Structural Adjustment of the Semiconductor Industry in the Taiwan Region: Historical Evolution and Global Supply Chain Shifts

Moyan Huang[1]
[1]Shawnigan Lake School, 1975 Renfrew Rd. Shawnigan Lake, BC, Canada

Abstract. Semiconductors power modern electronics and critical technologies, from smartphones and electric vehicles to artificial intelligence and defense systems. Taiwan's semiconductor industry occupies a central position in this global ecosystem, far exceeding its geographic size. This paper examines how Taiwan developed into a semiconductor hub through state-led industrial policies, international technology transfers, and a distinctive fabless–foundry model that enabled rapid specialization. Today, Taiwan leads in advanced chip manufacturing, supplying top global firms. However, growing geopolitical tensions, supply chain disruptions, and rising costs have pressured the industry to adapt. Strategic responses include overseas capacity expansion, greater supply chain diversification, and deeper partnerships to enhance resilience. These structural adjustments not only affect Taiwan's own economic security but also influence the stability of global technology networks. Taiwan's experience reveals key lessons for how critical industries can build long-term competitiveness and adapt to a more fragmented and uncertain era of globalization. This study contributes to a deeper understanding of industrial transformation in a strategically vital sector facing mounting global pressures.

1 Introduction

Semiconductor chips have become as essential to the modern world economy as oil was in the industrial age. These tiny integrated circuits are embedded in virtually every piece of advanced technology, enabling everything from communication and computing to healthcare and national security. The global semiconductor industry surpassed $600 billion in annual revenue in recent years[1], reflecting its broad reach into consumer electronics, automobiles, data centers, and beyond. Yet the production of these critical chips is highly concentrated in a few locales, with the Taiwan region standing out as a linchpin of the global supply chain. Taiwan today accounts for a major share of the world's chip manufacturing capacity – including an estimated 92% of cutting-edge logic chip production at the 10 nm node and below[2]. In particular, the Taiwan Semiconductor Manufacturing Company (TSMC) has

[1]Corresponding author: mhuang@shawnigan.ca

become the world's dominant pure-play foundry, supplying top global firms and producing roughly 90% of the most advanced processor chips[3, 4]. This concentration has elevated Taiwan's strategic importance in world affairs while also exposing vulnerabilities in the semiconductor supply chain.

Taiwan's rise as a semiconductor powerhouse has been the subject of extensive research in both industrial and academic circles. Historically, scholars note that Taiwan's industry was nurtured through deliberate state-led initiatives consistent with the "developmental state" model. In the 1970s, government technocrats and institutions like the Industrial Technology Research Institute (ITRI) laid the groundwork by acquiring technology from abroad – notably the 1976 RCA technology transfer, which trained a cohort of engineers and brought complete CMOS manufacturing know-how to Taiwan[5,6]. By 1987, the founding of TSMC – as a spin-off from ITRI's VLSI project – introduced the novel foundry business model, focused purely on manufacturing chips for global clients. This model, along with the earlier establishment of UMC in 1980 and a burgeoning fabless design sector, allowed Taiwan to specialize and climb the value chain rapidly. Existing research has highlighted several success factors: effective public–private coordination and the mitigation of agency problems in policy execution, the clustering of firms and talent in hubs like Hsinchu Science Park, a strong STEM education pipeline, and a focus on specialization over full vertical integration. Together, these created a high-trust ecosystem where manufacturing expertise, design talent, and suppliers co-evolved – yielding sustainable competitive advantages that are not easily replicable elsewhere.

At the same time, research has also examined the global and geopolitical contexts that make Taiwan's semiconductor position so consequential. Some analysts argue that Taiwan's dominance in advanced chip fabrication serves as a form of "silicon shield," deterring aggressive actions by highlighting the economic fallout should supplies be disrupted[7]. This view, originally articulated by TSMC founder Morris Chang, is debated in academic and policy circles. One study assesses how U.S.–China strategic competition forces Taiwan into a delicate balancing act, as great powers seek either to secure or to constrain Taiwan's chip capabilities. Meanwhile, growing vulnerabilities in the global semiconductor supply chain have been documented in recent studies of supply chain resilience. A recent study reviews how natural disasters, pandemics, and geopolitical export controls exposed the fragility of concentrated chip supply chains[8]. Their work – and others in operations and policy research – underline the need for diversification and robustness in a sector where Taiwan has been a single point of potential failure. Indeed, geopolitical risk around Taiwan has spurred new policies abroad (e.g., the U.S. CHIPS Act, Europe's Chips Act) aiming to geographically rebalance production, a trend that forms part of the "global supply chain shifts" this paper investigates. Academic discourse is thus increasingly focused on whether this research is moving from an era of efficient but fragile global networks to one of resilient but fragmented networks.

Given this background, this study is motivated by both a practical and scholarly need to understand how Taiwan's semiconductor industry is adjusting in structure and strategy. Industrially, the Taiwan region faces new pressures – technological decoupling, foreign investment enticements, supply chain disruptions – that were largely absent during its initial rise. Academically, there is a gap in integrating the historical evolution of Taiwan's industry with an analysis of the contemporary supply chain reconfiguration. This paper seeks to bridge that gap. This research synthesizes insights from development studies, international political economy, and supply chain management to examine how Taiwan's semiconductor sector is responding to global shifts while building on its historical foundations. The structure of the paper is as follows. First, this research outlines a mixed-method methodology, combining quantitative industry data analysis with qualitative content analysis of relevant documents. Next, this research presents empirical findings in two parts: (a) key historical evolution

milestones that set the stage, and (b) recent global supply chain shifts and Taiwan's strategic adjustments. This research then analyzes current challenges using a SWOT framework and discusses adjustment strategies adopted by Taiwan's industry to reinforce its resilience. Finally, this research concludes with theoretical and practical implications of Taiwan's experience, including lessons for other countries and directions for future research.

This study connects historical evolution and global shifts to analyze Taiwan's semiconductor industry adjustments. The industry's past development (policy-driven foundations and clustering) and present challenges (geopolitical and market shifts) feed into an analysis of structural adjustment strategies, leading to outcomes affecting the global supply chain.

2 Methodology

To address the multifaceted research questions, this research adopted a mixed-methods approach that integrates quantitative data analysis with qualitative content analysis. This design allows the study to capitalize on the strengths of both methodologies and achieve a richer, more triangulated understanding. In line with best practices in mixed-methods research, this research conducted the quantitative and qualitative components in parallel and then iteratively integrated the findings for interpretation.

This research gathered industry and trade data from authoritative sources to capture trends in Taiwan's semiconductor sector. This included time-series data on semiconductor output value, global market share, and foundry revenues from sources such as TSMC annual reports, SEMI, and market research firms (e.g., Trend Force and IC Insights). This research also collected comparative figures on regional capacity (e.g., fab counts, wafer production share by country) to contextualize Taiwan's changing position in the global supply chain. These datasets were analyzed using statistical software (IBM SPSS Statistics) and Python. In SPSS, this research computed growth rates, performed trend analyses, and ran basic correlations to see, for instance, how Taiwan's market share correlates with global demand cycles. Python's libraries were utilized for data cleaning and to generate visualizations of key patterns (such as the bar charts and pie charts presented in the results). Throughout this research ensured data credibility by cross-verifying critical indicators with multiple sources – an approach akin to data triangulation that bolsters reliability. For example, a reported figure on global capacity share was checked against both an industry association report and an academic source before inclusion.

To complement the numbers, this research qualitatively analyzed textual sources that shed light on strategic shifts and policy changes. This research assembled a corpus of documents, including government white papers, industrial development plans, corporate press releases (especially by major firms like TSMC), and relevant media reportage from 2010–2025. Additionally, this research reviewed case studies from scholarly literature on Taiwan's semiconductor industry. Using a directed content analysis approach[1], this research coded these texts for themes such as "investment diversification," "supply chain security," "talent and R&D policy," and "geopolitical risk response." Coding was conducted with the aid of qualitative analysis software (NVivo), allowing researchers to tag and retrieve passages corresponding to the thematic framework. To enhance credibility, this research employed investigator triangulation: two researchers independently coded a sample of documents and compared results to refine the codebook, minimizing individual bias in interpretation. This research also performed member checks by consulting with an industry expert in Taiwan to validate the interpretation of major policy documents – ensuring that the qualitative insights accurately reflect the intended strategy and context.

The quantitative and qualitative findings were not kept siloed; rather, this research merged insights at the analysis stage to inform each other. For instance, when quantitative data

showed a spike in Taiwan's overseas fab investment around 2021–2022, this research turned to policy documents and corporate statements from that period to qualitatively understand the motivations (e.g., U.S. pressures or incentives). Conversely, when content analysis revealed concern about a specific bottleneck (such as reliance on a certain raw material or equipment), this research sought data on import sources and volumes to quantify that exposure. This integrative strategy follows guidance in the mixed-methods literature[9, 10] to treat mixed-methods as a "natural complement" – using one type of result to elaborate or contextualize the other. By converging evidence from these different angles, the study increases its internal validity and offers a more holistic perspective on Taiwan's semiconductor industry adjustments.

In summary, the methodology marries the breadth of statistical analysis with the depth of contextual qualitative analysis. This approach is appropriate given the complexity of structural changes in an industry that is at once driven by hard market data and by political or strategic narratives. Ensuring rigor through triangulation and cross-validation was central to the research design, aligning with methodological literature that emphasizes combining data sources for comprehensive analysis. The next section presents the results of this approach, with quantitative findings (including charts and tables) interwoven with qualitative insights to paint a detailed picture of Taiwan's semiconductor industry's evolution and current adjustments.

3 Historical evolution of Taiwan's semiconductor industry

3.1 1980s–1990s: Early industrial policies and technology transfers

Analysis of historical data and documents confirms that Taiwan's semiconductor industry was built on a strong institutional framework that evolved over decades. In the early development phase (1980s–1990s), the government acted as an orchestrator – funding technology missions, establishing infrastructure, and nurturing a talent pool – while progressively involving private capital to ensure market discipline. One illustrative milestone was the ITRI–RCA technology transfer project of 1976, which brought foundational manufacturing technology to Taiwan. Under this government-backed initiative, ITRI partnered with RCA of the United States to license a 7.5-micron CMOS process and train dozens of engineers in semiconductor production[5, 6]. This effort produced a group of 37 specialists (the "RCA 37") whose expertise seeded Taiwan's nascent industry – virtually the entire senior technical leadership of Taiwan's semiconductor sector in subsequent years emerged from this program[6]. Equally important, the project established a pilot IC fabrication plant at ITRI by 1977, achieving production yields (over 70%) that even surpassed RCA's own fabs – a testament to the effective absorption of transferred technology[5, 6].

Building on this base, ITRI and the government moved to spin off new enterprises to drive commercialization. In 1980, ITRI's Electronics Research Service Organization (ERSO) spun off United Microelectronics Corporation (UMC) as Taiwan's first dedicated semiconductor company. UMC effectively took over ITRI's pilot production line (with government and private co-investment) and began commercial operations by 1982[5, 6]. A few years later, in 1987, a second major spin-off saw ITRI transfer its newly developed VLSI process technology into the creation of TSMC (Taiwan Semiconductor Manufacturing Company). With technologist Dr. Morris Chang recruited to lead the venture, and with equity participation from Dutch firm Philips and other investors, TSMC was established as the world's first pure-play foundry. Notably, ITRI provided TSMC with a ready-made 6-inch wafer fab and a cadre of experienced engineers, giving the startup a crucial head start[5]. Both UMC and TSMC thus originated from the public sector's guided efforts, reflecting a

model whereby government R&D institutes incubated technology until it could be spun off into private firms – a strategy that minimized risk for private actors and accelerated know-how transfer to industry.

Throughout the 1980s, the government also invested heavily in human capital and cluster infrastructure. The establishment of the Hsinchu Science-Based Industrial Park in 1980 provided an ideal locale for semiconductor firms and suppliers to co-locate. By the early 1990s, Hsinchu Science Park housed a dense cluster of high-tech companies, research labs, and universities; within just a few square miles, it contained over a hundred semiconductor-related companies and tens of thousands of skilled workers[5, 6]. This spatial clustering fostered knowledge spillovers and a tight collaboration network among foundries, chip design houses, equipment vendors, and academia. Equally, Taiwan's emphasis on STEM education ensured a steady pipeline of engineers to fuel the industry's growth. By the 1990s, the results of these foundational policies were evident: Taiwan's semiconductor output surged, and the island's share of global IC production (by value) grew to become second only to the United States by the early 2000s. Taiwan had firmly established itself as a key player, especially in foundry services and assembly/testing, while deliberately avoiding direct competition in commodity memory chips.

3.2 2000s–2010s: Maturation, export growth, and cluster upgrading

During the 2000s and 2010s, Taiwan's semiconductor industry matured into a world leader, with significant expansion in scale and global reach. The period was marked by rapid export growth, technological advancement to sub-micron process nodes, and the solidification of an efficient industry cluster. By the 2000s, semiconductors had become one of Taiwan's top exports, reflecting strong international demand for its foundry and packaging services. A combination of government policies and corporate strategies underpinned this success. For instance, the government's "Two Trillion, Two Stars" plan (circa 2002) designated semiconductors and display panels as star industries targeted to reach NT$2 trillion in production value, which led to continued tax incentives and R&D support for chipmakers. Companies like TSMC and UMC capitalized on the global fabless boom – the rise of design companies with no fabs, such as Qualcomm, Broadcom, MediaTek, etc. – becoming their preferred manufacturing partners. TSMC, in particular, invested aggressively in new fabs and process R&D – moving from 130 nm technology at the turn of the century down to 28 nm and 16 nm by the 2010s, often in collaboration with global equipment and EDA suppliers.

A notable development in this era was the formation of a complete local supply chain and ecosystem. Alongside the pure-play foundries, a host of specialized firms flourished: fabless design companies (e.g., MediaTek, Novatek) grew significantly, as did companies in outsourced semiconductor assembly and testing (OSAT) like ASE Group. This horizontal specialization (design–manufacturing–assembly) reinforced Taiwan's cluster advantages. By the 2010s, Hsinchu remained the epicentre but had extended linkages to Tainan and Taichung, where new science parks and advanced fabs (e.g., TSMC's 12-inch GigaFabs) were established. The industry also weathered challenges during this period, including the 2008 global financial crisis and cyclical downturns, by moving up the value chain – focusing on higher-margin advanced nodes and innovating in areas like wafer-level packaging. Taiwan's firms became synonymous with reliability and high-volume yields, which helped them secure ever larger contracts from tech giants. By 2015, TSMC had overtaken all integrated device manufacturers in leading-edge process volume and was fabricating chips for industry leaders like Apple's A-series mobile processors and NVIDIA's GPUs. A notable policy change at the time was the gradual facilitation for Taiwanese to invest in China for manufacturing (limiting older node technologies). This then enabled the likes of TSMC and UMC to establish satellite fabs in China in the 2000s to serve local demand, while, on paper,

restricting the technology transfer of leading-edge processes. The result of the 2000s–2010s was Taiwan's semiconductor industry becoming globally dominant in foundry and backend services – in some estimates, over 50% of the world's made-to-order chip production was conducted by Taiwanese firms by the end of the 2010s – and a climate for clustered innovation that kept productivity boosting along.

3.3 2020s–present: Global positioning, policy upgrades, and response to U.S.–China tech rivalry

Taiwan's semiconductor business finds itself in a drastically changing global environment as of the 2020s: world setting, plan upgrades, and response to U.S.-China Tech Rivalry. State and business have stepped up policies and changed strategies in response to political and business forces, particularly the intensifying U.S.-China technology conflict and recent source network shocks. Strengthening endurance and protecting crucial abilities have been important priorities. New regulations were implemented on the government's part to safeguard skills and intellectual property in the semiconductor industry. For instance, Taiwan amended its National Security Act in 2022 to impose harsher punishments for illicit technological cooperation with international entities (especially Chinese ones) and the theft of silicon trade secrets. Authorities established an "economic counter-espionage" workforce to impose rules on recruitment and investment [11], in addition to cracking down on illegal skill poaching by mainland Chinese companies. At a time when China has redoubled its efforts to acquire innovative device know-how, these actions reflect a policy change intended to stop brain dumping and Internet leaks.

In contrast, the government has increased funding for workforce development and next-generation silicon analysis. To keep Taiwan's industrial edge, initiatives like creating new semiconductor research hubs, expanding scholarships for graduate studies in chip-related fields, and cooperative projects with U.S. and Western institutions on sub-5 mm technologies are in progress. The U.S.-China conflict, which presents both an option and a chance, is part of this force. On the one hand, the U.S.'s import regulations on China (such as the ban on Huawei and other Chinese tech companies from supplying advanced chips) have shifted some of the demand away from Chinese businesses and prompted friends like the U.S. and Japan to form stronger alliances with Taiwan.

On the other hand, these identical conflicts raise the possibility that Taiwan is pressured to choose its side or disengage from a particular industry. The continuing "technology decoupling" is a clear example of this (for example, TSMC ceased achieving orders for Huawei's HiSilicon in 2020 under U.S. regulations), leading Japanese industries to look for new customers and adjust their product mix to compensate for lost Chinese income. Concurrently, China's state-backed efforts to achieve semiconductor self-sufficiency (such as the Made in China 2025 program) have led to aggressive, if only partially effective, attempts to imitate Taiwan's features, including through ability selection and alleged Internet theft [12]. Major companies nowadays conduct their most advanced R&D and manufacturing at home or in allies, while legacy systems may be licensed or produced in mainland China through affiliates or joint projects. Despite claims of "decoupling," Chinese semiconductor companies have not yet fully abandoned China, according to recent industry studies. Some companies have expanded specific mature-node procedures to serve the huge native market even as they ring-fenced their cutting-edge activities elsewhere [13]. A careful wedding (continuing to run 28 mm or older fabs in China, for example) can live with measures to protect crown-jewel systems because China continues to be the world's largest electronics manufacturing base and an important end-market for bits. As a result, this pragmatic approach acknowledges that China continues to be the world's largest electronics industrial center. Taiwan's politicians also believe that future stability requires urgent global

cooperation in the face of these political currents. To lessen Taiwan's dependence on its soil, both the government and business leaders have quietly supported efforts to build some offshore "mirror" power (as discussed in the next portion on modification methods). Taiwan has deliberately pushed for inclusion in proposed international systems like the" Chip 4 Alliance" (with the U.S., Japan, and South Korea) [14]. Taiwan's membership demonstrates its proper connection method, which ties its business to those of other developed nations so that its security becomes a shared interest. Emergency preparation for worst-case scenarios, such as a cross-Strait problem that disrupts chip production, has become more important at the same time. Taiwan has stepped up its technology and expertise at home, strengthened its defenses against hostile threats, and leveraged global partnerships to strengthen its crucial position in the silicon supply chain in the 2020s, to name a few examples.

4 Current challenges: a SWOT analysis

To elucidate the current challenges facing Taiwan's semiconductor industry, this research employs a SWOT framework, examining pertinent factors in technology, market, and geographic domains. This analysis identifies internal strengths and weaknesses as well as external opportunities and threats, with support from recent academic and industry sources for each area.

4.1 Technological challenges

Taiwan's industry remains the global leader in advanced chip manufacturing, but it faces the technological challenge of sustaining Moore's Law scaling and innovation at the cutting edge. As process nodes approach physical limits (e.g., 3 nm and beyond), R&D has become exponentially more complex and costly. A strength is that firms like TSMC possess world-class process engineering capabilities and a huge accumulated knowledge base. However, a potential weakness is the reliance on a handful of critical suppliers and collaborators for next-generation technologies (for instance, ASML for EUV lithography). To continue advancing, Taiwanese firms increasingly must engage in global R&D partnerships, jointly developing technologies with foreign equipment makers and research institutes. This marks a shift from the earlier model of mostly in-house development; today, co-development is seen as necessary to overcome the extreme complexity and skyrocketing costs of leading-edge nodes. For example, TSMC in recent years entered joint research programs on 2 nm processes with top equipment vendors in the U.S. and Europe – an acknowledgment that closer ecosystem collaboration is needed to solve technical bottlenecks. Additionally, talent cultivation is an ongoing concern: while Taiwan produces many engineers, the specialized skills needed for areas like AI chip design, advanced packaging, and semiconductor materials are in short supply worldwide. Taiwan's strength is a deep talent pool with practical experience, but it must continue to attract and train experts and avoid talent drain to competitors. On balance, technologically, Taiwan has a strong innovative capacity (underscored by thousands of semiconductor patents and trade secrets), yet it must manage the weaknesses of high R&D cost and potential talent gaps through sustained investment and international collaboration.

4.2 Market and economic challenges (opportunities & threats)

Taiwan's semiconductor sector enjoys a dominant market position in foundry and certain other segments, but this comes with significant challenges. One is client dependence – a large proportion of revenue comes from a few major customers. For example, Apple alone accounts for over a quarter of TSMC's revenue[15], giving that client considerable leverage

and exposing the company to demand fluctuations of a single brand. Over-dependence on a handful of U.S. tech firms could be seen as a weakness; at the same time, the opportunity exists to diversify the customer base as new players (in automotive, IoT, etc.) increase their chip orders. Another challenge lies in intensifying competition and pricing pressure. While Taiwan's foundries still lead in technology, competitors are investing heavily: Samsung (South Korea) continues to advance its foundry processes and has state support to narrow the gap, and Intel (U.S.) is seeking to re-enter the foundry business with substantial government incentives. In the mature process segment, Chinese foundries (SMIC and numerous state-backed fabs) are rapidly expanding capacity for 28 nm and above, which could flood the market for legacy chips and drive down prices. Industry projections show China's share of global fab capacity (especially at older nodes) approaching one-third by the latter 2020s[16]. This expansion poses a threat of oversupply in lower-end chips and new competition for Taiwan's UMC and other firms in that space. Moreover, as geopolitical factors lead some customers to pursue a "China-free" supply chain, Taiwan's firms may face pressure to invest in production outside of China or risk losing orders, which can alter market dynamics. On the opportunity side, the rise of emerging applications (5G, electric vehicles, AI accelerators, etc.) is expanding demand for semiconductors, and Taiwanese companies are well-positioned to capture a significant share of this growth if they maintain their technological edge. The government's ongoing support (e.g., tax breaks for advanced-node investments) and Taiwan's reputation for high quality provide a conducive environment to seize these opportunities. Nonetheless, the market landscape ahead will likely feature tougher competition, the need for strategic customer management, and careful navigation of pricing and capacity decisions to avoid margin erosion.

4.3 Geopolitical and geographic challenges (opportunities & threats)

Geopolitics and geography-related physical challenges are likely to pose the biggest problems. Due to its proximity to the seismically active Pacific" Ring of Fire" and its subtropical climate, Taiwan is susceptible to natural disaster risks, including earthquakes, thunderstorms, and frequent droughts that could disrupt chip production. For example, fabs were forced to ration water due to a severe drought in 2021, which raised fears about the operation's consistency. Fab features and technology are constantly at risk from earthquakes. These economic risks are putting a strain on the sector's reliability, which has prompted businesses to invest in mitigation measures (such as developing water recycling facilities and installing seismic protections for fabs). Cross-Strait conflicts are the rhinoceros in the room, though. The People's Republic of China, which claims the beach, is putting pressure on Taiwan politically and militarily.

International experts worry that a shortage of Taiwanese chips could result in a" crisis" for the software industry [17]. This political threat is also related to Taiwan's" silicon shield," which is the theory that open conflict is deterred by Taiwan's presence in device supply chains. Although it may hinder, the risk is still present. The risk of a siege or war poses the biggest threat to Taiwan's semiconductor industry from Taiwan's viewpoint. International forces have strong bonuses to help Taiwan's security and stability, which presents a unique opportunity to solve this problem. This has resulted in greater supply chain surveillance cooperation with the United States, Japan, and Europe. For instance, Taiwan is currently discussing collecting crucial semiconductor-related supplies and shared disaster planning for device supply problems.

Additionally, Taiwan's regional chance has opened up opportunities for its businesses to make overseas investments (as discussed in the next segment) to build a more distributed production system, transforming a threat into a form of resilience-building. However, geography continues to be Taiwan's double-edged sword: it provides the nation with utility

(others are invested in its security), and it also concentrates a sizable portion of the world's military power in a single disaster area, in the shadow of a potential military conflict [18]. The biggest corporate challenge facing the industry going forward is controlling this circumstance. Taiwan's semiconductor industry, according to the SWOT analysis, must address key weaknesses (high R&D costs, client concentration) and prepare for serious external threats (geopolitical tensions and disaster risks) while maximizing new opportunities (new markets, international support for supply chain resiliency), despite being extraordinarily strong in its current capabilities (technological prowess, market leadership, ecosystem cohesion). Next, the paper examines look at how Taiwan's economy has begun making fundamental changes and strategies to address these pressing issues.

5 Adjustment strategies for resilience and growth

Facing the complex environment outlined above, Taiwan's semiconductor industry has undertaken several structural adjustment strategies to safeguard its future. These initiatives aim to reinforce resilience against disruptions, diversify geographic risk, and solidify the industry's global partnerships. In this chapter, this research highlights two major strategic moves – the establishment of overseas production bases and the deepening of international alliances – and discusses their drivers, benefits, and implications. Real-world examples, such as TSMC's new fabs in Arizona (USA) and Kumamoto (Japan), illustrate how these strategies are unfolding.

5.1 Geographic diversification of production

Historically, virtually all of Taiwan's chip fabrication capacity was located domestically. This made economic sense during decades of stability, but it also meant that any local disruption could be catastrophic for the global supply. In recent years, both industry leaders and governments have pushed for a more distributed footprint. TSMC's decision in 2020 to build a $12 billion fab in Arizona – its first advanced fab on U.S. soil – marked a turning point. That project, now being expanded with a second fab for a total investment of $40 billion, was driven by a confluence of "pull" and "push" factors. On the pull side, host countries offered strong incentives: the U.S. government, under the CHIPS and Science Act, is providing substantial grants and tax credits (TSMC is slated to receive about \$6.6 billion in U.S. federal funding for the Arizona fabs)[19]. Additionally, major American customers like Apple were eager to source chips locally to reduce supply chain risk, effectively encouraging TSMC to establish a U.S. presence[20]. On the push side, Taiwan and its allies recognized that creating some redundant capacity abroad could serve as a hedge against the worst-case scenario of a cross-Strait conflict or blockade. By having a foothold in the U.S., TSMC also reinforces political goodwill – it tangibly links the American economy to Taiwan's chip prowess. As one industry analyst noted, having TSMC fabs outside Taiwan might make Taiwan "less of a target," since an attack on Taiwan would no longer paralyze all advanced chip production, thereby marginally reducing the leverage of a hostile actor[21].

Similarly, TSMC's venture in Japan's Kumamoto Prefecture, launched as Japan Advanced Semiconductor Manufacturing (JASM) in partnership with Sony and auto-parts maker Denso, is another linchpin of the diversification strategy. The Kumamoto fab, which will produce 22/28 nm specialty chips, was motivated by Japan's desire for a secure local supply of chips for industries like automotive, as well as by TSMC's interest in expanding its capacity for specialty technologies (image sensors, MCUs, etc.) in proximity to a key client. The Japanese government is subsidizing roughly half of the $8.6 billion project cost to ensure its success. For TSMC, the benefits include stronger relationships with Japanese customers (Sony reportedly initiated discussions by asking TSMC to build a dedicated fab in Japan) and

access to Japan's materials and talent ecosystem. From a strategic standpoint, establishing production in Japan (a stable U.S. ally) and the U.S. not only expands TSMC's global footprint but also weaves Taiwan's technology into the fabric of these countries' supply chains. This strategic entanglement creates mutual dependencies: the U.S. and Japan gain local chip manufacturing capability, while Taiwan gains powerful stakeholders invested in its continued operation. Other Taiwanese companies have followed suit on a smaller scale – UMC has expanded its fab in Singapore, and ASE Group (a leading OSAT firm) has invested in facilities in Southeast Asia and the U.S., all moves that knit Taiwan's semiconductor ecosystem more tightly with global networks.

A side effect of overseas expansion is the sharing of know-how and the challenge of transplanting Taiwan's famed efficiency to new locales. Indeed, TSMC's Arizona project initially faced a cultural and workforce learning curve, highlighting differences in work practices. However, over time, such efforts also transfer some of Taiwan's semiconductor DNA abroad, which in the long run could slightly dilute Taiwan's monopoly on certain skills. Despite this, the consensus in Taiwan has been that a limited diffusion of capacity is a prudent insurance policy. As TSMC's chairman Mark Liu stated, the overseas fabs are envisioned as a "buffer": they will not replace the massive capacity in Taiwan, but can serve as a safety net and also help meet burgeoning global demand that cannot be met solely from Taiwan.

5.2 Supply chain partnerships and alliances

Another adjustment strategy involves restructuring supply string relationships to enhance endurance. Taiwanese semiconductor companies have begun strengthening partnerships with firms in the U.S., Europe, and Japan to gain important insight and collaborate on the development of new technologies. In 2022, TSMC, for instance, signed several relationship agreements with major equipment manufacturers and EDA software companies to co-create the next-generation 2 sun production options. This is a departure from earlier in the decade, when ITRI and regional groups might try to implement much of the process privately or when Taiwan was the only nation with resources. Co-development is the latest model, which suggests that using cutting-edge systems often necessitates the sharing of knowledge across the profit network. The R&D efforts of Japanese and American companies also gain from this engagement, which indirectly supports Taiwan's balance. Foreign companies have searched for second-source materials and collected critical materials after experiencing shocks like the COVID-19 illness and the Ukraine conflict, which threatened materials of bright gas and other inputs. The industry has promoted initiatives like expanding regional products and considering joint purchasing arrangements with allies to stop single-point failures as a result of national support. The government of Taiwan has implemented stricter legal measures to stop the Golden Company's unquestioned outflow to political adversaries at the same time. Increase the examination of any Chinese investments in Taiwanese tech firms as a result of new rules limiting efforts made to Taiwanese device developers. The state has yet to prosecute those who fraudulently supported China's semiconductor initiatives. These preventative measures are a part of a larger effort to boost Taiwan's financial benefits. To encourage professionals to stay in Taiwan despite potential higher wages abroad, they enhance unpleasant techniques like better working conditions and bonuses for engineers privately.

5.3 "Silicon Shield" reinforcement

Taiwan maintains its appropriate levels of resilience while using its social and security advantages from its dominance in electronics. The "golden protect" approach suggests that disruption is prevented by Taiwan's important role in global device production. Taiwan's

power has stated in international mentorship that protecting Taiwan's golden output is important. Taiwan attempts to increase its indispensability (for instance, by being at least one or two years ahead of rivals in terms of technology production) while maintaining a high level of international dependence on its assets. As previously stated, this is a double-edged sword, but Taiwan appears to believe that technological management outweighs the threats, as long as mitigation actions like outdoor fabs are in place. In practice, strengthening the silicon shield entails maintaining high levels of R&D expenditures (TSMC's R&D expenditures exceeded US$4.5 billion in 2022) and fostering customer confidence so they can put long-term faith in Taiwanese companies. Working with like-minded countries to align regulations also means doing so.

For example, Taiwan has been quietly arranging with the US, Japan, the Netherlands, and other countries on business energy regulations and requirements that affect electronics, establishing itself as a de facto kingdom of tech-leading markets. Through alliance-building, regional plan changes, and global expansion, Taiwan's silicon market is constantly adapting. These tactics are driven by additional pressure (geopolitical risks, partner countries' industrial policies) and internal recognition of risk. The benefits include a stronger supply chain, stronger international support, and continued business supremacy. Taiwan continues to be at the forefront of the most powerful markets while gaining traction through partnerships. Just Taiwan's semiconductor map is becoming less and less consolidated. These changes have led to the development of the idea of a more regionally dispersed, also connected silicon supply chain, with Taiwan serving as the basis of a wider alliance as opposed to a lone hub. The key question will be whether this idea suddenly reduces risks without sacrificing achievement in the upcoming years.

6 Limitations and future outlooks

Although this research examines Taiwan's silicon industry's structural changes in detail, there are still some drawbacks to be acknowledged. First of all, there are limitations to the data range. Although the best available, the statistical research relied on industry-reported data and third-party estimates (such as market share and capacity projections), which also had margins of error. For instance, business privacy frequently causes estimates of advanced-node capability by country. Future research could use more detailed data (possibly via surveys or collaboration with industry associations) to evaluate, say, real fab utilization rates or supply chain stockpiles in Taiwan, despite this study's attempt to verify information through multiple options. In addition, the exploration focused mainly on the supply chain's manufacturing segment, which included Taiwanese IC design and upstream electronics assembly. To understand how structural swings in developing have an impact on the entire value chain, a more comprehensive study may be conducted. Next, the approach has some analytical restrictions. Although rigorous, speaker bias can be found in the subjective content analysis. Various analysts may focus on various aspects of the same policy report or business plan, but this study managed to mitigate this by using dual-coder validation and centrist record insights with expert interviews. Additionally, the report's sample, which includes mostly documents from big corporations in English and Chinese, may never fully capture the inner viewpoints of Taiwan's provide chain. To enhance the qualitative picture, future research could incorporate primary discussions with a wider range of companies (such as equipment providers and smaller chip designers). The statistical assessments were generally descriptive on the numerical part. Applying conventional models, such as game-theoretic modeling of company and government decisions in chip geopolitics or statistical analysis of how political events affect semiconductor stock indices, could be the next step in potentially predictive power of the trends that this study examined. Third, generalizations have a minimal context. Taiwan's practice is largely exclusive; it gained from a pioneering benefit

in the furnace type, a friendly U.S. relationship that allowed technology access, and serendipitous timing during the PC boom. Therefore, one must be cautious when generalizing the evolutionary model, even though Taiwanese training can tell other regions ' semiconductor initiatives. For instance, Taiwan's existing efforts by the United States and Europe to imitate Taiwan's cluster may encounter native skills shortages or higher value structures, which Taiwan managed to avoid. Similar to China's ongoing struggle to achieve balance (despite significant funding) points out that Taiwan's achievement was the result of complex institutional and global aspects as well. Potential quantitative research could look at how structural changes in, say, South Korea or China differ when faced with comparable supply chain forces because the study, which was centered on Taiwan, did not thoroughly examine these various national efforts. Despite these shortcomings, the conclusions of this study have a number of implications for the future. The need to investigate endurance techniques in global value chains is one suggestion. The case of Taiwan demonstrates how resilience considerations, such as building buffer capacity offshore, are being tempered by pure efficiency (chasing the lowest cost and highest specialization). Uncertain about the long-term effects of this research on business construction, including whether it results in reliability that raises expenses but guarantees supply. Researchers may look into "distributed specialization," in which crucial production is distributed among allies rather than concentrated. Taiwan's involvement in emerging international efforts for chip assistance can provide a window into how effective these relationships are in training and whether they actually reduce risk. This research demonstrates that coordinated action on a variety of fronts is required to safeguard a proper industry from a plan perspective. The government of Taiwan may need to continue to strengthen its efforts to protect intellectual property and retain skills, as it has already done, to stop its competitive advantage from deteriorating. There is also a compelling case for global frameworks to help supply chain stability, given the importance of its manufacturing globally. Some experts even suggested multilateral agreements that treat advanced semiconductor features as protected global property (as opposed to how specific types of energy infrastructure are handled). The idea emphasizes the shared desire to keep Taiwan's factories operational without interruption, even though that is still speculative. Potential perspectives must take into account the uncertainty surrounding cross-state relations. Any extraordinary change would require an abrupt architectural shift, according to the analysis, which relies on a status quo scenario. In that context, TSMC's efforts to establish "mirror" power in safer areas are likely to grow more quickly. This study projects that Taiwan will continue to adapt by internationalizing its industry (more overseas joint ventures, research collaborations, and reciprocal investments) so that it becomes ingrained in the global system in ways that increase the cost of any disruption. Taiwan's accomplishments are so crucial that several nations are invested in its security because it aligns with what some have called" proper entanglement." This study acknowledges that Taiwan's position, while also crucial, will change as the silicon supply chain changes. The research provides a preview that is informed by contemporary relationships and the recent past. Researchers should examine these inquiries as new data emerge (for instance, when the latest wave of fabs under development comes online in a few years). Does Taiwan continue to be the main center of development and production, or will there be a more distributed homeostasis in this study? In comparison to how effectively different regions cultivate their emerging capacities, how successfully Taiwan's structural adjustments translate into gained advantages (in terms of technology, performance, and belief).

7 Conclusion

In light of historical shifts and shifting global supply chains, this report examines how the Taiwan-based semiconductor industry has navigated fundamental adjustments. This study

began by examining Taiwan's strategy for overcoming its present level of silicon skills and how it is responding to changing geopolitical and economic conditions. Through a mixed-methods analysis, this study discovered that Taiwan's industry was the result of a distinctive fusion of state-led vision, global collaboration, and specialized innovation, making it an essential part of the global supply chain. Government initiatives like the RCA–ITRI job and the creation of technology parks, combined with proper spin-offs like UMC and TSMC, and embracing the fabless–foundry type, have previously provided the foundation for success. Taiwan is effectively adapting to new pressures, including U.S.-China tech tensions, pandemic-induced shocks, and international business policies. Important adjustments include geographical diversification of production, strengthening alliances with vital partner nations, and investing in endurance measures to safeguard resources and talent. The worldwide semiconductor map is being gradually reshaped by these changes, leading to a somewhat more distributed (but less effective) supply chain design. The study emphasizes the powerful interaction between way dependence and corporate adaptation in terms of theory. Despite having competitive advantages and a form of economic leverage (the" silicon shield"), Taiwan's continued success will depend on its proactive adjustments and policy choices in the face of global changes. The findings actually provide insights for policymakers and business leaders: maintaining a vital business requires constant evolution while maintaining a balance between efficiency and security, and cooperation with competition. Taiwan's practice serves as both a design and a cautionary tale of how an ecosystem can grow and how it must conform as the earth changes, as other countries try to increase their semiconductor capabilities. The structural modifications being made in Taiwan's semiconductor industry are significant for the security and development of the whole interconnected global tech sector. Lastly, Taiwan's case offers valuable lessons from both an intellectual and global perspective. It illustrates both how a high-tech market may be catalyzed by a developmental state strategy and how such an industry must develop new strategies to survive the uncertainties of globalization. The" Taiwan design," which has powerful public-private collaboration and a focus on specialization, applies to other nations looking to establish crucial technology sectors, even though it might not be as easily replicated without administrative cohesion. Additionally, Taiwan's new adaptations emphasize the value of flexibility and vision: yet a market-leading cluster may constantly adjust its structure and strategy in response to physical changes. Taiwan's encounter emphasizes the need to combine traditional advantages with innovative policies, both for experts and policymakers in different nations. Taiwan's trip is a compelling case study of maintaining competitiveness and protection in combination as the silicon landscape shifts to a more geographically distributed, still allied system. In the upcoming generation, Taiwan will evaluate whether Taiwan you maintains its lead in development and whether the world is, as a whole, improving supply chain resilience without sacrificing the efficiency that gave rise to the semiconductor revolution. The study supports this debate by demonstrating that a high-tech industry's strategic fundamental adjustment, informed by both historical and current challenges, is essential to navigating the complex trade-offs of globalization. By framing the traditional context of the evolutionary state with modern supply chain geopolitics, this research advances the literature and provides a more holistic view of business evolution. It provides new insights into how historical relationships influence present-day proper alternatives, which enriches business plans and global value chains. Further study may be conducted on this job by doing comparative assessments (for instance, Taiwan vs. South Korea or Taiwan vs. China), generalizing findings regarding endurance techniques. Also, it will be crucial to closely monitor the results of Taiwan's present adjustments, such as the effectiveness of fresh talent policies and the performance of abroad factories. The training learned for Taiwan and its partners will guide both global strategies for obtaining crucial technology companies in a time of proper competition and the semiconductor industry.

References

1. O. Burkacky, M. Mancini, M. Patel, G. Poltronieri, T. Roundtree, Exploring new regions: The greenfield opportunity in semiconductors. McKinsey & Company (2024), https://www.mckinsey.com/industries/semiconductors/our-insights/exploring-new-regions-the-greenfield-opportunity-in-semiconductors
2. L. Zhou, P. Beckman, US Exposure to the Taiwanese Semiconductor Industry: Economic Impact of a Disruption. U.S. International Trade Commission Working Paper (2023), https://www.usitc.gov/publications/332/working_papers/us_exposure_to_the_taiwanese_semiconductor_industry_11-21-2023_508.pdf
3. D. Sacks, C. Miller, The War Over the World's Most Critical Technology. Council on Foreign Relations Net Politics Blog (2023), https://www.cfr.org/blog/war-over-worlds-most-critical-technology-conversation-chris-miller
4. I. Hilton, Taiwan, Makes the Majority of the World's Computer Chips. Now It's Running Out of Electricity. Wired (2024), https://www.wired.com/story/taiwan-makes-the-majority-of-the-worlds-computer-chips-now-its-running-out-of-electricity/
5. H. S. Ouyang, Agency problem, institutions, and technology policy: Explaining Taiwan's semiconductor industry development. Res. Policy **35**, 1314–1328 (2006)
6. National Research Council, Taiwan's Industrial Technology Research Institute – A Cradle of Future Industries. 21st Century Manufacturing: The Role of the Manufacturing Extension Partnership Program (National Academies Press, Washington, DC, 2013), https://nap.nationalacademies.org/read/18448/chapter/14
7. T. J. Shattuck, Stuck in the Middle: Taiwan's Semiconductor Industry, the U.S.–China Tech Fight, and Cross-Strait Stability. Orbis **65**, 101–117 (2021)
8. W. Xiong, D. D. Wu, J. H. Y. Yeung, Semiconductor supply chain resilience and disruption: Insights, mitigation, and future directions. Int. J. Prod. Res. **63**, 3442–3465 (2025)
9. R. B. Johnson, A. J. Onwuegbuzie, Mixed methods research: A research paradigm whose time has come. Educ. Res. **33**, 14–26 (2004)
10. T. D. Jick, Mixing qualitative and quantitative methods: Triangulation in action. Admin. Sci. Q. **24**, 602–611 (1979)
11. E. Hale, Taiwan cracks down on China poaching tech talent. Al Jazeera (2022), https://www.aljazeera.com/economy/2022/5/4/taiwan-is-trying-to-thwart-chinas-efforts-to-poach-tech-talent
12. T. H. An, S. H. Chen, K. C. Yeh, Can semiconductors be a tool for Taiwan's economic diplomacy? In Strategies in Changing Global Orders: Competition and Conflict versus Cooperation (Springer, Singapore, 2023), pp. 73–102
13. K. Bourzac, The U.S. Will Start Manufacturing Advanced Chips (TSMC's Arizona Plant). IEEE Spectrum (2024), https://spectrum.ieee.org/tsmc-arizona
14. TSMC, TSMC to Build Specialty Technology Fab in Japan with Sony as Minority Shareholder. Press Release (2021), https://pr.tsmc.com/english/news/2880
15. M. Hamdani, I. Belfencha, Strategic implications of the US–China semiconductor rivalry. Discov. Glob. Soc. **2**, 1–14 (2024). https://doi.org/10.1007/s44282-024-00081-5
16. S. Grimes, D. Du, China's interdependent positioning in the semiconductor global value chain. Area Dev. Policy (2024). https://doi.org/10.1080/23792949.2024.2397973

17. W. Xiong, L. Cui, X. Jin, S. Wang, Semiconductor supply chain resilience and disruption: A review and research agenda. Int. J. Prod. Res. **63**, 1–27 (2025). https://doi.org/10.1080/00207543.2024.2387074
18. P. C. Y. Chow, Chip-Four Alliance for a Resilient Global Semiconductor Industry. In Technology Rivalry Between the USA and China (Springer, 2025), pp. 269–307. https://doi.org/10.1007/978-3-031-76169-0_9
19. Y. Peng, Can U.S. sanctions truly hinder the rise of China's semiconductor industry? An analysis from the perspective of "creative insecurity". Chin. Polit. Sci. Rev. (2025). https://doi.org/10.1007/s41111-025-00282-6
20. S. Park, Semiconductors at the intersection of geoeconomics and security. Soc. Sci. **12**, 466 (2023). https://doi.org/10.3390/socsci12080466
21. D. Kaur, As Apple diverts to American-made chips, its supplier TSMC triples US investment. Tech Wire Asia (2022), https://techwireasia.com/2022/12/as-apple-diverts-to-american-made-chips-its-supplier-tsmc-triples-us-investment/