

Appendix D

The Decline of the U.S. DRAM Industry: Trade¹

The Japanese Government protected the Japanese semiconductor industry when it was weak and, as it strengthened, supported its move into international markets. Conversely, American trade policy largely failed to prevent serious damage to U.S. industry caused by trade violations.

Scientists and engineers in the United States invented essentially all of modern solid-state electronics. By one accounting, of some 103 major product and process innovations in the semiconductor industry between 1950 and 1978, 90 were by American firms. Despite the technological lead of U.S. firms, they were never able to convert it into market share in Japan as they did in Europe.

U.S. firms found it all but impossible to establish subsidiaries in Japan or joint ventures with a significant share of the equity—unless the Japanese partner was given access to new technology or other appreciable benefits. Thus, whereas U.S. firms had established 46 subsidiaries in Europe by 1974, including 18 **manufacturing** operations, only Texas Instruments (**TI**) had a manufacturing operation in Japan.

TI succeeded where other U.S. firms failed because of its strong U.S. patent on the integrated circuit (**IC**). The Japanese Government refused to give **TI** permission to establish a wholly owned subsidiary in the early 1960s; in turn, **TI** refused to license its **IC** patent in the United States to Japanese firms. This generally stopped exports of Japanese **ICs** to the United States, but it did not stop Japanese firms **from** producing **ICs** for their domestic market as **TI's** application for a Japanese patent was refused. (**TI** applied for a Japanese patent on its invention of the **IC** in February 1960 but did not receive the patent until November 1989. The patent is estimated to be worth \$500 million annually in royalties to **TI**.)

Japanese firms rapidly gained expertise in IC fabrication—making TI's entry into their market evermore difficult the longer it waited to settle. In 1968, **TI** settled for a **50:50** joint venture with Sony; licensed NEC, Hitachi, Mitsubishi, Toshiba, and Sony; and agreed to limit its share of the Japanese **IC** market to less than 10 percent. Firms with weaker patent positions did not succeed in establishing manufacturing subsidiaries in Japan until much later.

Tariff and non-tariff barriers limited imports into Japan as well. Tariffs were roughly double those of the United States until the early **1980s**. Imports of **ICs** with more than

200 elements were **banned** until 1976, limiting the import market to the most simple types.

Unable to penetrate the Japanese market, most U.S. firms licensed their technology to Japanese firms as a means of realizing some earnings. The Japanese **Government** required that foreign firms license all Japanese firms so requesting at a single royalty rate. This prevented the competitive bidding up of the license fees; and the broad licensing prevented any one firm from capturing monopoly revenues. Competition among firms was thus effectively shifted **from** innovation downstream into **manufacturing**.

The battle for control of the DRAM market began in the late **1970s** with the strong Japanese push in 16K DRAMs. The 1979 boom in semiconductor demand created a capacity shortage among both Japanese and **American** producers. Japanese firms responded by increasing their export of chips to capture and hold market share **abroad**, while importing the same chips to **fill** their domestic needs until they could expand their production capacity. U.S. firms rushed to fill Japanese orders in the hope that this was a market opening, resulting in the highest levels of semiconductor imports into Japan at anytime between the early- **1970s** and 1989 (figure D-1). As additional capacity came on line, however, the vertically integrated Japanese producers cut back imports of U.S.-made DRAMs while hanging onto their market share gains abroad.

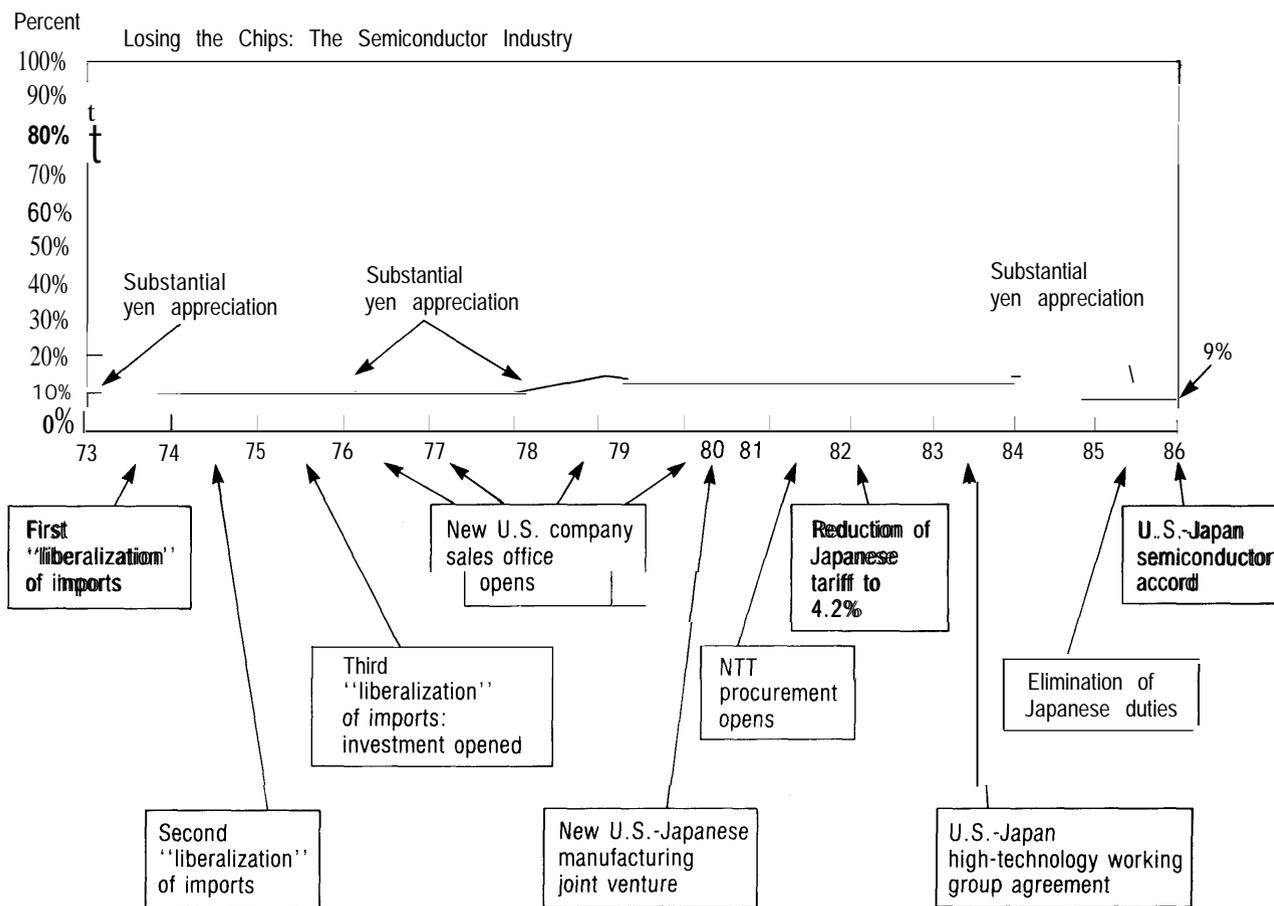
Japanese firms pushed DRAM prices down sharply in the early **1980s** (figure D-2). Repeated allegations of dumping were made, but no formal action was taken because it was **difficult** to distinguish the effect on price of dumping, if any, from that of the high value of the dollar. Over half of the U.S. DRAM producers dropped out of the market during this period.

The remaining American firms followed the Japanese lead in heavily investing in capital equipment in 1983-84. When recession hit the semiconductor industry in 1985-86, the large overcapacity and other factors drove down DRAM prices. Japanese firms lost an estimated \$3 to \$5 billion during 1985-86, while American **firms** lost an estimated \$2 billion.

Severe price competition also occurred with other commodity chips such as EPROMS. In 1985, Hitachi told distributors to quote 10 percent lower **prices**—irrespective of costs—than competing American firms

¹ Sources for this section include those cited in app. C and: John E. Tilton, "International Diffusion of Technology," *Brookings Institution*, 1971; Dennis J. Encarnati on, "Cress-Investment: A Second Front of Economic Rivalry," *California Management Review*, vol. XXIX, No. 2, Winter 1987; The Department of Commerce, "A Report on the U.S. Semiconductor Industry," 1979; "The United States Government Trade Policy Response To Japanese Competition in Semiconductors: 1982-1987," *OTA Background Report*, September 1987; Clayton K. Yeutter, "The Japanese Left Us With Little Choice," *New York Times*, Apr. 5, 1987; Andrew Pollack, "Chip Pact Falls Short of Goals," *New York Times*, Aug. 2, 1988; William F. Finan, Chris B. Amundsen, "Modeling U. S.-Japan Competition in Semiconductors," *Journal of Policy Modeling* 8(3): 305-326 (1986); John Burgess, "Japan Gives U.S. Firm Circuit Patent," *Washington Post*, Nov. 22, 1989;

Figure D-I—U.S. Share of the Japanese Semiconductor Market, 1973-66



SOURCE: Clyde V. Prestowitz, Jr., *Trading Places: How We Allowed Japan To Take the Lead* (New York, NY: Basic Books, 1988). Used with permission.

until the sale was won, while guaranteeing a 25 percent distribution profit. From January 1985, when the Japanese entered the 256K EPROM market, to August 1985 prices fell from \$17 per chip to less than \$4, while the estimated Japanese production cost alone was \$6.34.

In response, U.S. semiconductor firms filed **anti-dumping** cases against Japan in 1985 for below-cost sales of 64K DRAMs, and the Department of Commerce itself filed an **antidumping** case against Japan for below-cost sales of 256 DRAMs and EPROMs. The U.S. **International Trade Commission (ITC)** found that dumping had occurred. For example, constructed prices indicated that DRAMs were being sold at half their estimated production cost. A trade agreement was subsequently reached in September 1986. When this failed to stop below cost sales, the Reagan Administration imposed sanctions.

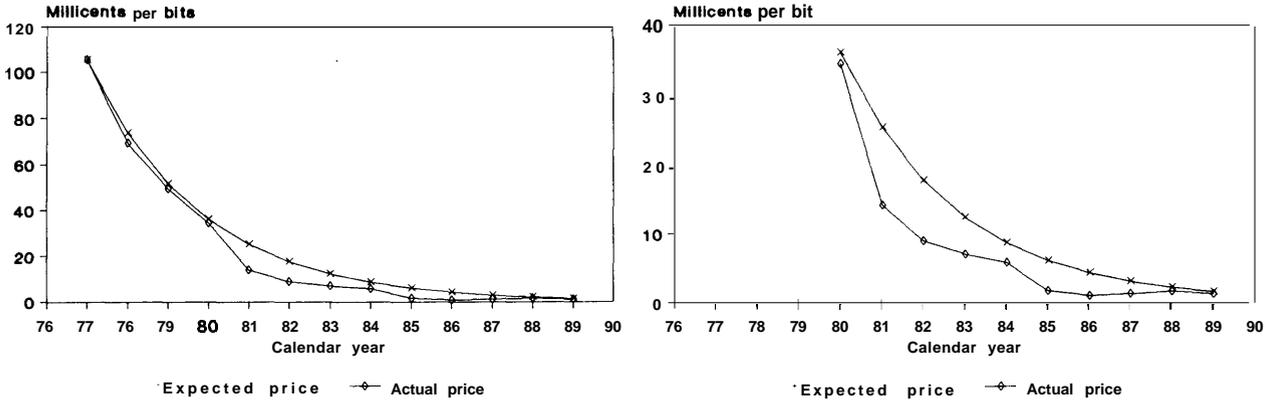
These remain in place in early 1990 on the issue of the lack of access to the Japanese market. Despite this relatively quick action, the only American firms in the merchant DRAM market today are TI, Micron, and Motorola.

Following the trade agreement, prices on the spot market rose sharply to as much as four to five times long-term contract prices. Further, prices charged to U.S. purchasers have typically been 30 percent higher than those for Japanese users. In sharp contrast, EPROM prices—where U.S. producers still have 40 percent of the world market and 70 percent of the U.S. market—have been much more disciplined.

Some analysts believe that Japanese producers, who now control the world DRAM market, have subsequently acted like a **cartel**²: driving prices up to capture excess

²Charles Ferguson, "DRAMs, Component Supplies, and the World Electronics Industry: An international Strategic Analysis," VLSI Memo 89-554, August 1989, Massachusetts Institute of Technology, Cambridge MA; Kenneth Flamm, "Policy and Politics in the International Semiconductor Industry," paper presented at SEMI ISS seminar, Newport Beach, CA, Jan. 16, 1989.

Figure D-2—Average Cost Per Bit for DRAMs, 1976-89



Showing the large price erosion that took place in 1981 and 1985.

SOURCE: Based on data in: "Mid-Term 1988," Integrated Circuit Engineering Corp., Scottsdale, AZ, 1988.

profits in 1988 and 1989, and driving prices down, as in fall 1989 to perhaps warn any would-be entrants into the DRAM market with the specter of enormous financial losses. The effort to launch U.S. Memories—a DRAM production consortium—was finally abandoned in Janu-

ary 1990, in part due to this sharp decline in DRAM prices; the same day, many of Japan's largest chip producers announced DRAM production cutbacks to turn the price declines **around**.³

³David E. Sanger, "Contrasts on chips," *New York Times*, Jan. 18, 1990.