The Fall of the Japanese DRAM Industry: Lessons from the US–Japan Semiconductor Trade War in the 1980s

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Abstract

This article examines the collapse of the Japanese DRAM industry through the structural dynamics of the United States–Japan semiconductor trade war during the 1980s. At the beginning of this period, Japan had achieved global leadership in DRAM, supported by high capital intensity, cumulative learning, vertically integrated keiretsu networks, and coordinated industrial policies. However, following the imposition of a series of bilateral agreements and U.S.-driven economic and institutional reforms, the competitiveness of the Japanese industry began to decline rapidly in the early 1990s, culminating in its eventual collapse in 2012. Drawing on an extensive review of the academic literature and documentary sources, the article seeks to analyze how the 1980s trade war served as an effective and decisive mechanism in dismantling Japan's DRAM industry. The analysis concludes that the trade war functioned as a powerful instrument of pressure and policy imposition, contributing to the erosion of the institutional foundations that had previously sustained Japan's successful industrial strategy. Once deprived of state coordination, support, and protection, and further constrained by internal institutional and organizational rigidities, the Japanese DRAM industry experienced an accelerated decline leading to its complete collapse by 2012. The study is grounded in a comprehensive bibliographic and documentary review.

Keywords: Semiconductor Industry; DRAM; Japan; United States; Trade War.

INTRODUCTION

The use of trade warfare as an instrument of coercion and as a means of reaffirming U.S. hegemony is not a novel feature of contemporary geopolitics. The most emblematic precedent to current dynamics is the U.S.–Japan trade war of the 1980s. During this period, after decades of rapid economic expansion, Japan had emerged as a potential challenger to the United States' hegemonic position. From the postwar era to the 1980s, Japan's economic development constituted one of the most successful reconstruction processes in modern history, particularly given the profound devastation wrought by World War II. This performance resulted not only from favorable external conditions, such as broad access to the U.S. consumer market, but also from a robust set of state-coordinated industrial policies. This environment enabled Japanese industries to accumulate capital, expand production scale, and develop the necessary know-how to undertake substantial investments in infrastructure, productive capacity, human capital, organizational capabilities, and R&D. By the late 1970s, Japan had secured leading positions in major global markets and was widely recognized for the superior quality, efficiency, and competitiveness of its manufactured goods.

The rise of Japan to the status of a global economic powerhouse was accompanied, in contrast, by an accelerated decline in the competitiveness of U.S. industry throughout the 1970s and 1980s, a process amplified by adverse macroeconomic conditions, including high inflation, currency appreciation, and persistently elevated interest rates. This decline became particularly evident in the late 1970s, when sectors in which the United States had historically maintained global dominance, such as automobiles, consumer electronics, and semiconductors—began to face intense competition from Japanese imports. The result was a substantial loss of market share, including within the U.S. domestic market, alongside firm closures, reductions in productive capacity, and rising unemployment.

This environment fueled interpretations among economists and policymakers that a "new international economic order" led by Japan was taking shape. Yet beginning in the 1990s, Japan's economic dynamism lost momentum, giving way to prolonged periods of stagnation. Between these two contrasting moments, rapid ascent and subsequent stagnation, lies a critical turning point: the trade war waged between the United States and Japan during the 1980s.

In the early 1980s, the severe effects of the U.S. economic crisis contributed to the election of Republican Ronald Reagan in 1980. Under the banner of *fair trade*, his administration began threatening Japan with the imposition of unilateral retaliatory tariffs, justified by what it alleged to be unfair trade practices. This pressure culminated in the signing of multiple bilateral agreements and the implementation of institutional and economic reforms, including the 1985 Plaza Accord. From that point onward, Japan's economic growth began to stagnate, and its industrial competitiveness declined substantially, leading the country to lose market share in strategic sectors and to see its regional and global leadership gradually eclipsed by neighboring Asian economies. Contemporary economic conditions therefore diverge sharply from those of the "golden era" spanning the 1950s through the 1980s.

Among the Japanese industries that lost prominence in the global market, the semiconductor industry stands out as the most emblematic case and the one most directly linked to the trade war of the 1980s. From the late 1970s to the mid-1980s, Japan's share of the global semiconductor market expanded rapidly as a result of substantial state and corporate efforts, developments that contributed to a significant contraction of the U.S. industry. Between 1980 and 1989, Japan's share rose from 27 to 51 percent, while the U.S. share fell from 57 to 36 percent. After 1989, however, the trend reversed: Japan's presence declined sharply, dropping to just 9 percent by 2023, whereas the United States regained leadership with 50.2 percent (SIA, 2024). This reversal is directly tied to the loss of competitiveness in the dynamic random-access memory (DRAM) segment. At the peak of Japan's dominance in 1987, the country controlled more than 80 percent of the DRAM market; today, its

share is effectively zero. The last remaining firm, Elpida, declared bankruptcy and was acquired by the U.S. company Micron in 2012.

Against this backdrop, several central questions emerge: in what ways did the 1980s U.S.–Japan trade war contribute to the decline of the Japanese semiconductor industry and the eventual collapse of the DRAM sector? And what lessons does this episode offer for understanding the current technological and economic rivalry between the United States and China?

The overarching objective of this article is to analyze the political, economic, and geopolitical determinants of the U.S.–Japan trade war, with particular emphasis on the semiconductor industry. More specifically, the article seeks to: (i) identify the structural causes of the trade conflict; (ii) examine the logic and strategic intent behind the United States' efforts to constrain the Japanese industry; and (iii) assess the effects of bilateral agreements and institutional and economic reforms on the subsequent trajectory of Japan's semiconductor sector.

The semiconductor industry constituted the central axis of the United States' commercial offensive in the 1980s and occupies a similarly pivotal position in today's global technological competition. It is a highly strategic sector for the world economy, as its components, ranging from LCD displays to integrated circuits, form the technological foundation of virtually all contemporary industrial activities, from durable consumer goods such as smartphones and computers to complex sectors including aerospace, automotive manufacturing, artificial intelligence, and data centers. Semiconductors also play a critical role in international geopolitics, as they are indispensable inputs for a wide range of military applications and defense industries (MEDEIROS and MAJEROWICZ, 2018).

Moreover, it is an industry characterized by high capital intensity, substantial technological complexity, strong dependence on cumulative knowledge, and extremely short innovation cycles, factors that create formidable barriers to entry and grant leading firms significant market power. In this context, commanding the technological frontier of semiconductors not only underpins long-term productivity gains but also constitutes a central requirement for sustaining geopolitical hegemony. Analyzing the U.S.–Japan trade war with a focus on the semiconductor industry is essential for understanding the logic underlying the United States' current strategy toward China. Although the structural conditions of the Japanese economy in the 1980s differ substantially from those of contemporary China, the two disputes reveal important parallels, including the rise of a new economic power perceived as a threat to U.S. hegemony, heavy dependence on the American consumer market, accusations of unfair trade practices, and the use of retaliatory tariffs as a coercive tool.

The article is organized as follows. Section 1 outlines the technological foundations and competitive dynamics of the DRAM memory industry, as well as its early development in the United States during the 1970s. Section 2 examines Japanese industrial policy and the conditions that enabled

the successful rise of Japan's DRAM industry to global prominence. Section 3 analyzes the pivotal events of the mid-1980s that culminated in the 1986 U.S.–Japan Semiconductor Trade Agreement. Section 4 discusses how the bilateral agreements imposed by the United States constrained Japan's competitiveness and contributed to the accelerated decline of its DRAM industry, culminating in its disappearance in 2012.

1. THE MEMORY INDUSTRY AND THE EARLY U.S. LEADERSHIP

The semiconductor industry is composed of several segments, including integrated circuits (ICs), discrete devices, optoelectronics, sensors, power components (for current and voltage management), as well as photomasks and substrates. Despite this diversity, ICs constitute the most significant segment, currently accounting for more than 85 percent of the industry's total revenue. This predominance reflects the fact that ICs form the essential technological foundation of nearly all major consumer electronics, telecommunications equipment, computers, smartphones, Internet of Things (IoT) devices, and navigation systems. These devices, in turn, underpin the infrastructure that supports the highly profitable software industry and a wide range of information technology services, which have been instrumental in driving substantial gains in labor productivity over recent decades through technologies such as real-time data transmission, computational processing, task automation, e-commerce, cloud infrastructure, and, more recently, artificial intelligence applications. In 2024, the global semiconductor market reached 630 billion dollars, making it one of the largest industries in the world (SIA, 2025, p. 21–23).

The semiconductor industry, in contrast to conventional manufacturing industries, is characterized by a high degree of capital intensity and the extensive use of tacit knowledge and highly specialized technology that is generally not available on the market. IC production begins with an extremely thin substrate, known as a wafer, typically composed of high-purity silicon. This substrate undergoes oxidation processes for electrical isolation and is coated with a photosensitive emulsion (photoresist), after which it is covered by a mask that contains the exact layout of multiple ICs, each composed of billions of transistors, as in the case of a Central Processing Unit (CPU). Subsequently, the photolithography step takes place, which consists of exposing the wafer to the light pattern projected from the mask, followed by the chemical etching process that defines the circuit contours. This is followed by doping, the introduction of impurity ions to modify the electrical properties of silicon, and by deposition and interconnection processes, in which successive layers of insulating and conductive materials are deposited and patterned, forming the multiple layers that interconnect the transistors and configure the IC (BALDWIN, 1994, p. 133–134).

The initial stage of IC production is characterized by a sophisticated process of "trial and error," since nanometric physics and the interactions among layers are not fully predictable, requiring testing after the completion of the initial fabrication. In addition, environmental factors, such as

contamination, minimal deviations in the etching and alignment processes, temperature, humidity, and vibration, can seriously affect production yield. Initial production typically exhibits very low yield, around 10 percent, but it tends to rise as firms accumulate knowledge and experience, enabling them to identify and correct manufacturing errors and reach rates close to 90 percent. Given this characteristic, manufacturers may initially underutilize production capacity to reduce financial losses, and subsequently increase output as yield rates improve (BALDWIN, 1994, p. 133–134).

Due to the high productive complexity, the substantial level of physical and financial capital investments, and the reliance on technical knowledge accumulated over time, fixed production costs are extremely high, constituting a considerable barrier to the entry of new manufacturers. The more complex the IC, the higher the barrier to entry. According to SIA (2020; 2024), semiconductor firms invest, on average, about 15 percent of their revenues in R&D and approximately 12.5 percent in capital expenditures (CapEx). By contrast, marginal costs, materials and labor, tend to be relatively low (IRWIN, 1998, p. 174). Because of these high fixed costs and the importance of learning by doing, a gradual reduction in the number of manufacturers has been observed since the 1960s, accompanied by an increasing concentration of global advanced chip production in an ever-smaller number of firms.

The IC industry is broadly divided into two major segments: logic and memory. Logic chips perform data-processing functions and encompass highly complex components, such as Central Processing Units (CPUs), Graphics Processing Units (GPUs), and Systems on Chip (SoCs), as well as simpler circuits, including sequential and combinational logic and basic logic gates. Memory chips, by contrast, fall into volatile and non-volatile categories. Volatile memories store temporary data during program execution, with the two principal types being Static Random Access Memory (SRAM) and Dynamic Random Access Memory (DRAM). Non-volatile memories store permanent data; the main segments are NAND Flash, used in solid-state drives (SSDs) and USB devices, and NOR Flash, commonly employed in microcontrollers. This article focuses exclusively on the DRAM segment.

Among the various types of volatile memory, DRAM played a central role in reducing production costs and enabling the mass adoption of personal computers. Owing to its simple structure, each bit is stored using a single MOS transistor paired with a capacitor, its development and manufacturing costs are substantially lower than those of SRAM, which requires six transistors. Beyond its use in personal computers, DRAM and its variants have supported a wide range of specialized applications, such as GDDR (Graphics Double Data Rate) for GPUs and LPDDR (Low Power Double Data Rate) for devices with thermal and energy constraints, including smartphones and notebooks since the early 2000s. Beginning in the mid-2010s, new DRAM families emerged to meet the demands of artificial intelligence accelerators, including High Bandwidth Memory (HBM)

and advanced modules such as SOCAMM (System on Chip Advanced Memory Module), based on LPDDR technologies.

Like the logic market, the memory market is characterized by high volatility due to the short product life cycle of its components. From the 1970s through the early 2010s, each new generation of DRAM increased memory capacity by two to four times, broadly consistent with Moore's Law. However, the DRAM market differs from the logic market in being highly commoditized. Whereas logic chips are generally customized for specific applications and require longer development cycles, DRAM is largely standardized by JEDEC, making products from different manufacturers readily substitutable. Moreover, until the mid-2010s, technological progress in DRAM relied primarily on process-node scaling while maintaining the one-transistor–one-capacitor cell structure, which resulted in shorter technology cycles and comparatively lower R&D and production costs. This shortened cycle also implies a limited window for recovering investments before the next generation is introduced (IRWIN, 1998, p. 174).

The total production capacity of DRAM manufacturers tends to be determined almost entirely by the initial investment in the targeted technology. Because of the short product cycle, it is generally not feasible to undertake substantial additional investments mid-cycle. At the beginning of production, supply is limited and prices are high due to low yield; over the course of the cycle, supply expands and prices fall as yield improves. In the initial stage, unlike in the logic market, producers may choose to price below average cost, and in some cases even below marginal cost, to increase output in the expectation of accelerating learning-by-doing. This practice, known as *forward pricing*, is common in the industry and does not necessarily constitute anticompetitive behavior. Since variable costs are low and sunk costs (fab construction, R&D, and engineering) are high, manufacturers tend to maintain maximum production as long as prices cover variable costs, even when market prices fall to very low levels (BALDWIN, 1994, p. 134–135; IRWIN, 1998, p. 174, 189–191).

Since the launch of the first commercial DRAM in 1971, the memory market has expanded substantially, rising from US$15 million in 1970 to US$1.2 billion in 1980, US$15 billion in 1990, US$80 billion in 2000, US$250 billion in 2010, and reaching US$165.5 billion in 2024 (PARKE et al., 2013, p. 174–177; SIA, 2025). Currently, the memory segment accounts for approximately 26.3 percent of total semiconductor industry revenues; within this segment, DRAM represents about 67 percent, equivalent to roughly 17.6 percent of global semiconductor revenues. DRAM plays a central role in South Korea's semiconductor industry, accounting for about 79 percent of its revenues. Today, South Korea is the most significant player in the global DRAM industry: in 2024, the country was responsible for approximately 76 percent of global DRAM revenues. This position explains why South Korea accounts for about 21.1 percent of total global semiconductor revenue, making it the

world's second-largest semiconductor industry, behind only the United States. Samsung alone accounts for roughly 10.6 percent of global semiconductor revenues (GARTNER, 2025; LAU, 2025; SIA, 2025; TRENDFORCE, 2025).

The DRAM industry emerged in the late 1960s in the United States. Although volatile memories such as SRAM already existed[1], their high cost, stemming from the need for six metal–oxide–semiconductor (MOS) transistors per stored bit, prompted the industry to seek alternatives. In 1966, Robert Dennard of IBM's Thomas J. Watson Research Center developed the first 1K (1-kilobit) DRAM architecture, patented in 1968, which relied on only one MOS transistor and one capacitor per bit. Despite being slower than SRAM and requiring periodic refreshing, it offered a far superior cost–performance ratio (IBM, n.d.). Although DRAM was invented by IBM, it was Intel, newly founded in 1968 by Robert Noyce and Gordon Moore, both formerly of Fairchild, that commercialized the first 1 KB DRAM, the "Intel 1103," in 1971 (PARKE et al., 2013, p. 173–176; PRESTOWITZ, 1988, p. 32). Unlike IBM, Intel did not integrate device production with a downstream systems division and instead marketed DRAM as a standardized product in the open market or under contract, a model known as a *merchant producer*.

Intel's early success quickly attracted additional firms into the DRAM industry, including Texas Instruments (TI), Mostek, and National Semiconductor, all of which, like Intel, operated as merchant producers. By contrast, the entry of IBM, AT&T, and Motorola was motivated by the desire to supply their own downstream divisions, such as consumer electronics and telecommunications equipment (IRWIN, 1998, p. 178). By the mid-1970s, Mostek had become a significant player in the DRAM market, emerging as the pioneering firm behind subsequent generations of DRAM, such as 4K and 16K devices. In 1976, Mostek accounted for roughly 75 percent of the 16K DRAM market, making it the global industry leader (PARKE et al., 2013, p. 176). However, from the late 1970s onward, the U.S. industry, until then the undisputed global leader, with eight of the world's top ten DRAM producers, began to face intensifying competition from Japan's rapidly emerging semiconductor industry (GILL & SWANN, 1993, p. 116–117).

2. THE RISE OF THE JAPANESE INDUSTRY

Although the U.S. semiconductor industry pioneered the commercial production of DRAM, its leadership was short-lived, lasting roughly a decade until the rise of a highly competitive Japanese industry. The speed with which Japanese firms absorbed, improved, and diffused advanced DRAM technologies was decisive for a rapid technological catch-up that ultimately surpassed U.S. performance in quality, efficiency, and production costs. Owing to Japan's success in the DRAM industry, by 1990 the country accounted for roughly 46 percent of global semiconductor revenues;

[1] The first commercial SRAM was released in 1964 by Fairchild.

among the world's ten largest firms, six were Japanese, including the top three: NEC (Nippon Electronics Corporation), Toshiba, and Hitachi (SON, 2014, p. 6, citing IC INSIGHTS; WEN et al., 2012, p. 616). One of the central factors underlying the emergence of Japan's DRAM industry was the state's capacity for strategic planning and coordination, led primarily by the Ministry of International Trade and Industry (MITI). Through this agency, the government implemented industrial policies aimed at building technological and productive capabilities: inter-firm coordination, subsidized financing, technology transfer, R&D incentives, support for physical-capital expansion, and macroeconomic conditions conducive to capturing both static economies of scale, via R&D and capital investment, and dynamic economies of scale (learning by doing), all of which are fundamental in high-technology sectors such as semiconductors.

Protectionism played a decisive role in the early stages of development and consolidation of Japan's semiconductor industry. Shielding the domestic market from foreign competition provided Japanese firms with a stable demand base, an essential condition for capital accumulation and for financing the substantial R&D expenditures and capacity expansion required by the sector. This strategy was complemented by subsidies for the purchase of domestically produced goods and by stringent restrictions on foreign direct investment, on patent registration by multinational corporations, and on the operations of foreign firms in the domestic market, with exceptions granted only when no domestically produced substitutes existed. In addition, the deliberate weakening of antitrust legislation facilitated industrial concentration and the formation of large corporate conglomerates. Public institutions such as the Japan Development Bank also played a central role by offering long-term preferential loans at reduced interest rates to industries deemed strategic (CUSUMANO, 1991, p. 47; IRWIN, 1998, p. 185; USCOTA, 1991, p. 249).

The transfer of American technology, through licensing, joint ventures, or specific agreements mediated by the state, was another decisive instrument that accelerated the development of Japan's semiconductor industry. The case involving IBM in Japan was the most notable example. During the 1960s, MITI induced IBM to license essential patents to fifteen Japanese firms as a condition for authorizing the establishment of a subsidiary in the country. The operation of this subsidiary, however, was tightly regulated to prevent IBM from threatening the nascent domestic industry.

Given the high risks and uncertainties inherent to the semiconductor industry, as well as the initial lack of capital and technological know-how among domestic firms, the Japanese state structured institutional arrangements aimed at technological development and the diffusion of knowledge to the private sector, fostering cooperation between firms and the government. In this context, technology-supporting organizations (TSOs), publicly funded institutions dedicated to technological development, played a central role in human-capital formation, in the development,

dissemination, and licensing of technologies, and in the provision of technical support services to the industry.

The most prominent of these institutions was the Electro-Technical Laboratory (ETL), created in 1952 and subordinated to MITI, which became one of the pioneering centers for research and development of domestically produced integrated-circuit technologies. In addition to ETL, other TSOs stood out, such as the Japan Research and Development Corporation, the New Energy and Industrial Technology Development Organization, and the Japan Small Business Corporation, all of which performed complementary functions in consolidating Japan's domestic technological capabilities (OKADA, 2006, p. 43–46, 48–50, 78).

These institutions played a strategic role in forming public–private consortia dedicated to joint technological development. Between 1964 and 1966, ETL led Japan's first national semiconductor consortium, bringing together the country's six largest firms with the aim of avoiding duplicated efforts and preventing the development of technologies already patented in the United States. However, the consortium that most profoundly shaped the DRAM industry was the VLSI Semiconductor Research Project (1975–1977), coordinated by the Telecommunications Research Institute (TRI), a TSO affiliated with the state-owned Nippon Telegraph and Telephone Public Corporation (NTTPC). The project brought together TRI and Japan's five largest semiconductor firms, NEC, Hitachi, Fujitsu, Toshiba, and Mitsubishi, in a state-subsidized collaborative effort that yielded the critical technological advances underpinning the development of 16K and 64K DRAMs in 1977.

TRI subsequently developed the 128K DRAM independently in 1978 and co-developed the 256K DRAM with NEC and Toshiba in 1980. In addition, the project strengthened Japan's national capabilities in essential integrated-circuit production equipment, including photolithography, crystallography, diffusion, and etching, thereby enhancing the country's technological infrastructure. Between 1975 and 1982, three VLSI projects were undertaken, complemented by other strategic consortia such as the Fifth Generation Computer Project, the Optical Measurement Project, and the Future Electronic Devices Project (FRANSMAN, 2009, p. 57-97; OKADA, 2006, p. 50-51, 78-80; SAKAKIBARA, 1993; SHIN, 2015, p. 10). The integration among the state, firms, and TSOs constituted what Okada (2006) terms a "techno-governance structure."

In addition to state support, the organizational structure premised on close cooperation between upstream firms, such as DRAM producers, and downstream electronics manufacturers provided Japanese firms with substantial structural advantages over their predominantly merchant-producer U.S. counterparts. This cooperation operated through complex networks of cross-shareholdings, interpersonal ties, and financial linkages that resembled the large corporate conglomerates known as keiretsu. These arrangements created a system of mutual dependence that

reinforced strategic coordination and centralized decision-making, oriented toward maximizing the performance of the keiretsu as a whole. One of the most distinctive features of this system was its high degree of vertical integration. In the case of the DRAM industry, such integration spanned every stage of the value chain, from chip fabrication to the production of computers and consumer electronics, as well as marketing and global distribution.

The vertical integration of the keiretsu played a central role by ensuring technological cooperation in the development of new products, reducing transaction costs, and, above all, securing a stable demand base for upstream firms through downstream companies within the same conglomerate, such as those in the television, computing, telecommunications, and consumer electronics sectors, especially during periods of global recession (Irwin 1998, p. 178; Kaufman 1994, p. 342–343). By contrast, the absence of vertical integration among U.S. merchant producers exposed them to substantially greater market-risk volatility, since a large share of their profits depended on a single product, DRAM, unlike the keiretsu, whose activities spanned multiple markets (GILL and SWANN 1993, p. 120).

Another advantage conferred by membership in a keiretsu was privileged access to capital, since major financial institutions were themselves integral components of the conglomerate. These banks centralized financial operations, coordinated resource allocation through long-term preferential lending, typically at reduced interest rates and without collateral requirements, and intervened during periods of distress, while exerting direct influence over the corporate governance of affiliated firms. Participation in a keiretsu enabled Japanese DRAM producers to manage cyclical market fluctuations more effectively, particularly during downturns in demand, thereby preserving their capacity to prioritize long-term investment (DALLMEYER 1989, p. 181; IRWIN, 1996a, p. 25–26; IRWIN 1998, p. 178; SHIN, 2015, p. 12–13). By contrast, U.S. firms, organized predominantly as merchant producers, lacked comparable mechanisms of financial support, rendering them more vulnerable to market volatility.

Whereas the Japanese industry benefited from coordinated industrial policy and the organizational structure of the keiretsu, the U.S. industry confronted a persistently adverse macroeconomic environment. Japan's savings rate, approximately 15 percent, compared with only 5 percent in the United States, facilitated capital formation and investment growth, while the U.S. cost of capital rose steadily beginning in the 1970s. Following the first oil shock in 1973, higher interest rates led U.S. DRAM firms to curtail R&D and capacity expansion. Between 1973 and 1978, the average capital-expenditure-to-sales ratio among U.S. producers was only 12 percent, below the 17.8 percent observed in Japan. Conditions worsened after the second oil shock in 1979, as its effects on interest rates and capital costs were even more pronounced. From 1978 to 1985, U.S. firms increased their average capital-expenditure ratio to 16 percent, but Japanese firms expanded investment far

more aggressively, raising their average to 28 percent. The substantial appreciation of the dollar during the first half of the 1980s further exacerbated these pressures by sharply eroding the competitiveness of U.S. exports. By 1983, total capital investment in the Japanese DRAM industry already exceeded that of its U.S. counterpart (DALLMEYER, 1989, p. 181; GILL and SWANN 1993, p. 103, 119; IRWIN 1996a, p. 26–27; SHIN, 2015, p. 11–12).

Beginning in the late 1970s, Japan's share of the global DRAM market began to rise rapidly, surpassing that of the United States in 1982. Between 1978 and 1986, the U.S. share fell from 70 to only 20 percent, while Japan's share climbed from 30 to 75 percent. Even within the U.S. domestic market, Japanese producers expanded their presence from 7.5 to 12.3 percent between 1982 and 1984 (IRWIN, 1996b, p. 7–8). Japan's performance in DRAM further propelled the country's ascent in the semiconductor market more broadly. In 1980, the United States and Japan held, respectively, 57 and 27 percent of the global market. By 1985, the two countries commanded roughly equal shares, at around 45 percent each. Three years later, in 1988, the Japanese industry reached its peak, accounting for approximately 51 percent of the global market, while the U.S. share had fallen to 36 percent (IRWIN, 1998, p. 179; WEN et al., 2011, p. 616).

The Japanese advance was also reflected in the total number of firms operating in the global DRAM industry. In 1974, there was only a single Japanese producer, NEC. By 1979, however, Japan had already surpassed the United States in the number of firms operating at the technological frontier, the 64K DRAM generation, with six manufacturers, compared to only three in the United States. The Japanese industry not only operated with lower production costs, but also outperformed its U.S. counterparts across multiple dimensions, including yield, technological capability, and chip quality. This technological lead was such that even U.S. firms turned to Japanese know-how, as illustrated by National Semiconductor's decision to license technology from Oki Semiconductor in 1982 (GILL and SWANN, 1993, p. 117–120; SHIN, 2015, p. 10; USCOTA, 1991, p. 249).

3. THE TRADE WAR AND THE U.S.–JAPAN SEMICONDUCTOR TRADE AGREEMENT (1986)

By the late 1970s, Japan's industrial policy had proven successful not only in the DRAM sector but also across a range of industries in which Japan had become highly competitive vis-à-vis the United States, notably steel, automobiles, consumer electronics, and shipbuilding. Following the second oil shock in 1979, the sharp appreciation of the U.S. dollar, driven by the Federal Reserve's substantial increase in interest rates, further undermined the competitiveness of U.S. industry relative to Japan. The economic downturn and rising domestic discontent facilitated Ronald Reagan's election in 1981, marking a decisive shift in U.S. trade policy. The Reagan administration abandoned the traditional post-1945 commitment to free trade, long the foundation of the commercial order between the United States and its allies, and instead embraced the principle of fair trade, under which

Washington demanded reciprocity, greater access to markets deemed closed, and action against practices characterized as “unfair” and harmful to domestic industry.

Even before the second oil shock, the U.S. semiconductor industry had begun expressing growing concern over Japan’s rapid advance. The first protests emerged in the early 1970s, when U.S. manufacturers accused Japan of protectionism, citing the limited penetration of foreign firms in the Japanese market, only about 10 percent. In response, between 1973 and 1975, Tokyo voluntarily removed part of its protective barriers; however, this liberalization did not lead to a significant increase in U.S. market presence, given the high degree of vertical integration among Japanese firms (Baldwin, 1994, p. 135). Dissatisfaction persisted, and as Japanese competition intensified, Fairchild, Intel, Advanced Micro Devices (AMD), National Semiconductor, and Motorola formed the Semiconductor Industry Association (SIA) in 1977 to coordinate industry lobbying efforts. In December 1978, the SIA petitioned the U.S. International Trade Commission to initiate an informal investigation into the competitiveness of the U.S. semiconductor industry (IRWIN, 1996a, p. 21–24).

With the second oil shock, industry lobbying intensified. Japanese penetration of the U.S. DRAM market had become substantial: in the 16K segment, Japan’s share had already reached 40 percent, driven by more competitive pricing (Flamm, 1993, p. 256–258; USC, 1979, p. 21). In 1982, under SIA’s influence, Washington pressured Tokyo to establish the U.S.–Japan High Technology Working Group to address bilateral disputes related to alleged unfair trade practices (BALDWIN, 1994, p. 135; IRWIN, 1994, p. 28–30).

In early 1983, the SIA released a report accusing Japan of targeting practices and urging the United States to bring a case before the GATT and to enact new legislation to counter them. U.S. Trade Representative William Brock, however, discouraged filing a formal petition, arguing that the case lacked sufficient gravity (Dallmeyer, 1989, p. 185–186; Irwin, 1994, p. 29). By the end of 1983, the two countries reached an understanding under which MITI would encourage greater purchases of U.S. chips in Japan, raising the American share only marginally, from roughly 10 to about 14 percent (BALDWIN, 1994, p. 135; IRWIN, 1994, p. 30–31; PRESTOWITZ, 1988, p. 50–53).

The U.S. industry, however, was severely affected by the contraction of the domestic computer market in 1984–85. After expanding nearly fivefold between 1981 and 1984, the market shrank abruptly by 8 percent in 1985, triggering an estimated 60 percent decline in global DRAM demand. The excess production capacity accumulated in the early 1980s, particularly among Japanese manufacturers, led to a collapse in prices. Between November 1984 and June 1985, the import price of 64K DRAMs plummeted from 4.10 to as low as $0.23 dollars per unit, a decline of nearly 95 percent (USITC, 1985, p. 48–49). Prices for 256K DRAMs fell from 31 dollars in early 1984 to roughly 3 dollars by mid-1985 (Irwin, 1998, p. 182), while 256K erasable programmable read-only memories (EPROMs) dropped from 17 to about 4 dollars (DALLMEYER, 1989, p. 193).

As a result, U.S. merchant producers incurred unprecedented losses. Earnings before taxes (EBT), as a share of sales, fell from more than 14 percent in 1984 to nearly –10 percent in 1985. Capacity utilization dropped from over 70 percent in 1984 to less than 45 percent in 1985. Employment in the sector declined by roughly 20 percent (about 55,000 workers) in the first three quarters of 1985 alone. The 1985 recession forced most U.S. manufacturers, including Intel, AMD, AT&T, National Semiconductor, and Motorola, to exit the DRAM business and shift toward other semiconductor segments, especially logic devices; Mostek, in turn, filed for bankruptcy. Although the downturn also hit the Japanese industry hard, lower capital costs and the organizational structure of the keiretsu allowed Japanese firms to manage the recession more effectively than their American counterparts. Among U.S. producers, only Micron, Texas Instruments (TI), and IBM remained active in the DRAM segment, albeit with modest global market shares; TI and IBM later exited the sector in 1998 and 2000, respectively. The only firm that continued to operate as a genuine merchant producer in the global DRAM industry into the contemporary period was Micron (GILL and SWANN, 1993, p. 121–123; IRWIN, 1998, p. 182–183; PRESTOWITZ, 1988, p. 54–55).

Amid the crisis, the U.S. semiconductor industry pressed the Department of Commerce for decisive action against alleged Japanese dumping. In May 1985, MITI rejected a U.S. request to curb DRAM production (FLAMM, 1993, p. 266). In June 1985, Micron, unaffiliated with the SIA, filed an antidumping petition against Japanese 64K DRAM, while the SIA petitioned the U.S. Trade Representative under Section 301 of the Trade Act ("measures against unfair trade practices"), claiming persistent trade barriers, industrial policies (subsidies, tax incentives, preferential financing, antitrust exemptions), price manipulation, and the low U.S. market share resulting from "Buy Japan" (the vertically integrated structure of the keiretsu). According to the SIA, these practices violated not only General Agreement on Tariffs and Trade (GATT) provisions concerning the transparency of trade barriers but also the 1983 bilateral agreement, which had guaranteed increased access for U.S. producers to the Japanese market.[2] Moreover, such practices denied U.S. firms equal market access and a level competitive playing field. In October 1985, Intel, AMD, and National Semiconductor filed additional petitions against Japanese EPROMs (DALLMEYER, 1989, p. 184-185; FLAMM, 1993, p. 267-270; GILL e SWANN, 1993, p. 123-124; IRWIN, 1998, p. 183-186; PRESTOWITZ, 1988, p. 55-61).

After the petitions were filed, bilateral negotiations began. During this process, both parties, except for Micron, sought to avoid the imposition of antidumping sanctions. From the Japanese perspective, a trade conflict was undesirable, as exclusion from the U.S. market through antidumping duties would further reduce the already narrow profit margins of the Japanese industry. Once the

[2] In 1984, the American industry's share represented only 11 percent of the Japanese market, in contrast to 83 and 47 percent in the American and European markets, respectively (IRWIN, 1996, p. 8–9).

administrative process was initiated within the U.S. Department of Commerce, the imposition of antidumping duties became almost certain, given that investigations conducted by U.S. authorities frequently concluded that there was robust evidence of dumping, often with high margins. Thus, for Japan, it would be preferable to "voluntarily" restrict its exports, thereby preserving at least part of its position in the global market, rather than face antidumping measures imposed unilaterally.

From the American perspective, however, the mere imposition of antidumping duties would not be sufficient to restore domestic competitiveness, since Japan would continue to engage in "dumping" in third-country markets, which would lead to the progressive reduction, and possibly the elimination, of the American share in the global market. The SIA argued that Japan should cease predatory pricing practices worldwide, not only in the United States. Moreover, the liberal orientation of the Reagan administration prioritized the "opening of foreign markets" over the adoption of protectionist instruments (BALDWIN, 1994, p. 136; IRWIN, 1998, p. 184).

By mid-1986, the United States had not only imposed antidumping duties on Japanese imports but had also reached a negotiated settlement with Tokyo. The duties applied to 64K DRAMs, however, had virtually no effect, since the global industry had already shifted to the next generation (256K). More relevant was the agreement concluded in June 1986, titled the Arrangement between the Government of Japan and the Government of the United States of America concerning Trade in Semiconductor Products, commonly known as the U.S.–Japan Semiconductor Trade Agreement, through which Japan committed to preventing dumping practices and to maintaining "fair prices" for an initial period of five years, later renewed for another five years in 1991.

The "fair-price" mechanism established a price floor below which Japanese manufacturers were prohibited from exporting. This value was calculated by the U.S. Department of Commerce based on detailed data supplied by the Japanese government regarding the prices, products, and costs of DRAM and EPROM producers, using as a benchmark the "average fair market value." To ensure compliance with the price levels defined by U.S. authorities, MITI began restricting the industry's own exports, applying a control instrument traditionally known as a voluntary export restraint (VER) (BALDWIN, 1994, p. 135–137, 140–142; DALLMEYER, 1989, p. 195–196; FLAMM, 1993, p. 270–272; IRWIN, 1998, p. 191–192; PRESTOWITZ, 1988, p. 61–66).

Moreover, the agreement required Japan to promote sales opportunities for foreign producers in its domestic market, explicitly establishing the goal of reaching a share "slightly above 20 percent" within five years (BALDWIN, 1994, p. 140–141). To meet this target, the Japanese government committed to creating an organization tasked with assisting foreign firms in expanding their sales in Japan. Foreign companies also began to benefit from tax incentives related to research and technological development, as well as equal access to government subsidy programs under the same

conditions as Japanese firms. In addition, they were granted access to patents generated through government-funded research projects (DALLMEYER, 1989, p. 196).

The agreement did not yield immediate results, as MITI lacked both the operational capacity and the statutory authority to enforce its directives on Japanese firms, whether regarding domestic production or the purchase of foreign semiconductors. Moreover, MITI had limited ability to monitor sales destined for third-country markets. The price increases not only shifted demand toward suppliers from Hong Kong, Singapore, and South Korea, but also fostered the emergence of a "gray market," in which Japanese DRAM was resold below the established floor price. Because the agreement covered only the chip itself, and not chips mounted on printed circuit boards, U.S. firms began importing chips attached to "dummy" circuit boards, from which the component would be removed upon receipt and then used in final production. In addition, due to excessive inventories, Japanese firms began smuggling DRAM into third countries, where the chips were repackaged and reexported to the United States at prices 20 to 40 percent below the floor established by the two governments (DALLMEYER, 1989, p. 197–198; FLAMM, 1993, p. 272; IRWIN, 1998, p. 192–193).

Meanwhile, U.S. firms gained little. The share of the United States in the Japanese DRAM market rose from 8 percent to only about 11–12 percent by mid-1987. Nor did the agreement manage to bring back into the DRAM industry those U.S. companies that had exited the segment, given the low profit margins and high risks associated with the industry. Ironically, Intel itself, one of the companies that had filed petitions against the dumping practices of Japanese producers, began marketing Mitsubishi EPROMs and Samsung DRAMs under its own brand in the U.S. market (DALLMEYER, 1989, p. 199–200). In June 1989, several U.S. firms, AMD, Hewlett-Packard, Digital Equipment, Intel, LSI Logic, and National Semiconductor, attempted to form a domestic consortium known as "U.S. Memories" to produce DRAM, an initiative that even received support from IBM. However, the project collapsed in January 1990 due to the high cost of production and the lack of assured domestic demand (IRWIN, 1998, p. 196).

In light of the agreement's limited results, the United States intensified pressure on Japan in 1987, threatening to impose additional tariffs or even to terminate the bilateral accord unilaterally. In February of that year, MITI began requiring advance approval of declared prices on export licenses and extended the processing period for those licenses from 2–3 days to 2–3 weeks. In March 1987, the United States announced the unilateral imposition of 100-percent tariffs on selected Japanese imports, such as laptops, desktop computers, televisions, and handheld power tools, amounting to US$300 million in retaliatory duties (US$135 million attributed to semiconductor dumping and US$165 million to lost sales stemming from the absence of access to the Japanese market), effective April 1987.

In response, in April 1987 the Japanese government announced a cut of more than 30 percent in domestic DRAM production, with the aim of raising prices in the international market and constraining supply to "gray markets." It also tightened export controls and substantially reduced the minimum exporting value requiring an export license, from 1 million yen (roughly US$6,850) to just 50 thousand yen (about US$342) (DALLMEYER, 1989, p. 195–196, 198, 201–202; PRESTOWITZ, 1988, p. 66–70). U.S. pressure led MITI to reinforce monitoring of the price floor and to decisively persuade the Japanese industry to cooperate, resulting in an effective reduction in DRAM output (GILL and SWANN, 1993, p. 124–125; IRWIN, 1994, p. 59).

Economic coercion through tariffs proved effective in the short term. In 1988, the global memory market faced a supply shortage, a direct consequence of the 1986 agreement. The price of 256K DRAM rose sharply from approximately $2.20 at the beginning of 1987 to around $3.50 by the end of 1988 (IRWIN, 1994, p. 61). U.S. companies, such as Micron and TI, experienced rapid recoveries: while Micron increased its sales roughly sixfold between 1986 and 1988, TI also saw substantial gains, with its DRAM segment accounting for about 60% of total sales in 1988 (IRWIN, 1998, p. 193-196). The Japanese industry also reversed its losses. Higher prices, especially in the 1M DRAM market, substantially boosted Japanese firms' revenues, reaching $1.2 billion in 1988 (IRWIN, 1996b, p. 11). By the end of the agreement's term, U.S. market share in Japan had also risen, from 9% to 14%. In November 1987, the United States removed part of the tariffs imposed on Japan in April of that year, related to the semiconductor dumping case, reducing them from $300 million to $165 million until the agreement's expiration in 1991 (BALDWIN, 1994, p. 142; DALLMEYER, 1989, p. 204-205).

4. THE FALL OF THE JAPANESE DRAM INDUSTRY

Far beyond the offensive against the semiconductor industry, the United States also directed its trade actions against several other Japanese sectors; among the most notable cases were the VER agreements for automobiles and steel in 1981. In parallel with the use of retaliatory tariffs and voluntary export restraints, Washington pressured Japan—as well as several other allies—to adopt a set of pro-market economic and institutional reforms throughout the 1980s. These reforms contributed to the dismantling of core elements of the techno-governance characteristic of the Japanese developmental state. Such reforms were decisive in the accelerated collapse of the Japanese DRAM industry over the course of the 1990s.

From the mid-1980s onward, as a consequence of the 1986 Semiconductor Agreement and U.S. pressure for pro-market economic reforms, the MITI's capacity to plan and coordinate industrial policies was substantially constrained. MITI, which had previously played an active role in domestic technological development, began, to some extent, to operate in the "opposite direction." TSOs, such as the ETL, which had been fundamental in developing the domestic semiconductor industry, saw

their research scopes modified by MITI and were redirected toward basic research, largely disconnected from the needs of domestic firms. In order to avoid friction with the United States, MITI prohibited any silicon-based semiconductor research and substantially reduced the budgets allocated to TSOs. Furthermore, the sharp increase in the cost of semiconductor fabrication equipment, which became too high for public institutions to acquire, contributed to the loss of relevance of TSOs in supporting the domestic semiconductor industry (OKADA, 2006, p. 78–91).

Beyond the "loss" of MITI's capacities, the Japanese DRAM industry specifically also lost a key ally: the NTTPC. As a result of the United States' liberal offensive in the 1980s, when Washington protested against the closed nature of the Japanese telecommunications market, then dominated by the state-owned NTTPC, and demanded its opening, the promotion of free competition, and the company's privatization, NTTPC was privatized in 1985 and renamed Nippon Telegraph and Telephone (NTT). Consequently, the TRI, the research unit of the former NTTPC that had led DRAM development projects in collaboration with domestic manufacturers, shifted its focus to other types of research unrelated to DRAM, now strictly concentrated on the telecommunications sector, such as logic chips and microprocessors. Moreover, following privatization, NTT adopted a competitive bidding model for procuring goods and services, including semiconductors, replacing the former direct-purchase system that had favored domestic firms such as NEC, Hitachi, and Fujitsu, to which it used to transfer technology and production capabilities. As a result, NTT limited itself to patent commercialization, ceasing the transfer of technologies or know-how. Its role in disseminating cutting-edge technological knowledge effectively ended with privatization (OKADA, 2006, p. 79–80).

At the macroeconomic level, Japanese industrial competitiveness was severely affected by U.S. pressure in favor of yen appreciation. In response to the high U.S. trade deficits in the mid-1980s, Washington pressured Japan, West Germany, the United Kingdom, and France to promote the depreciation of the dollar, culminating in the Plaza Accord in September 1985. The yen, which had depreciated by approximately 20% between 1978 and 1984, appreciated sharply by around 45% between September 1985 and mid-1986, a move that significantly reduced the competitiveness of Japanese exports. In parallel with the pressure for currency appreciation, the United States also demanded, and, to some extent, imposed, the deregulation and opening of the Japanese financial system starting in 1984. The combination of yen appreciation and pro-market reforms in the financial sector triggered an accelerated deindustrialization process in the following years, which also affected the DRAM industry (BELKE; VOLTZ, 2020; DEKLE et al., 2010; ITO; CORBETT, 2010; N'DIAYE, 2010, p. 11–12; OSUGI, 1990; YAMASHITA, 2015).

Furthermore, Okada (2006, p. 71–79, 82–84) emphasizes that both industry and the state failed to adapt to the new post–pro-market reform era. According to the author, several factors contributed

to this incapacity: (1) the persistent absence of dynamic contributions from academia; (2) the continued scarcity of venture capital firms willing to assume risks, as well as the lack of diversity in business models; (3) strong technological path dependence, which limited firms' ability to identify internal technological alternatives and potential substitutes for DRAM technology capable of improving cost-effectiveness and competitiveness, while also generating duplicated efforts since the industry as a whole remained locked into the same technological trajectory, contributing little to domestic innovation; (4) cultural factors in Japanese society, particularly the emphasis on employment stability, which restricted labor mobility and inhibited both innovation and entrepreneurial spirit; (5) excessively rigid vertical relationships along production chains, which hindered innovation and the development of new markets; (6) the lack of flexibility and prevailing homogeneous thinking within TSOs; and (7) the vertical division of TSOs across different ministries, which produced redundancies in public research and limited interdisciplinary exchanges.

While the foundations of Japan's techno-governance structure were disintegrating from the mid-1980s onward, the Korean industry emerged under the leadership of large chaebols, business conglomerates controlled by a single founding family, which had benefited from government industrial policies and accumulated considerable wealth throughout the 1970s. Unlike Japanese keiretsu, where investment decisions are coordinated by professional managers, in chaebols strategic decisions and resource allocation remained concentrated in the controlling family, resulting in less technical and more intuitive decision-making processes. Korea's entry into the DRAM industry was led by Samsung in 1983, quickly followed by other chaebols such as LG, Hyundai, and Daewoo. Although initial production relied on technology licensing, Korean manufacturers maintained a persistently high pace of investment in physical capital and technological development from the outset, aiming to accelerate catch-up with Japanese firms while simultaneously offering chips with a better cost-performance ratio. This process continued even during negative market cycles, such as the 1985 industry recession. Throughout the 1980s, Korean manufacturers sustained extraordinarily high investment rates relative to their revenues, reaching an annual average of about 50%. By 1989, Korean investments in new fabrication plants accounted for approximately 20% of the total global industry investment (BYUN, 1994, p. 709–710; SHIN, 2015, p. 14–18).

The Korean industry benefited significantly from the U.S.–Japan trade conflict during the early stages of its development. The sudden restriction on 256K DRAM production by the Japanese industry in 1987, imposed by the United States, combined with the appreciation of the yen following the 1985 Plaza Agreement, created favorable conditions for competing industries. While American firms that had exited the industry considered that the risks, market fluctuations, and relatively low profitability did not justify a return, Korean manufacturers fully seized the opportunity. The rise in

DRAM prices at the end of the 1980s provided relief for the Korean industry, allowing it to recover part of the invested capital and sustain the accelerated pace of investment.

This initial investment momentum not only allowed the Korean industry to seize the opportunity at the end of the 1980s but also continued throughout the 1990s. Among the manufacturers, Samsung stood out for its persistence and determination in consolidating its position in the sector. Between 1987 and 1992, the company allocated approximately 39.8% of its revenues to capital expenditures, nearly double the global industry average, estimated at around 20.5%. From 1993 to 2000, Samsung maintained a similarly high level, investing about 26% of its revenues, a percentage above the global average of 23.2%. During this period, its average annual investment reached approximately 1.134 billion dollars, around 4.7 times higher than the average of the four main Japanese DRAM manufacturers. The company's total accumulated capital expenditures reached 9 billion dollars, surpassing even the combined investments of these four Japanese manufacturers, which totaled about 7.7 billion dollars (SHIN, 2015, p. 18, 20–21; SHIN and JANG, 2005, p. 10–11). By 1991, Samsung was only one technological generation behind the Japanese industry.

The conditions for the Japanese industry, already unfavorable due to exchange rate shocks and forced supply restrictions, deteriorated further at the beginning of the 1990s with the collapse of the asset price bubble. After the Plaza Agreements in 1985, which led to a sharp appreciation of the yen, the Bank of Japan significantly lowered interest rates, increasing liquidity in the banking system. Partial deregulation of the financial sector throughout the 1980s, combined with declining profitability of traditional investments, led banks to aggressively expand credit, especially to companies and real estate investors. These agents then directed funds toward the purchase of assets such as real estate and stocks, driving rapid asset price increases. The inflated assets themselves were then used as collateral for new loans, fueling a cumulative cycle of leverage and asset appreciation. Starting in 1989, faced with clear economic overheating, the Bank of Japan began a process of monetary tightening, raising interest rates and reducing liquidity. This shift triggered successive declines in stock and real estate prices. The abrupt reversal of expectations, coupled with the deterioration of bank balance sheets heavily exposed to collateral whose value had plummeted, culminated in the bursting of the asset bubble in the early 1990s.

The weakening of the banking system significantly reduced banks' risk appetite and contracted the credit supply, raising the cost of capital for DRAM manufacturers. This process coincided with the maturity of zero-interest bonds issued by major Japanese corporations in the early 1980s to finance strategic investments. In this adverse macroeconomic environment, the Japanese DRAM industry became hesitant to undertake higher-risk projects, precisely at the moment when the global sector was transitioning from 6-inch to 8-inch wafer production (HUTCHESON, 2014; SHIN; JANG, 2005, p. 27). This cautious stance was decisive in enabling Samsung to achieve technological

leadership in the global DRAM industry, becoming the pioneer in the production of 64MB DRAM and later the 256MB (1994) and 4GB (2001) generations. The company also anticipated the Japanese industry by successfully transitioning from 6-inch to 8-inch wafer production in 1993, a feat previously achieved only by IBM. By 1992, although the Japanese industry still held the largest share of the global market, Samsung had already become the world's largest DRAM manufacturer (SHIN, 2015, p. 14, 18–19).

The technological catch-up and superior cost-performance achieved by the Korean industry led to a rapid decline in sales and profitability for Japanese manufacturers. This process directly affected sector investments and disrupted the previously solid network of cooperation among firms, including the traditional keiretsu relationships. The most emblematic case was the gradual breakdown of the partnership between DRAM manufacturers and semiconductor equipment producers. Reduced profitability compromised the ability of Japanese manufacturers to maintain exclusivity arrangements and joint technological development programs with equipment companies. These suppliers, which historically delivered newly developed equipment exclusively to the associated company, delaying sales to competitors by 1 to 2 years, began selling to other semiconductor manufacturers, including Korean and Taiwanese firms, within shorter periods of up to 6 months after launch. Due to high testing costs and declining demand from Japanese clients, several equipment companies started establishing closer cooperation with American, Korean, and Taiwanese manufacturers. Simultaneously, Japanese semiconductor manufacturers replaced the cooperation model with competitive bidding processes for acquiring new equipment, profoundly altering the dynamics of industrial coordination and cooperation in the country (OKADA, 2006, p. 84–85, 113–144).

The crisis in the Japanese DRAM industry led manufacturers to diversify their activities into other semiconductor segments, such as flash memory and system LSI (large-scale integrated system), also known as system on a chip (SoC), in the expectation of recovering, at least partially, their lost prominence. From the 1990s onward, these companies also began developing technologies in cooperation with foreign manufacturers. For the development of 256 Mb DRAM, for example, Toshiba cooperated with IBM and Siemens (1992); Hitachi, with Texas Instruments (1993); and NEC, with AT&T (1993) and later with Samsung (1994). For 1 Gb DRAM, Toshiba established cooperation with IBM, Siemens, and Motorola (1995). However, these strategies did not yield the expected results, and Japanese manufacturers continued to accumulate significant losses in the sector (OKADA, 2006, p. 106–110).

The decisive outcome marking the "end" of the Japanese DRAM industry occurred with the structural changes that led to a sharp contraction in the global market between 1995 and 1998. The growing storage capacity of DRAM was not matched by a proportional expansion in demand, which slowed the development of new technology cycles. Simultaneously, persistent competition from

Korean manufacturers, combined with high global production capacity, pushed prices downward, causing the global market value to plummet from 40.8 billion dollars in 1995 to only 13 billion in 1998. Faced with this increasingly adverse scenario, by the late 1990s almost all Japanese manufacturers chose to exit their DRAM divisions: Mitsubishi (1996), IBM Japan (1996), Nippon Steel (1997), Oki Electric (1997), Fujitsu (1999), and Matsushita (1999). In 1999, the DRAM divisions of NEC and Hitachi were merged to create Elpida. In 2002, Toshiba sold its DRAM division to Micron. Finally, in 2012, Elpida, the last remaining Japanese company in the sector, declared bankruptcy and was also acquired by Micron (OKADA, 2006, p. 39–41, 71–72, 110–111).

In terms of global DRAM market share, the Japanese industry declined rapidly: from around 80 percent in 1987, to 50 percent in 1993, 40 percent in 1997, 20 percent in 2001, 13.5 percent in 2012, and finally 0 percent from 2013 onwards, following the bankruptcy of Elpida (JETRO, 2010; TRENDFORCE, 2013). The shifts in DRAM market share were directly reflected in the relative Japanese position within the global semiconductor industry as a whole. The Japanese's share declined from 51 percent in 1989 to 40 percent in 1994, 29 percent in 2000, 20 percent in 2010, and finally 9 percent in 2023 (SIA, 2024; WEN et al., 2011, p. 616).

CONCLUDING REMARKS

The trade conflict between the United States and Japan in the 1980s constitutes the clearest example of how economic coercion, such as unilateral retaliatory tariffs, can force structurally dependent economies to accept asymmetrical agreements with partners that possess greater bargaining power. Beyond the economic dimensions, the "reactive" behavior of the Japanese bureaucracy, characterized by difficulties in taking autonomous initiatives and a tendency to adopt pragmatically flexible stances under external pressure, also played a central role. This pattern is particularly evident in sectors such as finance and high technology, where market forces are intense, relative bureaucratic power is declining, and domestic interest groups are relatively weak. According to Calder (1988), the combination of strong political and market pressures from abroad and the "reactive" nature of the Japanese state was decisive in leading the country to concede in several rounds of negotiation and accept "unequal" agreements with the United States, ranging from voluntary export restraints (VERs) in the automobile, steel, and semiconductor sectors, to the opening of the market for American agricultural products, such as meat and oranges in 1978, and for telecommunications equipment in 1980, culminating in the substantial appreciation of the yen under the Plaza Accord in 1985.

The 1986 agreement, by itself, was not decisive for the collapse of the Japanese DRAM industry nor for the loss of its technological leadership. However, it opened a "window of opportunity" that allowed the consolidation of the nascent Korean industry, led by the chaebol and

characterized by a high appetite for risk. The decline of Japan in the 1990s was primarily the result of the institutional pro-market reforms and the Plaza Accord in the mid-1980s, which triggered a sequence of adverse shocks to the domestic industry. Among these, two factors were particularly decisive: (i) the significant appreciation of the yen, which reduced export competitiveness, and (ii) the bursting of the asset bubble in the early 1990s, which substantially increased capital costs and forced manufacturers to restrict essential investments for maintaining competitiveness, leading them to adopt excessively conservative strategies. Furthermore, the dismantling of the techno-governance structure, a cornerstone of the innovation ecosystem and of coordination and cooperation among companies, sectoral organizations, and the state, exacerbated the situation. In this context, the Korean industry advanced rapidly and achieved technological leadership. The persistent competition from Korean firms, coupled with the difficulty of Japanese manufacturers in adjusting their production and innovation models to the more volatile and flexible semiconductor market of the 1990s, deepened the losses. The contraction of the DRAM market, resulting from structural changes in demand in the mid-1990s, precipitated the definitive collapse of the Japanese industry, which remained in the sector only through Elpida until 2012.

The American strategy against Japan in the 1980s partially achieved its long-term objectives. On one hand, the Japanese DRAM industry was effectively "destroyed"; on the other hand, the American industry did not regain the prominence it had previously held. Although the establishment of a "price floor" temporarily raised international prices and made U.S. production momentarily "competitive," these incentives were insufficient to attract back the U.S. firms that had already exited the segment, nor to encourage the entry of new companies. Currently, only Micron remains active in the DRAM industry. Nevertheless, the trade war may have been crucial, at least, in preventing the Japanese industry from further deepening vertical integration and competitively expanding into higher value-added segments, such as logic semiconductors.

In this regard, the 1986 agreement proved to be substantially more beneficial for the then-emerging Korean industry, which was under significant financial pressure due to predatory price competition in the mid-1980s. The global rise in DRAM prices provided the necessary relief for Korean companies to regain financial footing. Strategic persistence, particularly by Samsung, combining price aggressiveness with innovative capacity was decisive for South Korea's technological and competitive catch-up, enabling it to rapidly replace Japan from the 1990s onward. Today, the Korean industry holds a share of the global market comparable to that which Japan commanded at the height of its leadership in the 1980s.

The "dismantling" of the Japanese DRAM industry did not reverse the trend of semiconductor production shifting outside the United States. Beyond the anticipated return of U.S. companies to the DRAM segment after the 1986 agreement, logic chip production was increasingly outsourced abroad

by non-American firms. Although competitive pressure in the logic chip manufacturing segment was relatively low during the 1980s and 1990s, the rapid rise in production costs led much of the U.S. industry to outsource chip fabrication to Taiwan, particularly to the Taiwan Semiconductor Manufacturing Company (TSMC), with the notable exception of Intel. Meanwhile, American firms increasingly focused on higher value-added segments, such as design, marketing, and branding. Companies that remained in manufacturing also relocated a substantial portion of their production capacity abroad. Both Micron and GlobalFoundries (a foundry segment company spun off from AMD) established significant parts of their fabrication facilities in Taiwan and Singapore, reinforcing the trend of U.S. offshore semiconductor production.

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