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The Chip 4 Alliance and Technological Geopolitics: Taiwan and South Korea's Economic Security Responses

Bumsig Ha*

Professor of Department of East Asia Languages and Literature, National University of Kaohsiung, Kaohsiung, TAIWAN

Tzu Chun Lee**

Master's Degree Student of Korean Studies Program, Department of East Asia Languages and Literature, National University of Kaohsiung, Kaohsiung, TAIWAN

Abstract

Thisarticle examines the evolving dynamics of the global semiconductor industry in light of the CHIP 4 alliance, with a particular focus on Taiwan and South Korea's strategic responses. It argues that semiconductors have emerged not only as a core driver of economic growth but also as a critical element of national security and geopolitical strategy. The study analyzes how Taiwan, as a global leader in logic chip manufacturing, and South Korea, with its dominance in memory semiconductors, have navigated the challenges and opportunities presented by the U.S.-led CHIP 4 framework. Drawing on official trade data, policy reports, and recent academic literature, the article explores each country's efforts to mitigate geopolitical risks, secure supply chain resilience, and enhance technological autonomy. The findings suggest that while both Taiwan and South Korea face significant external pressures—particularly from the U.S. and China's strategic rivalry—they have adopted differentiated but complementary strategies to reinforce their positions within

* bsha@nuk.edu.tw.

** m1101703@mail.nuk.edu.tw.

the global semiconductor ecosystem. This study contributes to a deeper understanding of economic security and technological geostrategy in East Asia.

Keywords: Taiwan, South Korea, economic security, technological geopolitics, Chip 4 Alliance.

I. Introduction

Since the outbreak of the U.S.-China trade war in 2018, the global semiconductor industry has become a focal point in the intensifying competition between major powers. With the emergence of technological nationalism and supply chain restructuring, semiconductors are no longer seen solely as economic goods but as critical strategic assets. The COVID-19 pandemic and the Russia-Ukraine war have further exposed the vulnerabilities of global supply chains, prompting the United States to reinforce its leadership in semiconductor technology and supply chain security through industrial policies such as the CHIPS and Science Act and the promotion of the "Chip 4" alliance (Chow, 2025: 272-82).

Taiwan and South Korea, both key players in the global semiconductor supply chain, have been drawn into the strategic logic of U.S. technological-geopolitics. While Taiwan's TSMC leads in advanced foundry technology, South Korea's Samsung and SK Hynix dominate the global memory chip market. However, both countries also rely heavily on the Chinese market and production capacity, creating a dilemma of strategic ambiguity (Yoon, 2023: 42-44).

The establishment of the Chip 4 alliance by the United States in 2022 represents a strategic initiative to consolidate the comparative advantages of the U.S., Japan, South Korea, and Taiwan across different segments of the semiconductor supply chain. The alliance aims to enhance supply chain resilience, promote technological cooperation, and jointly address emerging geopolitical risks. However, divergent national interests and political constraints have thus far hindered consensus on the alliance's institutional design and operational scope. In particular, South Korea's cautious diplomatic approach and Taiwan's constrained international status remain key challenges to the full realization of the Chip 4 framework (Chow, 2025: 272-78; Yoon, 2023: 51-53).

Against this backdrop, this article analyzes the strategic intentions and structural changes resulting from the establishment of the Chip 4 alliance. It focuses on the economic security and policy responses of Taiwan and South Korea, with a particular emphasis on how both countries navigate the strategic competition between the United States and China while safeguarding their core national interests. Through comparative analysis, the study also seeks to examine the technological geopolitical implications and limitations of the Chip 4 mechanism, thus offering policy recommendations for Taiwan and South Korea's medium- and long-term responses.

II. Theoretical Framework: Economic Security and Technological-Geopolitics

2.1 Economic Security: The Core of National Strategy

The concept of economic security emerged in the post-Cold War expansion of national security discourse. It emphasizes a nation's ability to maintain economic autonomy and social stability amid internal and external shocks. With the rise of technological interdependence and geopolitical risks, economic security has become a central element in strategic national planning. Specifically, economic security encompasses not only the protection of energy, food, infrastructure, and capital flows but also the autonomy in technology and strategic industries (Yuzue & Sekiyama, 2025).

Semiconductors, as high-value-added and technology-intensive strategic goods, have become a top priority for economic security policies. In recent years, the United States, the European Union, Japan, and China have each invested heavily in building domestic chip production capabilities to prevent supply disruptions and technology leakage. Control over semiconductor supply chains has thus become a central asset in geopolitical competition. Miller (2022: 102-105) highlights that the dominance of the U.S., Taiwan, and South Korea in advanced manufacturing processes positions semiconductors not only as tools for economic competition but also as key levers for national security and global power balance.

The chip shortage during the COVID-19 pandemic revealed vulnerabilities in global semiconductor supply chains. In response, the U.S. promoted the *CHIPS and Science Act* to strengthen domestic production. The proposal of the Chip 4 alliance aims to build a trusted supply chain system among allies and reduce the risks associated with heavy reliance on China (Chow, 2025: 270-285).

2.2 Technological-Geopolitics and Semiconductor Competition

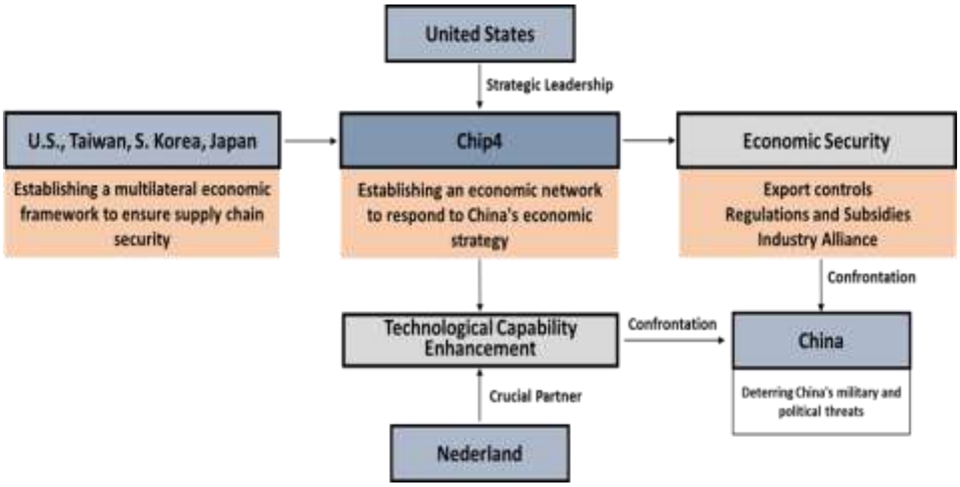
Technological-geopolitics refers to the process by which international political actors leverage technological power and institutional frameworks to compete for regional or global influence. Semiconductors are a representative domain of this dynamic. According to PChow (2025: 271-74), semiconductors are viewed as strategic assets and essential components in both economic and security domains. The United States has increasingly incorporated semiconductors into its national security strategy through mechanisms such as export controls, subsidy programs, and alliances like Chip 4, aiming to limit technological transfers to China and maintain its leadership in critical technologies.

In October 2022, the U.S. Department of Commerce (2022) announced a new round of export controls on China, restricting American firms from exporting semiconductor manufacturing equipment and technologies for processes below 14nm. It also prohibited U.S. citizens and green card holders from participating in advanced semiconductor R&D projects in China. These measures cover key equipment such as DUV and EUV lithography machines and require foreign firms using U.S. technologies to comply with these export restrictions as well. These actions have significantly impacted China's semiconductor industry and demonstrate the U.S. strategy of reinforcing its leadership in the global tech order through rules and export systems.

The Chip 4 initiative reflects a broader ambition by the U.S. to lead technological standards and establish a dependent alliance structure. Chip 4 represents the de-Sinicization of technological governance frameworks and the reorganization of supply chains among democratic nations- an emerging trend they term the “new Cold War tech alliance” (Hwang & Huang, 2022: 43-55).

The following conceptual framework (Figure 1) visualizes the theoretical logic that underpins this study’s analysis. It integrates the perspectives of economic security and technological geopolitics to demonstrate how U.S. strategic leadership, through policy instruments such as export controls and subsidies, facilitates technological capability enhancement and alliance formation. The arrows denote directional and causal relationships among these components, providing a structural guide for the comparative analysis in Sections 3 through 5.

This figure illustrates the strategic sequencing of the U.S.-led Chip 4 alliance based on the integration of economic security and technological geopolitics. The arrows represent causal and functional linkages between key strategic elements. U.S. leadership initiates export control regulations and subsidies as policy instruments to enhance technological capabilities among allied partners. This process leads to the institutionalization of an industry alliance (Chip 4), which in turn supports economic security goals and shapes a collective response to China’s technological and geopolitical challenge. In order to visualize the strategic logic underpinning the Chip 4 alliance and its implications for Taiwan and South Korea, the following analytical framework integrates the core elements of economic security and technological geopolitics. This structure serves as a conceptual roadmap for subsequent empirical analyses.



Source: Created by the author, based on Chow (2025).

Figure 1: Analytical Framework of Economic Security and Technological-Geopolitics in the Chip 4 Context

2.3 Comparative Perspectives: Taiwan and South Korea's Response Patterns

Taiwan: With TSMC at the core of its manufacturing advantage, Taiwan is a critical member of Chip 4. Although it faces pressure from the Chinese market, Taiwan retains strong bargaining power due to its irreplaceable capabilities in advanced processes. However, it must also guard against the outflow of cutting-edge technologies and talent that could weaken its long-term competitiveness (Chow, 2025: 288-91).

South Korea: While South Korea leads in memory chip production, it remains dependent on external sources for logic chips and materials. The country is simultaneously strengthening cooperation with the U.S. and Japan while seeking to maintain stable relations with China, reflecting a preference for a strategy of "strategic ambiguity"—a dual-track approach that balances security and economic interests (Rousselot, 2022; Seo, 2023).

In terms of participation in supply chain governance structures, Taiwan emphasizes deepening cooperation with the U.S. in advanced manufacturing and critical materials while gradually expanding its international production footprint to balance technological leadership with political security. South Korea, by contrast, focuses on enhancing domestic materials technological R&D and attracting foreign investment to strengthen its semiconductor ecosystem. The South Korean government's "K-Semiconductor Strategy" underscores a dual-track approach combining international cooperation and internal technological development (Ministry of Trade, Industry and Energy of Korea, 2021).

In addition, Taiwan adopts a high-alert, risk-diversification strategy in interactions with China, particularly by imposing strict controls on TSMC's investments in the Chinese market. South Korea, on the other hand, continues to seek a balanced and pragmatic approach to bilateral trade with both the U.S. and China, maintaining a relatively high level of engagement with China's semiconductor market.

III. Global Semiconductor Development and the Evolution of Taiwan and South Korea's Industries

3.1 The Evolution of the Global Semiconductor Industry

Since its inception in the mid-20th century, the semiconductor industry has gradually become a key driving force behind modern technological and economic development. The earliest technological breakthroughs originated in the United States, from the invention of the point-contact transistor in the 1940s to the planar transistor in the 1950s. U.S. companies such as Bell Labs, Texas Instruments, and Fairchild Semiconductor played pioneering roles in these innovations (Flamm, 1996: 120-45). During the 1960s, the U.S. further solidified its dominance by developing integrated circuit (IC) technology, fueling the large-scale expansion of computers and electronic products (Brown & Linden, 2009: 45-67).

However, from the late 1970s to the early 1980s, Japan rapidly rose to global leadership in semiconductors, particularly in the DRAM memory market, thanks to strong government support and successful technology transfers (Saxenian, 2006: 34-56). Intensified competition between Japan and the U.S. led to the signing of the *U.S.-Japan Semiconductor Agreement* in 1986. This agreement aimed to limit Japanese semiconductor exports and increase the market share of American products (Prestowitz, 1988: 33-47). Although it temporarily reduced Japan's market share, it also contributed to the economic bubble that followed (Johnson, 1982: 58-72).

In the 1990s, global semiconductor production gradually shifted toward South Korea and Taiwan. The United States outsourced part of its manufacturing to Asia in order to cut costs and focus on high-value-added design and R&D (Mathews & Cho, 2000: 88-110). Taiwan's TSMC and South Korea's Samsung Electronics quickly emerged as indispensable players in the global supply chain. This marked the beginning of a highly specialized and collaborative global semiconductor ecosystem, where South Korea and Taiwan became major production hubs, the United States retained leadership in innovation, and global markets became increasingly integrated (RAND Corporation, 2021).

From the late 1990s to the early 2000s, the global semiconductor market experienced another surge driven by the digital revolution. With the widespread adoption of personal computers and smartphones, semiconductor demand skyrocketed, and the division of labor became more defined: the United States focused on advanced process R&D and design, Taiwan led in efficient foundry production, and South Korea advanced in memory technology (Saxenian, 2006: 78-99). This global division of labor laid the foundation for future supply chain restructuring and deepened technological interdependence among the United States, China, Japan, South Korea, and Taiwan. As geopolitical tensions rise, semiconductor supply chain security and technological sovereignty have become critical concerns. U.S. technology restrictions on China have further amplified global market uncertainty, underscoring the strategic importance of South Korea and Taiwan in the global supply chain and positioning them at the center of future technological competition (Congressional Research Service, 2023).

3.2 Development of Taiwan's Semiconductor Industry

In the early 1970s, Taiwan's decision to develop a semiconductor industry was rooted in strategic considerations to transform its economy from labor-intensive manufacturing to high-technology production, ensuring long-term competitiveness and reducing vulnerability to global market volatility. This policy shift was reinforced by geopolitical imperatives, as Taiwan sought to deepen technological cooperation with the United States while maintaining strategic autonomy during the Cold War (Tso, 2004: 301). Within this framework, Pan Wen Yuan led the establishment of the Technical Advisory Committee (TAC) and facilitated the transfer of 7 micron CMOS technology from RCA to the Industrial Technology Research Institute (ITRI), enabling the creation of a demonstration plant to build domestic manufacturing capabilities (Fuller, 2005: 485-90). United Microelectronics Corporation (UMC) was subsequently founded in 1980, inheriting ERSO's technology and personnel to initiate commercial production. In 1987, Morris Chang founded TSMC, pioneering the foundry-only model—focusing exclusively on contract manufacturing rather than chip design—which avoided direct competition with clients, leveraged economies of scale, and positioned Taiwan as a trusted partner in the global semiconductor supply chain (Fuller, 2005: 490-93). Building upon this strategic foundation, Taiwan's semiconductor industry entered a phase of rapid institutional development in the 1980s.

During this formative stage, the government actively promoted the establishment of the Hsinchu Science Park to consolidate technological R&D and create industrial clustering, strengthening the foundation of semiconductor technology (Chiang, 2023: 36-37). Taiwan Semiconductor Manufacturing Company (TSMC) 's innovative process technologies disrupted the traditional Integrated Device Manufacturer (IDM) model by establishing the foundry-only business, enabling the company to secure a central role in global supply chains (Chiang, 2023: 39-42). Through targeted industrial policies—such as R&D subsidies, tax incentives, and technology transfers—the government successfully attracted multinational firms to establish operations in Taiwan, further integrating the island into the global semiconductor ecosystem.

Entering the 2000s, Taiwan's semiconductor sector achieved significant technological milestones, with TSMC and United Microelectronics Corporation (UMC) breaking through the 90nm and 65nm process nodes and expanding into global markets. During this period, fabless design firms such as MediaTek emerged as major players in the global mobile device market (Chen & Jan, 2005: 855-60). Taiwan's government policies, including the "Two Trillion and Twin Star" initiative, accelerated technological upgrading in both foundry and IC design segments. In the 2010s, TSMC's breakthroughs in 7nm and 5nm production established it as a critical supplier for Apple, AMD, and NVIDIA (Miller, 2022: 210-13), while national strategies promoted 5G and high-performance computing (HPC) chip development, reinforcing Taiwan's global leadership.

By the 2020s, TSMC announced plans for mass production of 3nm and 2nm processes and expanded manufacturing sites in the United States and Japan to diversify markets and mitigate geopolitical risks (Mathews & Cho, 2000: 115-20). In parallel, the Taiwanese government launched semiconductor-focused initiatives aimed at enhancing supply chain security, strengthening ties with democratic partners such as the United States, Japan, and European countries, and safeguarding technological leadership. The success of Taiwan's semiconductor industry is thus the product of sustained policy support, continuous innovation, and integration into global markets—positioning Taiwan as both the world's most important foundry hub and the leader in advanced process technology at a time of intensifying global technological competition.

3.3 The Development of South Korea's Semiconductor Industry

In the early 1980s, South Korea's entry into the semiconductor industry—led by large business conglomerates such as Samsung, Hyundai, and LG—was driven by a combination of state-led industrial policy, abundant capital resources within the chaebol[1] system, and the government's strategic vision to secure technological autonomy (Kim, et al., 2015). The Park Chung Hee administration (1961-79) and the Chun Doo-Hwan administration (1980-88) identified semiconductors as a future growth engine capable of upgrading the country's industrial structure and reducing dependence on low-value manufacturing, while also improving the trade balance through high-value exports. The chaebols, benefiting from diversified business portfolios, access to state-directed credit, and preferential policy support, were well-positioned to absorb the high initial costs and risks of entering this capital-intensive and technology-intensive sector (Kim, 1997: 102-105). providing the private-sector

[1] Chaebol are large, family-controlled South Korean business conglomerates such as Samsung, Hyundai, and LG, SK. They are characterized by their diversified business portfolios, centralized ownership and management by a founding family, and close historical ties with the government. These groups played a pivotal role in South Korea's rapid economic development by leveraging their abundant capital and government support to expand across various industries.

capacity that government initiatives in the 1980s would build upon

Leveraging both this chaebol capacity and targeted state policies, the rise of South Korea's semiconductor industry accelerated in the 1980s, supported by strong government programs and fiscal subsidies that laid a solid foundation for its growth. In the memory chip segment in particular, Samsung Electronics and SK Hynix quickly became global market leaders, driving South Korea's export growth and technological self-reliance (Amsden, 1989: 55-58). In 1983, Samsung launched a DRAM development project, which became a critical turning point in South Korea's semiconductor development. Soon after, LG Semicon[2] and Hyundai Electronics (now SK Hynix) also entered the race, rapidly expanding their global market share. Since then, South Korea's semiconductor firms have continuously strengthened R&D investment, secured technological leadership, and actively participated in the integration of global supply chains to consolidate their international status.

In the 1990s, the South Korea's government further promoted technological upgrading and globalization of the semiconductor sector. Samsung and SK Hynix not only maintained their lead in memory technology but also expanded into system semiconductors and advanced processes. In the 2000s, the South Korea's government introduced the *Industrial Technology Promotion Act* to further enhance R&D investment and innovation and to promote corporate participation in global market competition. Notably, in the early 2010s, Samsung began investing in sub-5nm advanced processes, securing its position in the high-performance computing (HPC) and artificial intelligence (AI) markets (Kim & Kim, 2006: 50-55).

In 2019, the Korean government announced the K-Semiconductor Strategy,

[2] LG Semicon, a former semiconductor arm of LG Group, was merged with Hyundai Electronics (now SK Hynix) in 1999 as part of government-mandated industrial restructuring during the Asian financial crisis.

aiming to establish South Korea as the world's largest semiconductor supply hub by 2030. This strategy includes three core objectives: (1) strengthening R&D for 5G, AI, and automotive chips; (2) improving infrastructure by expanding production capacity and enhancing domestic supply chains; and (3) promoting international cooperation to reduce reliance on Chinese manufacturing (Ministry of Trade, Industry and Energy of South Korea, 2021). Especially after COVID-19 exposed the vulnerabilities of global supply chains, Korea accelerated efforts to achieve technological self-sufficiency and diversified deployments. This included setting up domestic R&D centers, attracting international investment, and deepening cooperation with advanced economies such as the United States, Japan, and Europe (Congressional Research Service, 2023). These initiatives have not only strengthened Korea's influence in the global market but also consolidated its leadership in the high-tech industrial chain.

Furthermore, South Korea actively participates in the United States-led Chip 4 alliance to ensure its competitive edge in memory technologies. This internationalized technological layout helps to mitigate geopolitical risks and establishes South Korea as a key hub in the global semiconductor industry.

3.4 Strategic Complementarity and Challenges of the Semiconductor Industries in Taiwan and South Korea

Taiwan and South Korea serve as two critical pillars of the global semiconductor supply chain. Each has developed unique strengths while forming a high degree of complementarity in key areas. TSMC's technological breakthroughs in advanced nodes such as 5nm and 7nm enabled it to become a key supplier for major global tech firms including Apple, AMD, and NVIDIA. By 2022, the Taiwan-based company commanded nearly 60% of the global foundry market, maintaining clear leadership in cutting-edge process technologies (TSMC, 2023: 6-9, 15-16, 38). Taiwan's IC design companies, such as MediaTek, also maintain strong market competitiveness in the global mobile device sector, leveraging their leading position in AI, 5G, and connectivity chipsets (Tung, 2024). In contrast, South Korea dominates memory semiconductor production, with Samsung Electronics and SK Hynix leading the global DRAM and NAND Flash markets. Their strengths lie in high-performance processing and large-scale manufacturing capabilities, positioning them as major international suppliers (Shin, 2017: 404-16). This industrial division of labor fosters technological complementarity rather than direct competition, strengthening East Asia's significance in the global semiconductor supply chain (Wong, et al., 2024).

In addition, both Taiwan and South Korea exhibit strong potential for collaboration in supply chain management and technological exchange. Although TSMC and Samsung Electronics remain key competitors in advanced semiconductor manufacturing, their respective positions in the global value chain also enable opportunities for cooperation—particularly in areas such as supply chain risk mitigation, technology governance, and equipment coordination—highlighting a strategic complementarity between the two firms (Wong, et al., 2024). Especially amid rising geopolitical tensions, enhanced integration and cooperation between Taiwan and South Korea can help diversify market dependencies and improve supply chain resilience, particularly in areas of strategic importance within the semiconductor value chain (Wong, et al., 2024).

However, both face shared challenges. The intensifying U.S.-China technological rivalry has pressured Taiwan and South Korea to restructure supply chains and recalibrate strategic alignments. The United States-led Chip 4 alliance, intended to ensure supply chain security, has simultaneously complicated their economic relations with China and required significant policy adjustments (Chow, 2025: 270-74). Furthermore, the development of advanced semiconductor process technologies demands extensive capital investment, prompting both Taiwan and South Korea to increase funding for R&D, talent cultivation, and infrastructure upgrades in order to sustain their technological leadership (Wong, et al., 2024). Facing increasingly uncertain technological transitions and evolving market demands, the governments and industries of Taiwan and South Korea must adopt more adaptive and forward-looking strategies to foster innovation, enhance sustainability, and maintain global competitiveness (Wong, et al., 2024). A comparative overview of their respective semiconductor strategies is presented in Table 1, highlighting the key similarities and differences in their industrial approaches.

Table 1. Comparison of Taiwan and South Korea's Semiconductor Strategies

Category	Taiwan	South Korea
strategic background	1970s shift to high-tech; Cold War U.S. cooperation.	1980s entry; state-led, chaebol-driven industrial upgrade.
industry structure	Foundry-only model (TSMC); fabless-foundry separation.	IDM model; memory-dominant chaebol control.
government role	ITRI/ERSO support; R&D subsidies; Hsinchu Science Park.	Directed credit; subsidies; *Semiconductor Promotion Plan, K-Semiconductor Strategy*.
key enterprises	TSMC, UMC, ASE, MediaTek.	Samsung, SK Hynix, LG Semicon (legacy).
technological focus	Advanced nodes (7-2nm); HPC and foundry leadership.	Memory leadership (DRAM, NAND); expansion into system semiconductors, sub-5nm.
global supply chain strategy	Trusted foundry partner; diversify sites (U.S., Japan); allied cooperation.	Maintain memory lead; join Chip 4; diversify supply chains, reduce China reliance.

IV. The Background and Strategic Significance of the United States-Led CHIP 4 Alliance

4.1 The Evolution and Current Structure of the Global Semiconductor Supply Chain

The global semiconductor supply chain has undergone significant structural changes since the mid-20th century. Initially, the United States dominated technological innovation and production, with companies such as Bell Labs, Texas Instruments, and Fairchild Semiconductor pioneering key developments, including the point-contact and planar transistors (Miller, 2022: 19-23, 36-42).

In the 1970s and early 1980s, Japan emerged as a dominant force in the memory chip market, fueled by coordinated industrial policies and state support. This expansion triggered U.S. concerns and led to the 1986 *U.S.-Japan Semiconductor Agreement,* which aimed to curb Japanese dominance in global markets (Johnson, 1991). By the 1990s, the center of semiconductor manufacturing began shifting to East Asia. Taiwan's TSMC and South Korea's Samsung Electronics rapidly grew into key players, leveraging foundry specialization and vertical integration, respectively (Mathews & Cho, 2000: 115-20).

This transition marked a new regional configuration in the global value chain, in which Taiwan and South Korea became increasingly indispensable to upstream fabrication and downstream packaging and testing processes (Wong, et al., 2024). In the 2000s, China introduced long-term strategic plans to build a competitive domestic semiconductor industry. These efforts aimed to reduce external dependence and position China as both a major consumer and emerging producer (Saxenian, 2006: 78-99; Wong, et al., 2024).

Globalization further fragmented production geographically. Core manufacturing capabilities became concentrated in East Asia, while design, equipment, and materials remained distributed across the United States, Japan, and Europe (Mathews & Cho, 2000; Wong et al., 2024). The COVID-19 pandemic and the Russia-Ukraine war have revealed the fragility of globally dispersed semiconductor supply chains. The sharp increase in demand during the pandemic, followed by the disruption of key raw materials due to the war, has amplified concerns over overconcentration and just-in-time manufacturing vulnerabilities (Lin, 2022: 17-20).

Amid mounting geopolitical tensions, nations now seek to localize strategic production nodes and reduce asymmetric dependencies in the semiconductor ecosystem (Wong, et al., 2024).

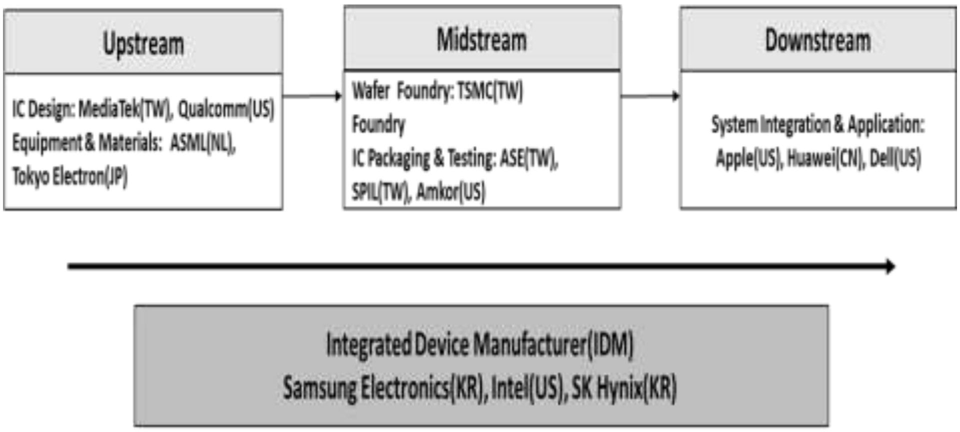


Figure 2. Global Semiconductor Supply Chain Structure

This figure illustrates the division of labor within the global semiconductor value chain, structured across three main segments: upstream, midstream, and downstream. The upstream segment comprises IC design (fabless companies), semiconductor equipment, and materials. This segment is predominantly led by firms from the United States and Japan. Key players include Synopsys and Cadence (EDA tools), Lam Research and Applied Materials (equipment), and Tokyo Electron (materials). Fabless companies such as Qualcomm and

MediaTek design chips but outsource manufacturing.

The midstream segment includes both wafer fabrication (foundries) and back-end processes such as testing and packaging (OSAT). This segment is heavily concentrated in Taiwan and South Korea. TSMC and UMC dominate global foundry services, while Samsung Electronics operates as both a foundry and a vertically integrated device manufacturer. In the back-end, Taiwanese firms such as ASE Technology and Ardentec provide advanced outsourced semiconductor assembly and testing services, ensuring yield and reliability.

The downstream segment refers to system integration and application companies that incorporate semiconductors into end-user products. This includes technology giants like Apple, Huawei, Dell, and Tesla, which integrate logic and memory chips into smartphones, servers, PCs, and automotive systems. These companies shape market demand and influence semiconductor design priorities, even though they typically do not manufacture chips themselves. In contrast to this horizontally segmented value chain, vertically integrated device manufacturers (IDMs)—such as Intel (U.S.), Samsung Electronics, and SK Hynix (South Korea)—cover the entire production process in-house, from chip design and wafer fabrication to testing, packaging, and even product-level integration. This vertical integration enhances strategic autonomy, strengthens supply chain resilience, and mitigates geopolitical and logistical risks, especially in light of ongoing U.S.-China technological decoupling.

4.2 Geopolitical Rivalry and the Struggle for Technological Sovereignty

As globalization deepens, semiconductors have become both economic growth engines and strategic assets. In the wake of the U.S.-China trade war, technological sovereignty has emerged as a pivotal concern. The United States has responded with legislative and institutional tools aimed at securing leadership in semiconductor technologies. The *CHIPS and Science Act*, for instance, allocated around $52 billion to strengthen domestic manufacturing and R&D systems (Kannan & Feldgoise, 2022: 1-2), while the *Defense Production Act* has been invoked to mobilize resources for national defense technologies and reinforce industrial preparedness (U.S. Department of Energy, 2021; Bown & Wang, 2024: 14). These industrial-policy measures are complemented by enhanced export controls targeting firms like ZTE and restrictions on advanced-process technologies, signaling a multifaceted strategy to contain China's semiconductor ambitions and maintain U.S. technological dominance (Yoon, 2023: 29-32).

On the other hand, China launched the Made in China 2025 (《中國製造 2025》) initiative with the goal of achieving self-sufficiency in critical technologies—particularly semiconductors, artificial intelligence, and quantum computing—by the year 2025 (State Council of the People's Republic of China, 2015). Through the National Integrated Circuit Industry Investment Fund (commonly known as the "Big Fund"), China has heavily invested in domestic fabrication, IC design, and equipment development to reduce its dependence on foreign technologies. Additionally, the country has pursued international mergers, acquisitions, and technology transfers to narrow its technological gap and enhance its influence in the global supply chain.

Taiwan and South Korea, as critical manufacturing hubs in the global semiconductor supply chain, have become strategic pivots in the U.S.-China technological rivalry. Taiwan's TSMC leads globally in wafer fabrication, particularly with its dominance in 5nm and 3nm process nodes (Mathews & Cho, 2000: 115-20). Meanwhile, South Korea possesses an unshakable advantage in memory technologies (DRAM and NAND), with Samsung Electronics and SK Hynix together commanding over 70% of the global market (Semiconductor Industry Association, 2023: 12-15).

The U.S. has consolidated its technological alliances through the CHIP 4 framework, aiming to secure advanced manufacturing supply chains and prevent China from gaining technological superiority (Yoon, 2023: 45-48; Kannan & Feldgoise, 2022: 5-7). In response, China has accelerated domestic investment and import substitution strategies to expand indigenous capacity. This contest for technological sovereignty is reshaping the structure of the global supply chain and altering the geopolitical balance of regional economies.

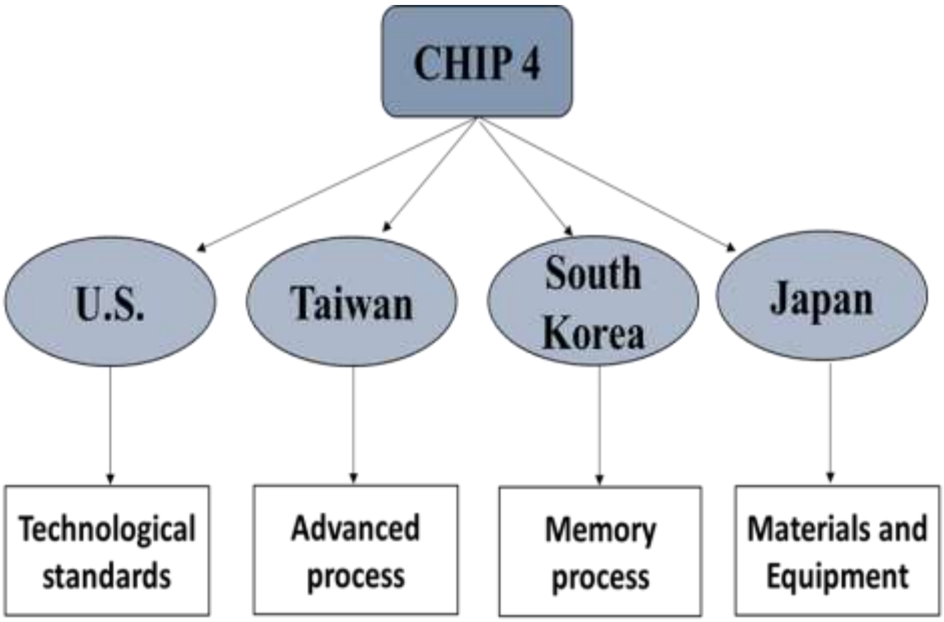


Figure 3. The Roles of CHIP 4 Members

This strategic division of labor allows the United States to reinforce its technological leadership while leveraging Taiwan and South Korea's manufacturing strengths. Japan contributes further by supplying advanced materials and equipment, stabilizing the upstream segment of the supply chain, and reducing dependence on Chinese sources.

4.3 The Transformation of U.S. Semiconductor Policy

The supply chain disruptions caused by the COVID-19 pandemic exposed the United States' heavy dependence on semiconductor manufacturing in Taiwan and South Korea, particularly in sectors such as automotive, telecommunications, and national defense. In 2020, a shortage of automotive chips halted production lines, revealing the fragility of U.S. supply chain resilience (Semiconductor Industry Association, 2023: 18-20). This incident highlighted the global supply chain's overreliance on a few countries, especially Taiwan's dominance in advanced foundry processes and South Korea's leadership in memory manufacturing—an unsustainable risk for U.S. manufacturing.

In response, the U.S. government swiftly enacted the *CHIPS and Science Act,* passed in August 2022. This legislation allocates $52 billion over five years to enhance domestic manufacturing capacity and provides an additional $10 billion for research and development (Kannan & Feldgoise, 2022: 2-3). The act aims to reduce excessive reliance on Taiwan and South Korea and to build a more secure and resilient U.S.-based semiconductor supply chain. Specifically, the main objectives of the *CHIPS and Science Act* include:

(1) Revitalizing U.S. Semiconductor Manufacturing: The *CHIPS and Science Act* aims to revitalize U.S. semiconductor manufacturing by offering $39 billion in incentives to support the construction, expansion, and modernization of domestic fabrication facilities. This effort responds to the dramatic decline in U.S. semiconductor manufacturing capacity—from 37% of global production in 1990 to about 12% in 2020—and the heavy concentration of leading-edge production in East Asia, especially Taiwan (Congressional Research Service, 2023: 1-3, 8-9).

(2) Enhancing Supply Chain Resilience: To mitigate vulnerabilities associated with the geographic concentration of semiconductor production, particularly in regions facing geopolitical risks like the Taiwan Strait, the *CHIPS*

Act promotes reshoring, diversification of supply chains, and partnerships with trusted allies. These initiatives seek to build a more secure and resilient semiconductor ecosystem in response to disruptions caused by the COVID-19 pandemic and growing strategic competition with China (Congressional Research Service, 2023: 2-5, 11-12, 17-18).

(3) Supporting Advanced Node R&D: The Act allocates $11 billion for research and development through programs such as the National Semiconductor Technology Center (NSTC), the National Advanced Packaging Manufacturing Program (NAPMP), and other initiatives aimed at strengthening U.S. capabilities in next-generation semiconductor technologies. These R&D investments are critical for maintaining U.S. leadership in advanced logic, AI, and high-performance computing amid increasing international competition (Congressional Research Service, 2023: 1, 3, 12-14, 23-24).

In parallel with legislative efforts like the CHIPS Act, the United States has increasingly relied on the *Defense Production Act* (DPA) to expand and secure its domestic industrial base for national defense. Between FY2018 and FY2024, the Department of Defense and other agencies made over 220 Title III investments valued at approximately $3.2 billion to sustain or expand production in areas including shipbuilding, hypersonics, energy storage, and medical resources. These efforts aim to mitigate vulnerabilities in critical supply chains and ensure industrial responsiveness in times of geopolitical disruption (U.S. Government Accountability Office, 2025: 6-8).

4.4 The Strategic Objectives of the United States in the CHIP 4 Alliance

The United States launched the CHIP 4 alliance in 2022 in response to mounting uncertainties in the global semiconductor supply chain. By collaborating with Japan, South Korea, and Taiwan, the initiative seeks to reduce dependency on Chinese technology, stabilize advanced semiconductor manufacturing, and reassert U.S. leadership in the global technology ecosystem (Benson, et al., 2023: 2). To achieve these aims, the alliance promotes joint technology standards, coordinated R&D, and multilateral supply chain management.

The strategic objectives of CHIP 4 can be summarized in four key areas. First, it seeks to reduce reliance on Chinese technology and enhance supply chain security by diversifying sources of advanced process technologies and critical materials through multilateral cooperation (Benson, et al., 2023: 2-3).

Second, the alliance aims to establish common technical standards to prevent the leakage of critical technologies. By harmonizing protocols—particularly for sub-5nm nodes and EUV lithography—among member states, the initiative strengthens internal technological coordination and limits access by geopolitical competitors (Chow, 2025: 271-73).

Third, CHIP 4 promotes production complementarity among its members to mitigate geopolitical risk. TSMC in Taiwan specializes in advanced foundry operations, Samsung in South Korea leads in memory technologies, and Japan provides vital materials and equipment. This functional division reduces the vulnerabilities of geographic concentration and ensures continuity in case of regional instability (Ni & Wu, 2023: 45-47).

Finally, the alliance serves to reinforce U.S. leadership in global semiconductor governance. Through active standard-setting, design specification control, and supply chain orchestration, the United States aims to shape the norms and architecture of the next-generation semiconductor ecosystem (Benson, et al., 2023: 3).

This strategic architecture not only repositions the United States at the helm of technological leadership but also prepares it to sustain competitiveness amid future geopolitical shocks. How Taiwan and South Korea adapt to this reconfiguration will be a pivotal issue for further observation.

V. The Impact of CHIP 4 on the Semiconductor Industries of Taiwan and South Korea

5.1 Taiwan's Role and Strategic Engagement in the CHIP 4 Framework

The CHIP 4 alliance has had a multifaceted impact on Taiwan's semiconductor sector, particularly by amplifying its strategic visibility and intensifying debates on industrial autonomy. Taiwan's global leadership in logic chips, driven by TSMC's technological superiority in advanced node manufacturing, has positioned the island as a core member of the U.S.-led initiative to secure semiconductor supply chains. As a result, Taiwan has sought to balance its growing alignment with democratic partners against economic vulnerabilities rooted in its trade dependence on China.

Following its participation in CHIP 4, Taiwan expanded TSMC's overseas investments, most notably in Arizona and Kumamoto. These projects were motivated not only by market incentives but also by political imperatives tied to Washington's export control measures and reshoring policies under the *CHIPS Act*. These investments allow Taiwan to "de-risk" its geographic concentration while reinforcing trust with partners like the U.S. and Japan (Jung, 2023: 2-3).

Beyond compliance with U.S. policy preferences, Taiwan has proactively aligned CHIP 4 with its broader national strategy. The National Science and Technology Council has expanded support for semiconductor research, workforce training, and cross-border R&D initiatives. These include bilateral innovation platforms with countries under the New Southbound Policy framework. In addition, Taiwan has strengthened its role in global semiconductor governance by aligning export control practices with key allies and promoting standard-setting participation. These initiatives reflect a strategic shift from passive participation to assertive engagement in shaping the international semiconductor order (Wong, et al., 2024).

Taiwan's strategic engagement also involves institutional coordination across economic and diplomatic agencies to integrate CHIP 4 into national planning. The Executive Yuan has emphasized cross-ministerial collaboration to promote supply chain resilience (National Development Council, 2024: 5). In parallel, the Ministry of Foreign Affairs has framed GCTF as a strategic diplomatic platform, enabling Taiwan to contribute to knowledge-sharing and global technology governance with like-minded partners. According to *Focus Taiwan* (2025), the 10th anniversary of GCTF featured a joint statement from Taiwan and partner representatives affirming their intention to deepen cooperation through extended programs and expanded participation.

Domestically, Taiwan has responded by tightening regulations on sensitive technologies and foreign investment. For example, in 2023, the Ministry of Economic Affairs amended the *Act Governing Relations between the People of the Taiwan Area and the Mainland Area* to restrict high-end semiconductor cooperation with China (Ministry of Economic Affairs, 2023). However, this internationalization has raised internal concerns. U.S. political demands for domestic manufacturing have pressured Taiwan to shift production capacity abroad, raising the risk of a "gradual erosion of Taiwan's silicon leverage" (Yang, 2025). Such concerns reflect a strategic dilemma: while external alignment enhances Taiwan's global standing, it may also hollow out its domestic ecosystem.

Moreover, Taiwan's semiconductor exports to China and Hong Kong accounted for over 38% of total exports in 2023, illustrating the high level of economic interdependence even as geopolitical tensions rise (Ministry of Finance, 2024). This structural duality—security dependence on the U.S. and economic entanglement with China—undermines Taiwan's maneuverability. In terms of diplomacy, Taiwan has complemented CHIP 4 participation by reinforcing informal alliances, expanding the New Southbound Policy, and deepening science and technology cooperation with Europe and ASEAN countries. These strategies help to diversify Taiwan's international partnerships and reduce reliance on volatile power dynamics between the U.S. and China.

Overall, while CHIP 4 offers Taiwan a platform to institutionalize its technological indispensability, it simultaneously reveals the risks of asymmetric interdependence and limited security guarantees. Without explicit defense commitments from the U.S. or alliance members, Taiwan must continue to hedge through multilateral engagement and domestic innovation.

5.2 South Korea's Strategic Engagement with the CHIP 4 Framework

South Korea occupies a pivotal position in the global semiconductor supply chain, particularly in the DRAM and NAND flash memory segments. According to KOTRA, the country commanded approximately 60.5% of the global memory semiconductor market in 2022, including 70.5% of the DRAM market and 52.6% of the NAND market, underscoring the dominant roles of Samsung Electronics and SK Hynix (KOTRA, 2023). Despite this strength, South Korea's engagement with the U.S.-led CHIP 4 initiative has been shaped by a combination of structural vulnerabilities and strategic opportunities.

One of the foremost concerns lies in South Korea's economic dependence on China. In 2023, over half of Korea's semiconductor exports were directed to China and Hong Kong, including 67% of DRAM and nearly 80% of flash memory exports (Jeong, 2024: 3-7). This dependency has raised apprehensions that alignment with U.S.-led initiatives could provoke retaliatory measures from Beijing, such as trade restrictions or non-tariff barriers. In addition, amid intensifying U.S.-China strategic competition, Seoul remains wary that participation in CHIP 4 may escalate geopolitical tensions and entangle South Korea in broader techno-geopolitical frictions (Lee, 2024: 9-10; Kumar, 2024).

Another challenge concerns South Korea's technological reliance on foreign suppliers, particularly from the United States, Japan, and Europe. Although South Korea leads in memory semiconductors, it continues to depend heavily on external sources for key manufacturing equipment and materials. Kang (2022: 6-9) notes that this dependence complicates efforts to achieve technological self-sufficiency and highlights the importance of stable access to strategic production inputs.

Despite these concerns, South Korea ultimately judged that the strategic benefits of joining CHIP 4 outweigh the associated risks. The alliance provides Seoul with an opportunity to secure technology supply chains, reduce overreliance on any single market, and reinforce global production networks. According to Kang (2022: 6-7), the diversification of equipment sources and the stable supply of critical technologies are essential to maintaining competitiveness in downstream industries. Yoon (2023: 54-55) similarly emphasizes that international cooperation through initiatives like CHIP 4 can help bolster supply chain security and strengthen national resilience. Moreover, participation allows Seoul to recalibrate its export strategies, expanding its outreach to Southeast Asia, Europe, and the U.S. to mitigate overconcentration in the Chinese market (Kang, 2022: 7-8).

South Korea’s role within the CHIP 4 framework is shaped not only by its industrial capacity but also by its geopolitical positioning. As a technologically advanced democracy allied with the United States, South Korea represents a strategic bridge between advanced economies and East Asian supply chains. Its participation in CHIP 4 underscores its dual function—as both a production hub and a potential policy intermediary among participating states. Seoul has emphasized its intention to contribute to rule-setting and standardization efforts within the alliance, particularly in areas such as export controls, IP protection, and workforce development (Lee, 2024: 11).

The South Korean government’s “K-Semiconductor Belt Strategy” aims to build the world’s largest semiconductor supply network by 2030, with over ₩510 trillion in combined public-private investment and extensive tax and infrastructure support (*KBS World News,* 2021). The Ministry of Trade, Industry and Energy (MOTIE) has linked CHIP 4 to this strategy, focusing on investment incentives, talent development, system-semiconductor technologies, and a materials-parts-equipment ecosystem (*Kim & Chang*, 2022). This approach seeks to position South Korea as a system integrator shaping next-generation semiconductor innovation and global governance, rather than a reactive actor in U.S.-China competition.

Institutionally, South Korea has responded by broadening its global production footprint. Samsung and SK Hynix have made significant investments in fabrication facilities in the U.S., Vietnam, and Europe to enhance supply chain continuity and operational flexibility. Simultaneously, the government has promoted strategic partnerships in emerging sectors, such as advanced packaging, AI chip development, and automotive semiconductors (Yoon, 2023: 56). In this context, the intensifying global competition for semiconductor talent and innovation reinforces the imperative for South Korea to align with allied countries to sustain its edge in next-generation technologies.

In sum, South Korea's engagement with CHIP 4 reflects a pragmatic strategy that seeks to balance economic exposure and technological vulnerability with the imperative to strengthen global alliances and secure national competitiveness. Rather than a binary choice, Seoul's calibrated approach allows it to navigate the pressures of great-power rivalry while asserting its role as a key actor in the reshaping of the semiconductor governance landscape. To better highlight the contrasting yet complementary roles of Taiwan and South Korea in the CHIP 4 framework, the following table summarizes key dimensions of their respective strategies, policy responses, and structural challenges.

The comparative analysis above underscores the distinct yet converging strategic responses of Taiwan and South Korea, which ultimately shape the future contours of the CHIP 4 initiative and regional semiconductor governance.

Table 2: Comparative Strategic Engagement of Taiwan and South Korea in the CHIP 4 Framework

Category	Taiwan	South Korea
global industry role	Leader in logic semiconductors (TSMC)	Leader in memory semiconductors (Samsung, SK Hynix)
chip 4 motivation	De-risk geographic concentration, align with U.S.	Diversify markets and suppliers, enhance resilience
domestic policy response	Tightened export control laws; innovation incentives	K-Semiconductor Strategy, global investments
geopolitical dilemma	Economic dependence on China; security reliance on U.S.	Export reliance on China, tech dependence on Japan and U.S.
key partners and strategies	New Southbound Policy, U.S.-Japan ties, informal diplomacy	CHIP 4, U.S.-Europe ties, Indo-Pacific outreach
strategic risks	Loss of ‘silicon shield’, U.S. offshoring pressure	Retaliation from China, tech input dependency
forward-looking strategy	Multilateral engagement, tech sovereignty, informal alliances	Governance participation, technology upgrading, alliances

VI. Conclusion

The evolution of the global semiconductor industry and the emergence of the CHIP 4 alliance underscore the growing interdependence between technological innovation and national security. As the COVID-19 pandemic exposed supply chain vulnerabilities and U.S.-China technological rivalry intensified, states have increasingly prioritized economic security and strategic autonomy in their industrial policies. Semiconductor governance has thus become central to efforts to restructure global value chains, reduce dependency on politically unstable regions, and safeguard national competitiveness.

For the United States, the CHIP 4 framework represents an effort to construct a resilient and trusted semiconductor ecosystem by integrating key allies—Taiwan, South Korea, and Japan—across various segments of the supply chain. By fostering collaboration in materials, memory, logic chips, and equipment, Washington aims to counterbalance China's technological ascent and realign global chip production toward like-minded partners.

Taiwan and South Korea—core pillars in the global semiconductor system—face a complex mixture of strategic opportunities and geopolitical risks under this framework. Taiwan, anchored by TSMC's dominance in leading-edge logic chip manufacturing, has expanded its international cooperation while seeking to balance supply chain integration with national security imperatives. At the same time, Taiwan must carefully manage heightened geopolitical exposure, particularly with regard to potential coercion from Beijing.

South Korea, for its part, has adopted a more cautious yet strategic approach. Although heavily reliant on the Chinese market, particularly for memory chip exports, Seoul has recognized the long-term benefits of multilateral engagement. Its participation in CHIP 4 reflects a deliberate attempt to secure stable access to critical technologies, diversify production bases, and strengthen collaboration with the United States and Japan. While concerns over technological dependence remain, South Korea's strategic recalibration highlights its intent to transition from a risk-averse posture to a proactive role in shaping global semiconductor governance.

Looking ahead, the global semiconductor landscape will continue to evolve rapidly under the pressures of technological innovation, supply chain realignment, and geopolitical competition. The demand for next-generation chips—driven by AI, HPC, quantum computing, and autonomous vehicles—will reinforce the need for cross-border collaboration and resilient production networks. In this context, Taiwan and South Korea must sustain their technological leadership, enhance industrial resilience, and navigate strategic alliances with agility. Their ability to strike a balance between global cooperation and domestic capability will be vital to maintaining their competitive edge in an era where technology is not just economic but strategic.

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晶片四方聯盟與科技地緣戰略——台灣與南韓的經濟安全回應

河凡植
國立高雄大學東亞語文學系教授

李姿均
國立高雄大學東亞語文學系韓語組碩士班研究生

摘 要

本文探討在晶片四方聯盟架構下全球半導體產業的動態變化，並聚焦於台灣與南韓的戰略回應。半導體不僅是經濟成長的核心動力，更是國家安全與地緣政治戰略的重要支柱。本文分析台灣作為邏輯晶片製造領域的全球領導者，以及南韓在記憶體半導體市場的主導地位下，如何因應美國主導的 CHIP 4 架構所帶來的挑戰與機會。研究結合官方貿易數據、政策報告與近期學術文獻，探討兩國如何降低地緣政治風險、強化供應鏈韌性與提升技術自主性。研究發現，儘管面對美中戰略競爭所帶來的外部壓力，台灣與南韓已採取不同但互補的策略，以鞏固其在全球半導體生態系統中的地位。本文對理解東亞地區的經濟安全與科技地緣戰略提供了新的觀察視角。

關鍵詞：台灣、南韓、經濟安全、科技地緣政治、晶片四方聯盟