact

13 OTA interviews. Recent wage declines in the electrical equipment, consumer electronics, and telephone and telegraph sectors have been accompanied by the growth of a low-wage, small-firm sector making specialized products in small volumes Clusters of these firms exist in several parts of the country, including Southern California, where they rely heavily on Hispanic workers and have been cited for violations of wage and hour regulations almost as frequently as garment factories. Maria Patricia Fernandez Kelly, "Labor Force Recomposition and Industrial Restructuring in Electronics: Implications for Free Trade, ' draft report prepared for the U.S. Department of Labor, Bureau of International Labor Affairs, Washington, DC, July 1992.

14 "Robert Wood, Director, Research and Economics Department, International Brotherhood of Electrical Workers, before the Office of the U.S. Trade Representative, Covering the Desirability, the Scope, and the Economic Effects of a North American Free Trade Agreement," Sept. 3, 1991, p. 18.

on U.S. employment than these alternatives. By staying in business, firms can retain U.S. jobs in engineering, marketing, and ''headquarters' operations that would otherwise disappear as well. A move to Mexico rather than Asia, may not disrupt supplier networks. Electronics *maquilas* import some 99 percent of their components, many from the United States; factories in Asia buy mostly from Asian suppliers.

Until the mid-1980s, growing sales, defense production, a regulated telecommunications industry, and union influence combined to cushion U.S. electronics workers from the layoffs and wage losses that affected other blue-collar workers. Now, many of these cushions are gone. A NAFTA would find production workers in electronics increasingly vulnerable to competition from imports and the threat of offshore production. Regardless of NAFTA, however, employment in high-volume, standardized electronics manufacturing will continue to shrink in the years ahead due to automation. At the same time, cost pressures in a highly competitive industry dominated by Asian companies with worldwide marketing strategies and correspondingly large economies of scale will drive smaller U.S. companies to seek lower costs through low-wage offshore labor. Labor-intensive work will continue to migrate to Mexico, Asia, and the Caribbean. Even when production does not move, the option of producing in Mexico will restrain U.S. wage increases.

There is an alternative: production of differentiated, high-quality goods with varied product attributes and features. With flexible organizational forms, high levels of worker skill and training, and corresponding commitment to the job, firms could pay high wages in U.S. plants to supply such markets. Small, high-technology firms have used these methods for years, especially in defense electronics. Sony expects that such an approach will just@ locating its new TV assembly (and picture tube) plant near Pittsburgh, bucking the pattern of movement of assembly to Mexico. The company plans to take over a former Volkswagen plant, receiving a substantial incentive package from State and local governments. To take advantage of the skilled and experienced labor pool in the area, Sony will replace traditional assembly lines with self-directed work teams responsible for tasks such as cabinet-making and installation of picture tubes. The groups will be responsible not only for assembly and quality assurance, but for scheduling and inventory control and for maintaining their equipment. Workers will be trained in multiple skills and share responsibility for the group's work. Because the groups will be self-directed, Sony plans to dispense with first-level supervisors.

## U.S.-MEXICO LINKAGES IN ELECTRONICS

Mexico has attracted foreign investment in electronics because of its low wages and because of government policies that controlled access to its markets. Mexico may continue to have cheap labor for many years, but market access has already been liberalized. Investment decisions will then depend more on Mexico's suitability as a location for manufacturing relative to alternatives. Production costs, skill levels, and the rate of growth of Mexico's domestic market will be primary considerations.

### *Location Decisions in Electronics*

Mexico's advantages are most visible in labor-intensive consumer electronics production. Nearly all the major TV manufacturers that sell in the United States have assembly facilities in Mexico-Zenith, Thomson-RCA, Philips, Sony, Matsushita, and Hitachi. Zenith is consolidating its TV assembly in Mexico; Philips has half its North American production in Mexico. Production of smaller TVs went to Mexico first; now many companies assemble at least some of their large-screen TVs there as well.

#### Production Costs

**In the low-margin** consumer electronics business, a few dollars saved in production can make the difference between profit and loss. Compared with manufacturing in the United States, reduced labor and overhead costs from Mexican production can save as much as $80 per set (table 8-10). Some *maquiladora* TV plants have now invested in considerable automation, seeking to drive costs down still further.

Cost savings of the magnitude summarized in table 8-10 are compelling: anew TV assembly plant can be built for about $100 million; with production of 1 million sets per year, this initial investment could be paid back from the savings in production costs in about a year. Zenith, which posted a $52 million loss in 1990, claims that its Mexican

**Table 8-10-TV Assembly Costs in Mexico and the United States**

| | Cost per TV (dollars) | |
|---|---|---|
| | Mexico | United States |
| Labor | $15 | $90 |
| Overhead | 60 | 70 |
| Components | 225 | 225 |
| Additional duty | 3.75 | NA |
| Additional inventory Costa | 0.60 | NA |
| Additional transportation | 1.50 | NA |
| | $305.85 | $385.00 |

[a]Assumes 10 percent cost of funds.

NA = Not applicable.

SOURCE: Office of Technology Assessment, 1992, based on industry interviews.

operations will save $400 million a year once its remaining U.S. production has been relocated.[15]

But such savings are not possible in other parts of the electronics industry. Much of the cost of electronics equipment is in fact the result of mechanical, rather than electronic components. The disk drives in computers, for example, are complex electro-mechanical assemblies. Good design practices can reduce labor content, and, particularly if automation becomes feasible, make it cost-effective to produce in the United States. Design for manufacturability and design for assembly-e. g., reducing the number of parts and designing each for ease of handling, either manually or with automated equipment-can dramatically simplify production processes. For example, fasteners such as screws, may account for 5 percent of parts cost but 75 percent of assembly cost if they must be inserted by hand. Reducing the number of fasteners or replacing them with snap-fit assemblies or adhesive bonding eliminates much of this labor. Better yet, two or three pieces can be replaced by one. In redesigning its ProPrinter, for example, IBM reduced the number of parts by two-thirds, cutting assembly time by 90 percent and improving the reliability of the finished product.

Miniaturization--especially in semiconductors—also contributes to reductions in labor content by putting greater functional capability on each chip, so that fewer chips are needed in each system. With reductions in the total number of components and interconnections, assembly becomes less important,

**Table 8-1 l-Cost Breakdown for a Typical Personal Computer**

| | |
|---|---|
| Direct labor | less than 5% |
| Overhead | 10% |
| Mechanical parts | 5% |
| Tooling, etc. | 2% |
| Electronic parts and components | 30-607. |
| Disk drives | 15-30'YO |
| Monitor | 5-Io% |
| Keyboard | 2-5%. |

SOURCE: Benjamin Gomes-Cassares, "International Trade, Competition, and Alliances in the Computer Industry, "paper presented at the World Trade and Global Competition Colloquium, Harvard Business School, Boston, MA, December 1991 (based on company estimates).

component manufacturing more important. As a result, electronic devices for which assembly labor represented 40 percent of manufacturing costs a few years ago, such as computers, now have direct labor content of 5 percent or less (table 8-1 1). A PC that costs $1,000 to manufacture in the United States might cost $950 in Mexico. It would take many years to recover the costs of a new plant in Mexico. Moreover, import duties on computers produced in Mexico would negate most of the potential savings. Under a NAFTA that eliminated these duties, computer assembly in Mexico could become more attractive. But other costs of manufacturing in Mexico--e. g., the more complicated logistics of production management-might nonetheless outweigh the savings in direct labor.

### Suppliers and Just-In-Time (JIT) Production

As a low-wage production site, Mexico competes directly with Asia. Mexico has the advantage of being near the United States, which simplifies the coordination of design and production for U.S. firms (box 8-D). Products shipped from Mexico can reach retail outlets in about a week, compared to 8 weeks if shipped from Asia. Reductions in inventories of goods in transit contribute to cost savings. On the other hand, for companies that currently manufacture in the United States, shifting production to Mexico can add considerably to inventory costs.

Where product cycles are short and companies must react quickly to changes in consumer demand, as in the PC industry, offshore production, even in Mexico, can penalize responsiveness and disrupt JIT production systems. Many firms in such markets, Dell Computer for one, carry very small inventories

[15]Zenith recently announced that it will close its Springfield, MO plant. In total, 1,200 jobs will be lost—600 in assembly and 600 in a cabinet finishing plant. John Burgess, "TV-Maker Zenith Will Move Assembly Operations to Mexico," *Washington Post*, Oct. 30, 1991, p. F3.

### *Box 8-D—Making Telephones in Mexico*[1]

Direct labor represents 30 percent of manufacturing costs for standard telephones. Assembly requires just a few steps—manual insertion of the circuit pack, assembly into the housing, and testing to make sure the phone rings, followed by packaging for shipment. These tasks can be easily conducted with unskilled labor in Mexico or elsewhere.

With deregulation and the opening of the U.S. market, AT&T shifted production of telephones to Asia. Inventory costs for parts and finished goods erased much of the savings the company hoped to achieve, keeping prices high and costing the company market share. Phones sometimes had to be shipped back to Asia for repair. By moving production and repair operations to Mexico, AT&T reduced its inventory and shipping costs, lowered prices, and regained lost market share. The company now makes about 9 million phones each year in Mexico, up from 2 million before the move. Success with phones led AT&T to make answering machines to Guadalajara, after unsatisfactory experiences with contract production in Asia. The company claims it would have been unable to stay in the answering machine market without its manufacturing operations in Mexico, which it expects will produce several million answering machines in 1993.

[1]This box is based on industry interviews.

of finished goods (as little as a single day's worth). While these firms may hold larger quantities of parts inventories, to allow rapid assembly of final products and to take advantage of dips in component prices, production in Mexico would require larger stocks of completed products, which, if they must be marked down because of rapid shifts in consumer demand, could erase at least some of the savings achieved through production in Mexico (table 8-12). In mature, high-volume industries, where demand is more stable and predictable, the chances of being left with unsold inventories are greatly reduced.

The cost differential shown in table 8-12 would probably not justify production in Mexico. ADDS Corp., for example, recently decided to move production of computer displays from Taiwan to the United States. The company estimates that production costs will rise from $300 to $320, but will be offset by reductions in overhead costs for managing

**Table 8-12—Personal Computer Production Costs in the United States and Mexico**

| | Cost per computer (dollars) | |
|---|---|---|
| | United States | Mexico |
| Direct labor | $35 | $ 5 |
| Overhead | 100 | 80 |
| Mechanical parts | 50 | 50 |
| Tooling | 20 | 20 |
| Components | 795 | 795 |
| Total manufacturing | $1,000 | $950 |
| Additional transportation | NA | 6 |
| Inventory in transit[a] | NA | 3 |
| Losses on inventory[b] | NA | 15 |
| Total cost | $1,000 | *$974* |

[a]Assumes 10 percent cost of funds.
[b]Assumes one week's production per year of finished goods sold at cost.
NA - Not applicable.
SOURCE: Office of Technology Assessment, 1992.

production-costs omitted from table 8-12 for simplicity, but not necessarily insignificant even for Mexican production.

Deficiencies in the Mexican supplier base will also limit investments by firms working towards JIT production. Electronic components produced by Mexican firms are high in price and low in quality compared with those available on the world market. MNCs operating in Mexico also note that delivery is unreliable. The local supplier base will probably be slow to develop. Most circuit boards for TVs are already stuffed in Mexico, with components imported from Asia. (Only Philips currently assembles circuit boards for TVs in the United State s.) Because most of these components are standardized, made in high volumes in low-cost Asian plants, and inexpensive to ship, there is little incentive for producing them in Mexico. Development of a supplier base for more complex products will be paced by the overall development of the Mexican electronics industry.

## Intrafirm Linkages and Investment Costs

Despite the global dispersion of manufacturing in recent years, many MNCs try to maintain close linkages among manufacturing, marketing, and R&D departments. This is true especially for development of goods made in low volume with customized features-as for large computers and telecommunications equipment—and also for high-volume, high-technology products such as laptop computers. Linkages between marketing and manufacturing become especially crucial when products must be customized for each user.

**Table 8-13-Distribution of Expenses in the Computer and Television Industries**

| | Computer | | | |
|---|---|---|---|---|
| | Mainframe | Minicomputer | Personal | Television |
| | (percentage of total expenses) | | | |
| Production | 49% | 51% | 58% | 89%. |
| R&D | 11 | 11 | 6 | 4 |
| Marketing | 32 | 31 | 25 | 7 |
| Other | 5 | 5 | 4 | — |
| Profit | 4 | 2 | 7 | — |

SOURCE: Benjamin Gomes-Cassares, "international Trade, Competition, and Alliances in the Computer Industry," paper presented at the World Trade and Global Competition Colloquium, Harvard Business School, Boston, MA, December 1991; and corporate annual reports.

The differences between products like computers and televisions are reflected in corporate expenditures (table 8-13). For minicomputer and mainframe manufacturers, R&D and marketing costs top 40 percent of annual revenues; even for PCs, they can exceed 30 percent. In contrast, TV manufacturers spend only 11 percent of total revenues on R&D and marketing; almost all their revenues go to cover manufacturing costs.

Compaq Computer, for example, recently announced two new portable computers priced for the low-end market. Compaq decided to produce these computers in its Houston plant rather than offshore so that the design engineering staff could work closely with production engineers. These products incorporate new technologies that may need refinement over the first few months as they are tested in the market.[16] In some segments of TV manufacturing, too, market considerations can make it advantageous to keep design and production teams near each other. Several TV firms state they will keep production of projection and large screen TVs in the United States at least until these markets stabilize. U.S. sales of projection TVs are only 200,000 per year, while product features have been in constant flux as companies strive to push costs down and improve performance.

### Investment Costs, Worker Skills, and Technological Infrastructure

For many sophisticated products, including telecommunications switches and semiconductors, the capital costs of manufacturing plants continue to increase. State-of-the-art semiconductor fabrication facilities cost between $500 million and $1 billion to construct; for telecommunications switches, investment costs run to hundreds of millions of dollars. At these levels, companies build no more plants than necessary, and examine location decisions very carefully. There is no reason to close existing plants and move them, even if the technologies are not demanding, unless costs can be recovered quickly—which is not the case when front-end capital costs are high.

Mexico is an unlikely choice for new capital-intensive manufacturing because of its relatively poor technological infrastructure. Whereas the production of TVs and electrical equipment is largely a matter of assembling components, the manufacture of products such as semiconductors and picture tubes requires workers and organizations able to cope with complex production equipment that may need constant ''tuning' to keep productivity and quality high. For products such as mainframe computers and telephone switching systems, each unit may be built to somewhat different specifications, requiring highly skilled workers. Mexico has little capability in these areas today. For reasons discussed in chapter 5, it would probably be several decades before Mexico could catch up even with NICs like Korea, where production of complex semiconductors began during the 1980s.

With declining direct labor content in many electronics products, the relative importance of indirect labor-engineers, equipment repair techni-

IS Joe Tasker, Compaq Computer Corp., personal communication, February 1992. Hyundai, too, recently announced plans to shift its PC operations from Korea to the United States. Despite the potential cost savings of a Mexican plant, Hyundai opted to build in the United States in order to be nearer new technical developments. Managers noted that assembly would be moved, along with design, development, and marketing, to help the company respond more quickly to shifting market demand, Hyundai has promised the new U.S.-based division substantial autonomy for worldwide PC operations. Jim Carlton, ''Hyundai Plants to Move Its Division for Personal Computers to the U.S.,' *Wall Street Journal*, Apr. 20,1992, p. A2. Reportedly, Goldstar and SamSung are considering exiting the PC market because they have been having so much trouble keeping up, yet do not wish to follow Hyundai to the United States.

**Table 8-14-Advantages and Disadvantages of Electronics Production in Mexico Compared to the United States**

| | Labor costs | Suppliers/ JIT | Interfirm linkages | Market size | Investment costs | Workforce skills |
|---|---|---|---|---|---|---|
| Television | | | | | | |
| Assembly | + | o | 0 | 0 | 0 | 0 |
| Picture tubes | 0 | | 0 | 0 | | |
| Computers | 0 | | | | 0 | |
| Peripherals | + | | 0 | 0 | 0 | |
| Semiconductors | 0 | o | | 0 | | |
| Telecommunications | | | | | | |
| Switches | O | 0 | | | | |
| Customer premises equipment | + | o | 0 | 0 | 0 | 0 |
| Electrical equipment | + | o | 0 | 0 | 0 | 0 |

Key: + = Mexico at an advantage.
O = Little or no difference, or not a significant factor.
-- Mexico at a disadvantage.

SOURCE: Office of Technology Assessment, 1992.

cians, managers, and administrative personnel-has increased. These are precisely the kinds of workers that are in shortest supply in Mexico. As a result, wages for skilled technicians, engineers, and managers are rising. Whereas wages for production workers are perhaps one-tenth those in the United States, pay for skilled technicians and engineers may be one-fifth to one-third of U.S. levels. Some Mexican managers earn as much or more as their U.S. counterparts. Thus, the growing importance of indirect labor reduces Mexico's ability to attract investment and jobs in electronics by requiring skills in short supply in the Mexican labor force and reducing the cost advantages of manufacturing in Mexico.

## *NAFTA Impacts*

By itself, a NAFTA is unlikely to radically alter patterns of investment and development in the Mexican electronics industry. Investment would continue without an agreement in response to Mexico's unilateral policies for attracting FDI, the dismantling of trade restrictions on computers, and the opening of TelMex procurements following privatization. NAFTA may, in some cases, speed the flow of investment dollars to Mexico by reducing uncertainty about the future. Specific NAFTA provisions, for example on rules of origin, will also affect trade and investment patterns in both near and long terms.

Table 8-14 summarizes Mexico's capabilities in electronics manufacturing compared to those of the United States. As the table shows, the relative advantages of each country vary greatly from sector to sector. For products such as TVs, customer premises telecommunications hardware, and electrical equipment, labor costs outweigh other factors, so that Mexico can attract production away from the United States.

While most of the movement in TV production has already occurred, as Mexico's infrastructure of suppliers and its design/development capabilities improve, Mexico will be able to attract more technologically sophisticated production. For example, Hitachi announced in February 1992 that it would move production of projection TVs from Anaheim, California to Mexico; Sony already makes projection TVs in Mexico.

Manufacture of picture tubes will probably remain in the United States, at least in the near term. New picture tube plants cost $100 million to $200 million, while existing plants can be retooled for $10 million to $20 million. Because production is highly automated, labor cost savings would not offset the investment costs associated with a transfer to Mexico, particularly given the narrow profit margins in this business. Newer entrants, such as Korean fins, are more likely to put tube plants in the United States than in Mexico, where skilled workers would have to be trained because no base of picture tube manufacturers exists today. Dependable supplies of water, a critical element in picture tube fabrication, also are a problem in Mexico, particularly in the border region. Perhaps most important, Mexican suppliers cannot at present supply the glass funnels and blanks needed for picture tubes. These would have to be imported from the United States or the Far East.

In the absence of government policies forcing them to do so, computer firms have little reason to manufacture in Mexico. The potential cost savings do not appear adequate to justify branch-plant forms of production. Leaders in the industry such as IBM, Apple, and Compaq differentiate their products through technology rather than pricing. Besides, most U.S. computer manufacturers are consolidating manufacturing operations due to overcapacity. Generally speaking, the Mexican market, by itself, is too small to just@ additional investments. However, some new production capacity for PCs may go into Mexico in the medium term to serve domestic and export markets. Rapid growth rates, estimated at 20 percent by the U.S. Department of Commerce, could see sales in Mexico doubling, to $2 billion from the current level of $1 billion, within 4 years. Mexico already has plants assembling micro and minicomputer systems, and companies might choose to expand them or supplement them.

From TV production, moreover, Mexico could probably move into computer displays. Zenith already manufactures color displays in Mexico, and has announced plans to move monochrome display production from Taiwan to Mexico, Development of skills for more advanced peripherals would require significant investments by companies based in the United States, or, more likely, Japan and Singapore, which excel in such products. While some incentive may exist for Japanese printer manufacturers to locate in Mexico to reduce transportation costs, disk drives are easy to ship, and manufacture in Mexico offers no apparent advantage to current producers. On the other hand, a major technological change in mass storage devices could conceivably see Mexico entering on the ground floor.

Mexico is not a contender for advanced semiconductor production. It would be very difficult to build and operate a clean room facility in Mexico today. Chip assembly operations that have not already been automated have long since moved to the Far East. Moreover, there are few fabrication facilities in the United States that could ship parts to Mexico for assembly, and few prospects for new wafer fabrication installations given current levels of overcapacity. Very high costs for building a state-of-the-art semiconductor facility, the economies of scale inherent in semiconductor production, and the very high risks involved, ensure that new capacity will be added in developed countries or in advanced developing countries like Korea.

Economies of scale will also prevent current U.S. manufacturers of telecommunications switches from shifting production to Mexico. In the United States, both AT&T and Northern Telecom produce major CO switches at only one location. The Mexican market, although it is expected to grow rapidly, is still only one-eighth the size of the U.S. market (800,000 lines per year compared with about 6 million here). Mexico would probably need to call on government inducements to attract switch production beyond what it has today. More likely, the output of U.S. plants, which have excess capacity, will be directed toward Mexico. If the Mexican market grows at a faster pace, perhaps at 1 million lines per year, OTA interviews indicate that it could be profitable for a third competitor to manufacture CO switches there-provided it could expect to capture a third of sales. Such an operation would be viable only if foreign manufacturers, with larger economies of scale, were prevented from shipping switches duty-free to Mexico. In effect, new investment in Mexico would only be attractive if competition were limited to existing Mexican manufacturers. Table 8-15 summarizes the results of the preceding discussion, and identifies the primary constraints on production in Mexico.

A NAFTA is likely to affect investment decisions in electronics primarily through rules of origin. These could have considerable impact on picture tube production, for instance. Currently, Asian picture tubes go into many sets assembled in Mexico for sale in the United States. Tubes from the Far East cost less than $65 ($61 to $62 in production costs and less than $3 for shipment to Mexico), and can be incorporated duty-free into sets assembled in *maquiladoras.*[17] When shipped to the United States, tubes face a 5-percent duty-the rate charged on value--added in Mexico for completed TVs (only one-third the 15-percent tariff levied on picture tubes imported separately). At the 5-percent level, Asian picture tubes cost about $68 delivered into the United States—substantially less than U.S.-made tubes, which run $72 to $75. A good deal of new tube capacity has been put in place or announced in Southeast Asia, with much of this directed at the North American market (since there is little new assembly capacity going into Asia). A NAFTA

[17] These cost figures come from Duane Welch, Corning Inc., January 1992.

**Table 8-1 5-Likely Effects of a NAFTA on Investment in Mexico's Electronics Industry**

| Product | Effect of a NAFTA | Comments |
|---|---|---|
| Consumer electronics | Continued transfers of production to Mexico. | High-end products such as projection TVs may remain in the United States until the market stabilizes. |
| Computer peripherals | Some movement of low-end peripherals such as keyboards, power supplies, and monitors from Asia and the United States. | Limited skills and suppliers for higher-end disk drives in Mexico. |
| Personal computers/minicomputers | Little movement to Mexico. some new capacity could be added in the medium- to long-term to serve the Mexican market. | Limited Mexican supplier base; additional inventory rests in a rapidly changing market; overcapacity in existing U.S. facilities. |
| Mainframes/supercomputers | No movement to Mexico. | Lack of skills. |
| Telecommunications switches and PBXs | No movement without government inducements and protection from third-country imports. | Relatively small market. |
| Semiconductors | No movement to Mexico likely except for simplest products. | Limited worker and organizational skills; economies of scale. |
| Customer premises telecommunications equipment | Some movement of production from Asia to Mexico to reduce shipping times and costs. | |
| Electrical equipment | Continued movement of high-volume production. | |

SOURCE: Office of Technology Assessment, 1992.

requiring a sufficiently high level of North American content could keep most or all of these tubes out.

Rules of origin would also have implications for computer manufacturers. U.S. producers currently import many components and subassemblies. Requiring a high degree of local content, while helping U.S. component manufacturers, could place U.S. computer manufacturers at a disadvantage. Some components such as active matrix displays for portable computers are not yet available from U.S. suppliers. Many other components are available more cheaply overseas.

## *Longer Term impacts: Paced by Skills Development*

Longer term evolutionary patterns will depend to a large extent *on* organizational and worker skills in both countries. In the United States, manufacturers must pursue high-wage production strategies to fend off low-wage rivals. Mexico must develop managerial and technical skills to move upscale in electronics. For Mexico, this will require three mutually supportive processes:

1. state-led programs to provide basic educational skills and attract foreign investment;
2. investments in worker training and supplier development programs by the government and by companies currently operating in Mexico; and
3. technology transfer from MNCs.

Mexico's government is unlikely to go back to full-blown protectionism and subsidization. But this does not mean that Mexico will not offer incentives to attract foreign multinationals through limited forms of managed trade, investment controls, or tax credits. Nations such as Taiwan, Korea, and Singapore have found these valuable in attracting foreign investors, fostering strategic alliances with domestic firms, and promoting local industries. Mexico has no such policies at present in electronics. Indeed, SECOFI, the Mexican Ministry of Commerce, has only $25 million available for facilitating technology absorption, funding research centers in Mexico's states, and stimulating private sector innovation.[18]

[18] Interview with Santiago Levy, SECOFI, May 20, 1992.

### *Box 8-E—Technology Transfer*[1]

***While many*** electronics **companies operating in Mexico have failed to locate or develop local sources for key inputs to their production, IBM in Guadalajara has recorded something of a success. IBM purchases planar boards for its PCs from a local company, ADTEC, a joint venture between one of** IBM's U.S. **suppliers and a Mexican firm. ADTEC** produces double-sided boards using surface mount technology on a state-of-the-art production line. Most of the 300-plus components come from the United States. Production yields in Mexico exceed 80 percent, compared to 65 percent in a comparable U.S. plant. ADTEC has now begun to sell to other computer manufacturers in Guadalajara, including Hewlett-Packard.

ADTEC has succeeded in part because its engineers learned from the experience of the U.S. plant that installed a surface-mount line in 1985,2 years before the Mexican plant opened. Training also played an important role. The first workers hired by ADTEC received a full 6 months of training--very unusual in the Mexican electronics industry-although the company now finds it can get by with 3 weeks of training for new workers. Turnover is low: 1 percent a month compared with 7 or 8 percent in typical electronics ***maquiladoras.***

IBM helped start ADTEC because it wanted a local source to aid in JIT production and because the Mexican Government required heavy investments in technology transfer as a condition for a fully-owned affiliate in Mexico. Still, while ADTEC produces quality products at high yields, the company hardly qualities as "high" technology: tie-quarters of the workforce are in direct production jobs, and their tasks resemble those in many TV assembly plants.

As part of its investment agreement with the Mexican Government, IBM also shares in the funding of a $22 million Semiconductor Technical Center for the custom design of semiconductor chips. In addition, the center began offering masters degrees in engineering in February 1991 and hopes to add a doctoral program in the future. Manufacture of chips designed at the center takes place in the United States, however.

[1]Based on "NAFTA and the Electronics Industry in Mexico," report prepared for OTA under contract No. H3-7200 by Patricia Wilson, February 1992 and OTA interviews.

## CONCLUDING REMARKS

Mexican-owned firms including contract *maquiladoras will* need to improve the skills of their workers if they hope to take on more complex production tasks. Automation—increasingly necessary for meeting quality standards in electronics production—raises skill requirements for workers who maintain equipment and trouble-shoot manufacturing processes. As more customers demand that their suppliers use statistical process control and JIT production methods, training needs will grow. Mexico will also have to develop an adequate supplier base to attract assemblers that wish to implement JIT systems.

Skills development—and concomitant increases in industrial capability-will depend largely on foreign investment. Multinationals control the technology that Mexico must learn to use. Government initiatives to provide training in the electronics industry have so far been weak. Only large corporations are likely to be willing to support supplier development programs or extensive workforce training (box 8-E).

Some upgrading of capabilities in electronics *maquiladoras* has taken place in recent years. *Maquiladoras* have been investing in automated equipment--e.g., for assembling circuit boards, injection molding plastic parts, winding transformer coils, and testing final products—in part to meet the quality standards of their customers in export markets.

Expansion of the Mexican electronics industry into more technologically sophisticated product lines, such as at Hewlett-Packard (H-P), suggest what the future may hold for Mexican electronics. H-P has established an R&D facility in Guadalajara that now designs memory boards for company-wide applications. Guadalajara has also become the primary center for production of impact printers and handles design changes. At present, however, this is the only electronics R&D center in Mexico operated by a multinational. Development of a modern electronics industry will be a long-term undertaking for Mexico.