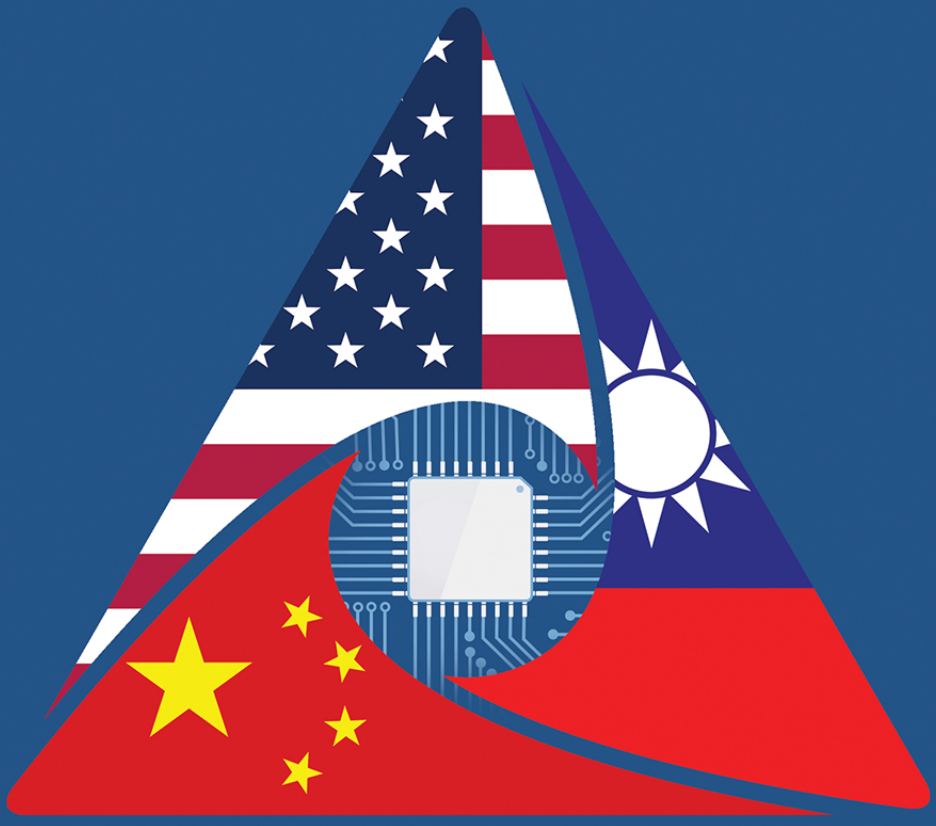

Silicon Triangle

The United States, Taiwan, China, and Global Semiconductor Security

Edited by Larry Diamond, James O. Ellis Jr., and Orville Schell

CHAPTER FIVE

Deepening US-Taiwan Cooperation through Semiconductors

KHARIS TEMPLEMAN AND ORIANA SKYLAR MASTRO

Taiwan is a close, trusted partner in the global semiconductor supply chain. The United States and Taiwan should seek to use the semiconductor industry to promote Taiwan's prosperity and stability by creating an environment that fosters deeper business-to-business, research, academic, individual, and civil ties with Taiwan and other global partners in the semiconductor arena.

This strategy includes the active promotion of Taiwan semiconductor firm activities, including manufacturing, design, and joint research and development (R&D) in the United States; income tax abatement for cross-border workers; two-way semiconductor internship programs and academic exchange; semiconductor supply chain information sharing and resiliency planning; and defense industry coproduction in Taiwan.

With Taiwan's particular strengths in semiconductors, and continued long-term US interests there, this is an attractive foundation for broader shared civil and business ties that helps to deepen US commitments to Taiwan's democracy—and deters efforts to end it.

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The fact that our partner Taiwan holds a key role in the global semiconductor industry should be seen as much as an opportunity for the United States as it is a risk. US interests in promoting Taiwan's stability and prosperity, and in preserving its way of life with values common

to our own, long pre-date the rise of the island's chip champions. And those same interests will outlast any business cycle or supply chain configuration.

As this report argues, semiconductors are a matter of central concern for the future of relations among the United States, Taiwan, and China. More US op-eds and think pieces have likely been written on Taiwan in the past two years than in the previous ten; that interest is due to words and actions that the People's Republic of China (PRC) has shown toward Taiwan, but it is also animated by the heightened US public and political interest in semiconductors. At the same time, the US-Taiwan relationship is about more than chips. Americans should resist a transactional view of Taiwan's role in this realm. And they should appreciate that those in Taiwan hear, and react in strategic ways to, what Americans say.

Leaders in the United States and in Taiwan should be realistic about the real threat that the island faces, and their response to that should be to build the capabilities and the confidence of their people to weather coercion and deter attack. To that end, our shared interests in capabilities in semiconductors can help. We can learn from one another, collectively extending technological leadership that is attractive to partners globally. We can use this heightened mutual level of interest to grow substantive people-to-people, business, and even appropriate government ties at the working level. And we can use this momentum to break through long-standing bureaucratic frictions and improve interoperability in our economic and security relationships.

This chapter shows what the United States might learn from Taiwan's successful experience in building a leading global role in the semiconductor supply chain—which is much broader than Taiwan Semiconductor Manufacturing Company (TSMC) alone—and as the United States now wrestles with the tension of market integration with China alongside growing strategic concerns, it illustrates how Taiwan has attempted to navigate those straits for decades. Finally, it offers concrete opportunities for deeper collaboration on the back of our shared interests in chips, which could improve mutual prosperity and enhance deterrence.

Learning from the Rise of the Semiconductor Industry in Taiwan

How did Taiwan end up as the home of TSMC, the world's most strategically important company—and more than a dozen other major players in the semiconductor supply chain?[1] The answer is a mixture of nurture, culture, and luck. With the future of US leading-edge semiconductor manufacturing now running directly through TSMC's investments in Arizona, those in the United States who wish to see such endeavors succeed should understand what underpins Taiwan's own domestic strategy. And it should not be taken for granted that these new US fabrication facilities (fabs) will succeed simply because they are being built.

Nurture

The beginning of the semiconductor industry in Taiwan can be traced back to 1966, when US electronics firm General Instruments set up the first semiconductor plant in an export processing zone (EPZ) in Kaohsiung. It was followed by the Dutch manufacturer Phillips and several other foreign electronics companies. But these plants were focused on simple assembly rather than advanced manufacturing, and they had limited links to local suppliers in the broader economy.

The moment that set Taiwan's electronics industry on its current path occurred in 1973, when the Ministry of Economic Affairs (MOEA) founded the Industrial Technology Research Institute (ITRI). ITRI was a government-funded body set up to provide research and development and to contribute to Taiwan's industrial upgrading. In 1974, it established the Electronics Research and Service Organization (ERSO) to develop domestic expertise in electronics manufacturing. ERSO's first project was an integrated circuit (IC) demonstration factory, for which it partnered with the US manufacturer RCA. ERSO sent about forty engineers to the United States to be trained by RCA, and when they returned they put together Taiwan's first IC manufacturing facility, which opened in 1977. Many of those forty trainees became key figures in the semiconductor industry, or stayed with ITRI for their careers, and they

played a fundamental role in developing Taiwan's electronics manufacturing capacity over the next several decades. The first domestic semiconductor company in Taiwan, United Microelectronics Corporation (UMC), was founded in 1980 when ERSO spun off the initial factory.

TSMC arrived on the scene in 1987 as the result of another ERSO project, this one focused on very-large-scale integration (VLSI) technology. Initial investment in TSMC was 48 percent from Taiwan's National Development Fund, 28 percent from Phillips, and 24 percent from other private sources. From the beginning, TSMC followed a pure contract foundry model: it focused exclusively on fabricating chips that met design specifications from its customers, and it eschewed any attempt to design its own. This pioneering decision freed electronics manufacturers from the need to build expensive factories themselves, and it led to a boom in chip design houses not only in Silicon Valley but also in Taiwan, which expanded from four in 1986 to forty by the end of 1987. The growth of these houses, in turn, led to rapid advancements in application-specific integrated circuits (ASICs), and the industry in Taiwan quickly attracted large investments from both foreign manufacturers (such as Sony and AMD) and domestic business groups.

In the 1990s, additional companies set up in Taiwan to fill other parts of the manufacturing process, and these clusters of companies built a more robust supply chain on the island. In 1994, ERSO spun off its submicron project to manufacture dynamic random access memory (DRAM) chips; the new company was called Vanguard International Semiconductor Corporation, or Vanguard for short. By 1995, six other companies manufacturing DRAM had also set up in Taiwan. By the end of the decade, Taiwan's semiconductor industry had many firms operating in at least one step of the chip-building process, including design, manufacturing, packaging, and testing.

In addition to public research and development funds and initial investment capital, government support has also come via subsidized land and infrastructure, preferential tax breaks, and investment in human capital. In 1980, the Taiwan central government created the Hsinchu Science-Based Industrial Park (now referred to as the Hsinchu

Science Park, or HSP) with the aim of re-creating some of the benefits of private sector clustering and interaction that had been so successful in Silicon Valley in California. HSP was created and has been run since its inception by the central government, which provides tax breaks for firms that locate there, as well as physical infrastructure for plants and parks and schools for the workforce. It is located near Taiwan's top two engineering universities, National Tsing Hua University and National Chiao Tung University, and it is also close to Taiwan's largest international airport, Taipei Taoyuan. ITRI's facilities are also located nearby. In 1999, three-quarters of the member firms of the Taiwan Semiconductor Industry Association (TSIA) were located in the park or nearby in Hsinchu or Taoyuan. Following the success of HSP, additional science parks have been established in Kaohsiung (Southern Taiwan Science Park, initially in 1994, then expanded to Tainan and renamed in 2003) and Taichung (Central Taiwan Science Park, in 2003). TSMC is building next-generation fabs in both parks.

The Taiwan government has also provided generous tax breaks for firms in the industry. From 1990 to 1994, for instance, the average effective tax rate for firms located in HSP was only 1.57 percent, as compared to 15.3 percent for the top one hundred manufacturing firms in Taiwan and 20 percent for the typical small and medium enterprises (SME).[2] Taiwan also does not have a capital gains tax. Semiconductor firms for many years exploited this feature by allowing employees to purchase a set number of shares at their nominal price and then immediately sell them at the much higher market price. This provided tax-free, risk-free bonuses to their employees. More recently, in January 2023, the government raised the tax credit firms will receive for R&D spending from 15 to 25 percent, capped at 50 percent of overall income.[3]

Taiwan has also invested in low-cost public higher education, which has provided a steady supply of engineering and managerial talent for the industry. The work of ITRI, especially in the industry's early years, also helped to develop an indigenous skilled workforce and to attract Taiwanese from abroad to return—including Morris Chang, the longtime leader of TSMC, who originally came back to Taiwan from the United States in 1985 to be the head of ITRI.

Culture

One hidden factor in the success of Taiwan's semiconductor industry is its culture of customer service. Unlike in Korea, where large *chaebol* (conglomerates) were the major exporters during the economic take-off there, in Taiwan, SMEs formed the backbone of economic growth. Taiwan's SMEs, many of them based on family or community networks, became especially good at contract manufacturing of consumer goods for buyers in advanced economies.[4] The best of these SMEs learned how to adapt to rapidly changing consumer preferences and to fill orders in a way that was cheap, fast, and reliable for the buyer. They also were entwined within a much larger network of subcontractors, which allowed them to quickly ramp production up or down based on the size of orders from US customers. This business culture of informal networks and complicated subcontracting relationships was eventually reproduced within the Taiwanese semiconductor industry. It also made TSMC's initial decision to strike out as a purely contract-based foundry company less of a leap than it might have appeared to outsiders; there was a precedent for this kind of business model in other parts of the Taiwan economy.

Taiwan's own work culture has contributed to the vitality of the industry in other ways, too. Workers in Taiwan log some of the longest hours in the world, and the country's labor rules remain relatively permissive. The chip manufacturing process requires a disciplined, knowledgeable, and reliable workforce, and firms in the industry have been able to require their employees to work regular overtime during particularly busy periods.[5] On a related note, semiconductor industry leaders in Taiwan have complained about American work culture as a formidable barrier to running manufacturing processes there.[6]

Taiwan's own quality of life, including its political transformation in the 1990s, has also made it a more attractive place for overseas Taiwanese to return to, and has helped with the talent-retention issues in the industry. The differences with the PRC mainland have been especially stark. As described in chapter 8, PRC efforts to poach semiconductor engineering talent and use Taiwanese expertise to jump-start its own domestic industry had some initial success. But in the last five

years, this threat appears to have subsided. Many industry engineers who were initially attracted by offers of greater independence and responsibility and much higher salaries have returned to Taiwan.[7]

Luck

Taiwan's semiconductor industry leaders are modest, with even leader TSMC—now one of the ten largest firms by market cap globally—describing itself as being in a horse race with Intel and Samsung, where one wrong investment or technology decision could cause it to stumble and quickly fall behind. As chapter 2 describes, this view is borne out by the reality of TSMC's recent rise to dominance, which coincided with failures in execution and strategy by its rivals in both the United States and Korea following their own strings of success.[8] Taiwan's foundries chose to aggressively reinvest their capital into capacity expansion following the 2009 global financial crisis and economic downturn, which resulted in increased market share when smartphone demand took off. TSMC made breakthroughs in applications of Advanced Semiconductor Materials Lithography's (ASML) extreme ultraviolet (EUV) technology that other early R&D partners were not able to replicate.[9] And a protracted series of industrial design intellectual property (IP) lawsuits by Apple against Samsung in the early 2010s—Samsung had provided most of the advanced chips for early iPhones—led to a much closer relationship (and substantial coinvestment and risk sharing) between alternative supplier TSMC and Cupertino's burgeoning consumer electronics powerhouse.[10] Taiwan's deep-rooted contract outsourcing model, in which the supplier intentionally avoided competing with the client's business, had found new resonance at a critical moment in the industry.

Taiwan's Semiconductor Industry Today: Clustering and Limits to Growth

Today, the Taiwanese semiconductor industry occupies a central position in semiconductor manufacturing, especially in leading-edge logic chips. The economic ecosystem surrounding TSMC has also grown

into concentrated business clusters, giving Taiwan one of the most diverse semiconductor supply chains in the world. This physical proximity of semiconductor and adjacent industries has led to significant economies of scale and tighter integration than that found elsewhere globally. Those in the United States may appreciate, for example, that one or two assembly plants do not make an auto industry—Taiwan's experience shows the need to similarly cultivate an industrial ecosystem will to reduce transactional costs and sustain global competitiveness beyond the limited window of government subsidies. And given that Taiwan has fast-growing firms in the semiconductor supply chains outside of manufacturing—such as in design, where US firms have significant strengths today—there is opportunity in both directions. US-Taiwan semiconductor collaboration is not a one-sided deal.

Taiwan Production and Consumption

TSMC is the largest semiconductor manufacturer in Taiwan and the largest pure-play semiconductor foundry in the world; it dominates the market for sub-10nm chip manufacturing and holds a virtual monopoly over logic chips at 5nm scale and below. Less appreciated is the strength of UMC, the world's second-largest pure-play semiconductor foundry (third in manufacturing volume overall); it focuses on specialized mature-node logic chips, such as for automotive and industrial applications. While both manufacturers have some operations in the PRC, the vast majority of their production takes place within Taiwan. In total, about one-third of global logic chip manufacturing capacity is physically located on the island.

Taiwan also has two major home-grown memory manufacturers—Nanya and Powerchip—and it has been quite successful in attracting foreign manufacturing investment. US-based Micron, the world's third-largest memory chip supplier, produces much of its leading-edge DRAM memory chips in Taiwan. As of 2020, 15 percent of global memory manufacturing capacity was located on the island.

Beyond front-end fabrication itself, Taiwan hosts more than half of global back-end outsourced semiconductor assembly and test (OSAT),

which is required before a chip can be integrated into an end product. ASE Technologies, the largest OSAT firm in Taiwan and the world, alone holds 24 percent of the global market share.

As noted above, Taiwan's semiconductor contract manufacturing strengths have also contributed to a large and growing domestic fabless design industry. MediaTek, Novatek, Realtek, and Himax are the fourth-, sixth-, eighth-, and tenth-largest fabless design houses by revenue share in the world, respectively. MediaTek, in particular, has been a competitor to US-based Qualcomm in the mobile chip category, and it overtook Qualcomm in Android smartphone market share (by device) in 2022. In total, Taiwan holds 21 percent of the global fabless market share, second only to the United States.

For manufacturing inputs and materials, Taiwan's GlobalWafers is the third-largest supplier of silicon wafers in the world, with a market share of 18 percent in 2020. The four largest silicon wafer manufacturers in Taiwan—GlobalWafers, Sino-American Silicon Products (SAS), Formosa Sumco (a joint venture with Japan's SUMCO), and Wafer Works—account for one-third of the global market. This makes Taiwan the second-largest manufacturer of silicon wafers in the world after Japan.

Even with its considerable strengths, Taiwan still relies heavily on links to the semiconductor supply chain abroad. Taiwan's fabless semiconductor designers are dependent on the same US and European electronic design automation (EDA) software tools that all such firms use globally. Its manufacturing facilities rely on Japanese suppliers of specialty gases, chemicals, and lithography masks. Taiwan produces little indigenous semiconductor manufacturing equipment, leading its firms to spend tens of billions of dollars annually—$24 billion in 2021—on tool imports from the Netherlands, the United States, and Japan. This is a level on par with equipment purchases by Korea and by the PRC and, therefore, a major source of revenue for these suppliers.

Taiwan's contract foundry model also intrinsically links its firms very closely to its global customers. TSMC, for example, supplies mainly foreign clients. In 2021, Apple alone accounted for 26 percent of its revenue, and the US market as a whole was 64 percent. Domestic

clients in Taiwan generated just 12.8 percent, while 10.3 percent of revenues came from firms in the PRC.[11]

In some senses, then, while policy makers in the United States may think mostly about US reliance on Taiwan, Taiwan is equally reliant on the United States. This reliance of course makes Taiwan a strong business partner for US-based firms, manifested by the typically conservative TSMC's willingness to invest in US-based manufacturing capacity—despite the significant cost premium and risk associated with that—to provide value to their key clients (read: Apple). In turn, TSMC likely expects that such added value to clients will be reflected in higher unit prices for its production in the United States.[12]

This closeness also makes Taiwan a necessary policy partner to US efforts to assert control over critical technologies. Taiwanese semiconductor firms' use of US technologies makes them vulnerable to US export controls or sanctions. For example, in 2020, TSMC terminated its relations with HiSilicon, Huawei's fabless semiconductor subsidiary, which was at the time its second-largest client. Given the intense global demand for its products at that time, however, the lost business was quickly absorbed elsewhere among the firm's nearly five hundred clients.

Domestic Issues

Taiwan's semiconductor industry leaders will regularly point to two looming domestic pain points: energy and worker availability.

As outlined earlier, Taiwan has long used a science park model to incentivize high-tech industrial operations, including through government support in the provision of land, electricity, and water. Rapid growth in the tech industry, including semiconductors, has nonetheless run up against constraints in these areas. For example, Taiwan recently experienced its worst drought in five decades (the drought ended in June 2021), which forced TSMC to tap groundwater from construction sites or to import supplies by truck from locations around the island.[13] While these periodic shortages can be disruptive, water is regarded as being a largely manageable proposition going forward due to continued advances in recycling and treatment technologies; it is worth

it to invest in these capabilities, given the value of the chips these water inputs produce.

Of more concern is the availability and reliability of affordable and clean energy supplies. A particular concern is over electricity, which has seen rapid demand growth—power consumption from the information and communications technology (ICT) subsector alone in Taiwan has quadrupled since 2000 and now represents 21 percent of the island's total, more than that from the entire residential sector. TSMC itself is said to have used nearly 10 percent of Taiwan's electricity in 2022, and the government estimates that its consumption will rise threefold from 2020 to 2030; the industry has twenty new fabs recently completed or under construction, and it plans to build more than a dozen new fabs on the island in coming years.[14] This tech sector demand is also concentrated in Taiwan's north. Meanwhile, Taiwan's electricity supply growth, much of it in the south, has at times in recent years faltered; the island's zero-carbon nuclear plants are being shut down under central government policy decisions or by local pressure, and clean replacement generation has seen delays.[15] A result has been periodic blackouts—in August 2017, twice in May 2021, and again in March 2022.

Given the high capital intensity, a semiconductor fabricator's profitability is closely tied to its facility utilization rate. Moreover, the hundreds of manufacturing steps and precise equipment within a fab require high-quality electricity supplies. While fabs have backup generators, blackouts are costly propositions in the short term, and industry concerns over longer-term electrical resource adequacy can impede larger investment.

Then there is skilled labor—a concern shared by the semiconductor industry around the world, including in China and the United States. But it is particularly acute here, given the industry's outsized role in Taiwan's economy. A majority of Taiwan's engineering graduates already go into the semiconductor industry, which employs 290,000 people overall. TSMC alone, with its strategy on leading-edge capabilities and an R&D staff of over ten thousand, is estimated to already recruit four-fifths of Taiwan's eligible PhDs each year. A report in 2022

estimated that the industry had thirty-five thousand unfilled positions, a situation that could grow worse over time with Taiwan's poor demographics (low fertility and immigration rates) and declining number of students overall.[16]

The government has taken some steps to address this shortage, partnering with academic institutions and companies themselves to set up new "chip schools" to train the next generation of industry workers.[17] TSMC itself directly sponsors about two dozen PhD scholarships each year within Taiwan, its employees design and teach university courses, and it offers about 350 internships each year. As chapter 2 describes, working in the semiconductor industry in Taiwan is viewed with prestige; salaries and benefits are high by local standards, though low by US standards (an average starting salary, plus benefits, for an engineer with a master's degree at TSMC is about $65,000).[18] Yet, the industry could benefit from more women in the engineering workforce—US DRAM manufacturer Micron reports that while 44 percent of its new hires in Taiwan were women over the past three years, they represent only 22 percent of its total Taiwan workforce.[19] And as with other developed economies, additional targeted immigration measures from South and Southeast Asia are likely needed as well to span this gap. Chapter 6 describes, for example, the growing number of Indian-origin university students studying in Taiwanese engineering programs; even so, of TSMC's approximately eight thousand new hires in 2020, only 280 were from overseas.[20] These concerns about the local workforce may also have helped to encourage Taiwan's semiconductor manufacturers to make more investments and enter into joint ventures abroad (for example, the TSMC joint venture with Sony and automakers in Japan).

Taiwan's semiconductor sector does have a related concern about its workforce—that of talent poaching by PRC firms. This is perhaps less of a large-scale issue today than it was five to ten years ago, given the declining interest among Taiwanese youth in working and building careers in mainland China. But between 2014 and 2019, more than three thousand of Taiwan's high-level semiconductor workers

reportedly moved to China, lured by large pay premiums.[21] It is still an area of considerable concern for leading industry talent, given China's industry ambitions and high levels of government support, so Taiwan has taken increasing steps over time to protect its industry.[22]

Taiwan's Investment Commission, for example, since the 1990s has required applications and screening for foreign direct investment (FDI), mergers, and acquisitions in high-tech areas; outbound investments into China over $50 million must also be registered, and Taiwan's government imposes limits on the level of production technology that can be used abroad (this affects TSMC's fab in Nanjing, for example).[23] Economic espionage is criminalized, with prison sentences of up to twelve years for those found guilty of transmitting "national core technology trade secrets."

In response to aggressive poaching of Taiwanese semiconductor talent, Taiwan has also begun cracking down on these recruitment efforts. This crackdown has included raids on PRC companies illegally operating in Taiwan's semiconductor science parks,[24] prosecutions of forty cases of illegal talent poaching by PRC firms,[25] limits on domestic advertising, and fines of 5 million New Taiwan (NT) dollars (roughly $170,000) for PRC semiconductor headhunters.[26] More recently, Taiwan's government has introduced a measure to require prior government permission for travel to China by chip company employees receiving some form of Taiwanese government support (most of them); this proposal, however, has received some pushback from Taiwan's semiconductor firms, which instead point to company internal trade secret protection protocols as a more important tool to prevent technology theft.

Notably, the US government now finds itself navigating similar concerns in balancing semiconductor sector economic freedoms alongside emerging national security dimensions—see, for example, the limits on US persons working in China's semiconductor firms unveiled in the October 2022 Bureau of Industry and Security export controls, as described in chapter 9. But Taiwan arguably has a much deeper experience to learn from here.

Postcards from the Future: For Taiwan, Economics and Security Have Always Been Linked

The scenario analysis of chapter 1 points to potential futures in which US international economic relationships become more oriented alongside shared values and security interests. If that came to pass, it would be a stark departure from a historical embrace of globalization; selective decoupling from China would imply new responsibilities for some of our leading enterprises and unfamiliar roles for US policy makers and regulators. Mistakes are likely and could be costly. Can we learn from Taiwan's heretofore unique experience in delicately managing a significant economic relationship with a country that is also its largest security threat—all under a democracy with the constant political undercurrents that entails?

For the Republic of China on Taiwan, economic development has always had fundamental security implications. In 1949, as the Chinese Nationalist Party's (Kuomintang or KMT) position on the Chinese mainland collapsed, the regime fled to Taiwan in disarray, bringing with it the institutions of the Republic of China (ROC) and over a million refugees from the mainland. From that point forward, it was caught in a relentless competition of political systems with the Communist Party–led People's Republic of China—one in which economic growth was a key part of political legitimacy.[27] In the early days of the Cold War, Taiwan was synonymous with "Free China": a beleaguered outpost of the capitalist West in imminent danger of an onslaught by the communists across the Taiwan Strait. Once the immediate danger of an invasion had been forestalled by US intervention at the beginning of the Korean War, stabilizing and revitalizing Taiwan's economy became the regime's foremost security imperative.

By the early 1960s, in an effort to wean itself off US aid, the KMT leadership switched to an export-oriented development strategy. It exploited the island's abundant labor and preferential access to Western markets to attract foreign direct investment, boosting economic growth rates and building a foreign currency reserve. The result was the vaunted "Taiwan miracle": for the next forty years, the island enjoyed

almost uninterrupted rapid economic growth with low inequality. It also gradually moved up the export value chain: from textiles and toys in the 1960s to shoes and bicycles in the 1970s and finally electronics assembly and computer hardware manufacturing in the 1980s.

This rapid development lifted millions of Taiwanese out of poverty and turned the island into an industrial powerhouse. It also gave Taiwan's leaders an enhanced sense of security. By the 1980s, the regime's annual defense budget was fully half of the PRC's, for an island with a population of less than 2 percent of the mainland's. Its growth gave it the resources to invest in indigenous defense production of increasingly sophisticated weaponry, and to purchase from foreign suppliers the latest-generation platforms—F-16s from the United States, Mirage fighters and Lafayette-class frigates from France, and Zwaardvis-class submarines from the Netherlands. The gap in sophistication between Taiwan's military and the People's Liberation Army (PLA) became a chasm by the 1990s, with the ROC armed forces enjoying an enormous qualitative advantage across domains that more than offset the PRC's quantitative advantages.

It is easy to overlook now, but from the vantage point of the early 1990s, Taiwan was operating from a position of strength in the cross-strait relationship. Per capita income was twenty times that of the mainland. Taiwan's foreign currency reserves were the world's largest. Taiwan's political system was liberalizing, a process that culminated in the first free and fair direct election of the legislature in 1992, and of the president in 1996.

Most relevant for present purposes, Taiwanese companies were nimble competitors in the global economy, while PRC firms were still trying to adapt to market principles. Thus, when rising costs of inputs—chiefly labor and land—in Taiwan led many Taiwanese contract manufacturing firms to look around for cheaper alternatives, it made considerable economic sense for both sides that they relocate some of their activities to the Chinese mainland. It is well known that the capital and business acumen of "overseas Chinese" were instrumental in the PRC's early reform and opening-up period in linking mainland China into the global economy. It is less widely appreciated

just how central Taiwanese businesspeople—*Taishang* in the local parlance—were in this process. They brought the advantages that Taiwan's SMEs had developed in contract manufacturing over the previous decades with them to mainland China as they moved production into special economic zones in coastal regions, especially the Pearl River Delta area and Fujian Province.[28]

Cross-Strait Ties and Partisan Politics

These deepening cross-strait economic ties took place in the face of a worsening political environment. Beijing viewed President Lee Teng-hui (1988–2000) with great suspicion, and government-to-government communication across the strait had ceased by 1999. Taiwan's regulatory frameworks continued to place burdensome limits on groups interested in traveling to, studying in, or holding cultural exchanges with the other side. The election in 2000 of Chen Shui-bian, the candidate of the China-skeptical Democratic Progressive Party (DPP), did not improve the political environment for cross-strait talks. Nevertheless, economic integration did *not* slow down but instead accelerated during his administration. Taiwan's investment in mainland China grew 50 percent per year during Chen Shui-bian's first term, and by the time he left office in 2008, cross-strait trade was nine times the volume of what it was in 2001.

These trends meant that when the KMT returned to power with the election of Ma Ying-jeou as president in 2008, Taiwan's economy had become deeply intertwined with the PRC's. At this point, the positions of the two main political parties on this economic integration began to diverge. The KMT's strategic approach under President Ma was to go "to the world through China." His government's central objective in cross-strait relations was to help the formal institutions "catch up" to economic reality by deepening the institutional and regulatory frameworks handling cross-strait relations. This, in Ma's telling, would eliminate the need for many of the costly workarounds in the economic relationship and further benefit Taiwan by hitching its economy more firmly to the Chinese growth engine across the strait.

A prominent example of this approach is the implementation of regular cross-strait commercial flights. Within days of taking office, Ma's

representatives were in productive negotiations with their counterparts from the PRC, and by 2009 the two sides had established a regulatory framework to allow direct commercial flights for the first time between the mainland and Taiwanese cities; even today, one can get on a plane in downtown Taipei and be in Shanghai in less than two hours.

The DPP, in contrast, began to argue more and more loudly for balancing: seeking to mitigate the security vulnerabilities that came from overdependence on the mainland economy by diversifying Taiwanese firms' economic partners, customers, and manufacturing bases to other countries in the region. This position had limited appeal in the 2012 election, when Ma Ying-jeou was able to win reelection over the DPP's Tsai Ing-wen. But in Ma's second term, public opinion shifted in a more China-skeptical direction. This change came amid concerns about broader PRC influence over Taiwan's economy and the economic risk that even Taiwan's most advanced industries, such as semiconductor manufacturing, might be "hollowed out" by shifting production to the mainland. And more recently, the change in attitude has been furthered by Beijing's shift to a more aggressive and nationalist approach in foreign affairs, including the centralization of power under Party General Secretary Xi Jinping, the demise of Hong Kong's "one country, two systems" model, and growing bellicosity toward Taiwan.

With the election of Tsai Ing-wen in 2016, the DPP returned to power. The party also won a majority in the legislature for the first time, allowing it to pass laws without the approval of the KMT or other opposition parties. The party interpreted its victory as an electoral mandate to implement its alternative cross-strait economic strategy: balance against China. DPP leaders generally view Taiwan's heavy reliance on the PRC market, and the large number of Taiwanese firms that now carry out at least some of their production on the mainland, as a serious security vulnerability. From this perspective, continued economic integration gives Beijing additional economic leverage to use for coercive political purposes. It also facilitates Beijing's efforts to erode Taiwan's own long-standing economic advantages in the relationship by poaching talent and using Taiwanese personnel to build competitors to Taiwanese firms.

Taiwan Government Responses to the Rising Cross-Strait Threat

With this threat in mind, the Tsai administration has searched for ways to blunt these vulnerabilities without hurting Taiwan's own economic vitality. It has not unilaterally rolled back any of the Ma-era agreements, but it has sought to direct its new trade and diplomacy initiatives elsewhere, especially with its traditional democratic partners in the United States and Japan. For example, its "New Southbound Policy" provides incentives for firms to shift production out of the PRC to other destinations in Southeast and South Asia, and the Tsai administration has sought free trade agreements (FTAs) and other formal cooperation agreements with the United States and its allies and partners around the world. Despite these efforts, the PRC (including Hong Kong) continues to be the immediate destination for 39 percent of Taiwan's exports by value.[29]

One problem that the Tsai administration faces is that the Taiwanese state has only limited sway over the business decisions of large conglomerates such as TSMC but even less on those with major investments on the mainland, such as Foxconn (Hon Hai). It cannot force these companies to shift investment, personnel, and customer markets away from mainland China. It instead has to find policy carrots to encourage production shifts that may already be taking place for nonpolitical reasons.

In the DPP's favor, several factors are pushing in the same direction to make the PRC a less attractive place for Taiwan's manufacturing firms to locate their production. These include rapidly rising labor costs and a less favorable regulatory and tax environment; growing concerns about the loss of intellectual property, and the concurrent trend of China-based partners turning into direct competitors; and, above all, the rise of US-China trade tensions and concern in destination markets about the security and resilience of complicated supply chains.

Taiwan's semiconductor industry is at the center of these longstanding security concerns today. The emergence of TSMC, UMC, MediaTek, and other companies as critical players in this industry is a source of pride in Taiwan, but their continued success is also increasingly viewed as a vital national interest. The broader high-tech industry contributes an astounding 18 percent of Taiwan's gross domestic

product.[30] Its economy boomed during the COVID-19 pandemic, despite near-total isolation for months from the rest of the world, because of the immense demand for semiconductors supplied by TSMC and others.

Many Taiwanese have also begun referring to TSMC in particular in starkly hard security terms, as a "silicon shield" (*huguo shenshan*) that protects Taiwan from a PLA invasion. The presence of such a strategically crucial company, the thinking goes, combined with the overwhelming reliance of industry in both the United States and the PRC on advanced semiconductors produced in Taiwan, gives both sides an incentive to preserve the status quo. The PRC would not dare to attack Taiwan and risk destroying such a crucial source of chips, and the United States would have to intervene in any conflict across the Taiwan Strait to defend Taiwan and protect its access to chips—regardless of any broader diplomatic or political calculations. From this perspective, Taiwanese public opinion is primed to resist the idea of TSMC diversifying its most advanced production away from Taiwan to other, less strategically vulnerable countries. Even putting aside the perceived economic downsides for Taiwan, doing so would conceivably go against the country's core security interests.

On the other hand, the DPP government remains eager to cooperate more closely with the United States, Japan, and other Western partners and allies to improve the security of semiconductor supply chains and limit PRC involvement in the industry. Foreign policy prioritization from the US government can be fickle, and the surging interest in semiconductors from policy makers and thought leaders in the United States has drawn broader attention to Taiwan generally from across Washington—more newspaper op-eds have probably been published about Taiwan in the past two years than in the previous ten combined. For a conservative US executive branch bureaucracy that has at times hesitated to engage more expansively with Taiwan, the sunlight brought by the semiconductor issue has been animating—even in areas that have little to do with semiconductors or critical supply chains.

And from Taipei's perspective, cross-national efforts to map out the next phases of chip development, to "friend-shore" production,

and to keep advanced production sites away from mainland China are likely to be supported, particularly if a DPP government remains in power. As Taiwan's formal diplomatic space continues to be eroded by Beijing's economic clout, Taiwan has not shied away from acknowledging its strength in the semiconductor supply chain in its global interactions. Morris Chang, the charismatic founder and former chairman of TSMC, has repeatedly represented "Chinese Taipei" at the Asia-Pacific Economic Cooperation (APEC) forum (one of the handful of multilateral forums in which Taiwan has representation) starting in 2006 and then again since 2018. During the COVID-19 pandemic and amidst PRC pressures on Western firms to limit vaccine distribution in Taiwan, the idea was floated of a possible chips-for-vaccines deal; TSMC, Foxconn, and the civil society Tzu Chi Foundation later worked to purchase and donate fifteen million Pfizer-BioNTech vaccines.[31] And following China's blocking of imports from Lithuania after Vilnius permitted a "Taiwan" representative office to open in the country, Taiwan announced a $200 million investment plan in Lithuania, including partnerships around semiconductor R&D and manufacturing.[32]

US-Taiwan Cooperation on Semiconductors to Preserve Stability in the Taiwan Strait

How should one think about the links between Taiwan's semiconductor industry, US interests in this field, and implications for cross-strait deterrence—and what steps could policy makers in the United States and in Taiwan take to use our shared interest in semiconductors to substantively improve mutual capabilities and confidence in the face of a motivated rival? Importantly, such steps will be taken in an information environment in which malign interests may seek to exploit words or policy actions that could shape narratives otherwise.

The Silicon Triangle from Taipei

As discussed above, there is a long-standing argument in Taiwan that US reliance on Taiwan for advanced semiconductors makes US defense of Taiwan more likely. Proponents of this "silicon shield" theory argue

that Taiwan's chip industry is an effective deterrent to invasion because attempting to take Taiwan by force would cause catastrophic damage to the PRC and the global economy.[33] There is some empirical basis for this idea. Taiwan accounts for 92 percent of the global production of advanced chips, and over 90 percent of semiconductors used by the PRC are either imported or produced by foreign companies. In Q1 2021, over 50 percent of Taiwan's exports to the PRC were semiconductors (largely for assembly and reexport, a key area of PRC employment and political sensitivity).[34] For these reasons, many have argued that the United States would use military force to protect its access to Taiwan's semiconductors as it has done in the past to ensure access to oil.[35] Indeed, TSMC's Morris Chang has referred to Taiwan's chip industry as "a holy mountain range protecting the country," a phrase popular in Taiwan.[36] This framing could therefore suggest that US moves toward securing its supply chains through onshoring would have the unintended consequence of signaling a disinterest in Taiwan's own safety—decreasing deterrence against the PRC.

On the other hand, some believe that Taiwan's leadership in semiconductors increases the probability of a PRC invasion instead of acting as a deterrent.[37] PRC writings are replete with arguments about the strategic nature of the semiconductor industry and its importance for national power and national security.[38] The critical nature of Taiwan's industry, and the PRC's inability to replicate it, only increases the attractiveness of the island to the PRC.[39] As chapter 8 describes in detail, the PRC has launched a herculean effort to build a domestic chip industry, with plans to invest over $150 billion in semiconductors from 2014 to 2030.[40] However, the results are mixed at best. Though the PRC has made inroads in importing large volumes of semiconductor manufacturing equipment and is quickly gaining market share in the production of some less-advanced chips as well as memory chips, its effort to build self-sufficiency in semiconductor manufacturing has faced numerous setbacks.[41] At least six new major PRC semiconductor manufacturing projects that collectively received over $2.3 billion in government funding have failed over the past three years.[42] Meanwhile, the PRC's semiconductor industry still relies on suppliers

in the United States, Taiwan, South Korea, Japan, and Europe, and US and partner export controls increasingly deny the PRC access to key chip production equipment and software.[43] Given these punishing export restrictions and the PRC's failed chip investments, some analysts expect that the PRC's goal to achieve self-sufficiency in chips is unlikely to be successful, making Taiwan even more important to the PRC's technology ambitions.[44]

But it is important to recognize that having control over Taiwan does not necessarily mean having control of Taiwan's semiconductor industry. Semiconductor equipment must be operated by highly skilled engineers and maintained by service engineers from semiconductor equipment manufacturers (the majority of semiconductor equipment comes from the United States, Japan, and Europe). Even if China could continue to manage Taiwan's manufacturing plants, it would likely be impossible to maintain the plants' equipment without help from equipment vendors. Semiconductor technology must be constantly improved to maximize its value. The ability to deliver new generations of semiconductor technology rests on a highly skilled workforce capable of conducting advanced research and development. It is an open question whether high-level Taiwanese research engineers and semiconductor executives, many of whom were educated and trained in the United States, would remain in Taiwan under PRC rule. More importantly, as chapter 2 describes, the key to success for a semiconductor foundry is not only technological capability but also customer trust. A China-controlled TSMC may not earn the same level of trust from customers worldwide. At best, taking Taiwan by force would cause disruption worldwide, but the direct benefit to China in terms of advancing China's semiconductor leadership or chip independence is questionable.

The semiconductor industry also looms large within the broader bilateral great-power competition between the PRC and the United States. According to one Chinese scholar, Washington's anxiety in response to China's rise coinciding with the dawn of new, semiconductor-driven technologies such as 5G and artificial intelligence (AI) is precisely because technological revolutions are a key component of power transitions.[45] US attempts to consolidate the domestic semiconductor

industry are seen in this light.[46] One researcher at the Chinese Academy of Social Sciences, Xu Qiyuan, even suggests that China can learn from the United States in terms of securing offshore supply chains through building relationships with other countries. Indeed, Xu notes specifically that his research found that "it is difficult [for a country] to maintain both competitiveness and influence *and* complete autonomy and supply chain independence when it comes to a globalized industry."[47]

PRC analysts and media outlets have also tried to take advantage of these dynamics to paint a transactional portrait of the US-Taiwan relationship, and to even sow distrust of the United States among the Taiwanese people. In this context, Chinese thinkers point to the US reliance on Taiwan for its semiconductors, speculating that this commercial concern may be a major motivator for US defense of the island.[48] And at least one Chinese writer has asserted that the United States plans to destroy TSMC equipment on the island in the event of invasion; coupled with US government encouragement for TSMC to build new factories on American soil, they suggest that the United States is not dedicated to the defense of Taiwan.[49] These narratives are corrosive and have troublingly found some resonance within Taiwan in the heated political environment of an election year—and among some ill-informed US commentators, too.

Consultations with Taiwan's Semiconductor Industry

US policies on its own semiconductor supply chain, on technological competition with China, and on Indo-Pacific security are followed closely in Taiwan. And economic interactions and coordination between the United States and Taiwan have generally been considered fair game diplomatically—see, for example, the US State Department's Economic Prosperity Partnership Dialogue with Taiwan, or the bilateral US-Taiwan Initiative on 21st-Century Trade, which was launched in 2022 given Taiwan's exclusion from the similar regional US-led Indo-Pacific Economic Framework for Prosperity (IPEF). Nonetheless, due in part to the island's continued formal international diplomatic isolation, Taiwan's businesses have long eschewed political engagement abroad and have been shy to acknowledge geopolitics at all.

Now the situation is changing, and Taiwan's companies have to change, too. Establishing a mechanism for collaboration between the semiconductor industries and academic research institutions of the United States and Taiwan on supply chain resilience, technology research and development, manufacturing capability, and workforce development could benefit both the United States and Taiwan.[50] TSMC has recently established a Washington office. Its chairman, Mark Liu, an engineer (US-trained) at heart, now regularly has to (perhaps grudgingly) deal with geopolitical issues. But the company has risen to the occasion, and so far navigated those challenges well. It would benefit our mutual interests if other companies in Taiwan could successfully navigate this dynamic geopolitical relationship, too.

Taiwan's ITRI—which has long acted as an interface between Western and Taiwanese technology firms—could be a conduit of this through an expanded mission. Since its establishment by Taiwan's government in 1973, ITRI has had an excellent track record of incubating new technologies and new companies (the most successful one being TSMC), and it carries out research on a broad array of topics, including semiconductors.[51] Notably, Taiwan's government in 2019 launched the Taiwan Semiconductor Research Institute (TSRI) under the Ministry of Science to conduct research in semiconductor manufacturing, design, and integration; to foster professional development; and to collaborate with industry and academia.[52] A key TSRI mission is to engage in cooperation with international partners, particularly the United States, including connecting with research communities, training workforce talent, and pursuing joint activities. ITRI and TSRI are logical Taiwanese partners for collaboration with the United States not just on technology research but on broader matters of supply chain resilience as well as geopolitical hopes and fears.

A potential American collaboration partner could be the American Semiconductor Academy (ASA) initiative, a proposed nationwide semiconductor education and training network of faculty at US universities and colleges engaged in semiconductor research and education.[53] Collaboration between TSRI and ASA could advance R&D and

training programs in both the United States and Taiwan. As described earlier, in 2021, Taiwan established four "semiconductor colleges" within the top four universities in Taiwan; one of the goals of these semiconductor colleges is to raise the level of research in Taiwan and collaborate with US universities and semiconductor companies.[54] The United States could similarly establish mechanisms for US universities and companies to collaborate with Taiwan's semiconductor colleges and interested firms.

Another potential US collaboration partner would be the National Semiconductor Technology Center (NSTC), established by the CHIPS Act provisions of the fiscal year 2021 National Defense Authorization Act. With nearly $11 billion now appropriated for this purpose, the NSTC will be established by the secretary of commerce as a public-private consortium with participation of the private sector, the Department of Energy, and the National Science Foundation to conduct research and prototyping of advanced-semiconductor technology to strengthen the economic competitiveness and security of semiconductor supply chains.[55] The NSTC is intended to conduct research in manufacturing, design, packaging, and prototyping; strengthen the competitiveness and security of supply chains; and promote workforce training. There is considerable overlap between the missions of the TSRI and the NSTC, and these two government institutions could foster collaboration between the semiconductor industries and research universities of the United States and Taiwan.

Joint Workforce Development

As described above, talent is becoming a key choke point for sustaining leadership in semiconductor technology. Taiwan and the United States have joint concerns about the shortage of skilled labor.

Joint training programs, such as those undertaken by TSMC in Taiwan to train US staff for its new Arizona plant, offer one constructive way to deepen US-Taiwan ties and aid the development of the workforce in both countries.

The United States, meanwhile, has the best universities in the world, and these universities attract the best students from around

the world for their education. There is a unique opportunity for the US government and US universities to partner with Taiwan on talent development with the goal of incentivizing chip manufacturers like TSMC or chip designers like MediaTek or others to grow their R&D efforts in the United States, and through US students. This could, in the long run, create the necessary conditions for TSMC and others to ramp up high-volume manufacturing of their most advanced technologies on US soil.

Partnering with US universities could also help these firms become more adept at working with foreign graduates, who represent only a small share of the semiconductor workforce in Taiwan today, but who could likely become more interested in the prospect of working in Taiwan, or with Taiwanese firms, through such early contact in their education and training.

A complementary strategic partnership opportunity is with the NSTC, which, if established properly (see chapter 4), will become a global center for semiconductor research. Encouraging global technology leaders such as GlobalWafers, MediaTek, TSMC, and UMC to join the NSTC as full-fledged members (along with semiconductor industry leaders outside of Taiwan, such as Samsung) would greatly accelerate the path from R&D to manufacturing.

Workforce and Cultural Exchange

While Taiwan's semiconductor industry already has a strong presence in and long-standing ties to Silicon Valley, more can be done on educational exchanges around the country. A potential model program is the initiative between the Taiwanese chip designer MediaTek and Purdue University to create a new chip design center.[56] Pairing Taiwanese chip designers and manufacturing firms with US engineering programs around the country could provide considerable benefits: industry experience and potential career opportunities for students, and access to engineering talent for firms. Less obviously, it could well have political and strategic benefits for Taiwan, bringing the island's semiconductor industry to the attention of politicians and educational leaders throughout the United States.

More attention should also be paid to reversing the decline in the number of Taiwanese students studying in US universities—a cohort that formed the original bedrock of Taiwan's chip industry. The number of Taiwanese students studying in US universities fell from approximately twenty-eight thousand in 2001 to twenty-four thousand just before the COVID-19 pandemic, and hit just twenty thousand in 2021—a declining trend that occurred alongside broadly rising international student enrollments in US schools.[57] Technology industry veterans in Taiwan will observe today that when they first entered their workplace after graduation decades ago, more than half of their colleagues would often have graduated from US universities; today the figure is much lower. There is no one magic bullet to address this, which is partly a reflection of attitudes among domestic Taiwanese students and their interest in engaging in the world, and partly a matter of competition within US graduate programs. One fruitful area for focus, however, would be on getting Taiwanese undergraduates into US master's degree programs, which are largely self-funded by the student and are a source of income for US university departments, so financial support would be needed from the Taiwan or US government to create such billets. But doing so at the master's level would, in turn, improve the pipeline of Taiwanese students to funded research PhD programs. Simultaneously, English coursework options should be expanded and encouraged within Taiwanese undergraduate programs.

In the other direction, Taiwan's appeal as a destination for Chinese-language study has been on a dramatic upswing over the past few years, as the PRC has become increasingly difficult for US students to enter. The US-Taiwan Education Initiative seeks to capitalize on this shift by encouraging American students to study Mandarin at Taiwanese universities.[58] This and other initiatives, such as summer internship programs for engineering, economics, and social science students, could be expanded.[59]

Finally, following the political crackdown in Hong Kong in 2020, Taiwan has become an increasingly attractive destination for nongovernmental organizations (NGOs) involved in social and political issues. Reporters Without Borders, Freedom House, the International

Republican Institute, the National Democratic Institute, and the Westminster Foundation for Democracy have all recently opened offices in Taipei, and the membership of the Taiwan Foreign Correspondents' Club has doubled as foreign reporters working the China beat who have been denied visas have relocated there. A US-led initiative to strengthen ties beyond the semiconductor industry should look to build on these trends and further institutionalize Taiwan's place as an alternative to mainland China.

Regular Evaluations of Shared Semiconductor Vulnerabilities

Periodic evaluations of both the United States' and Taiwan's semiconductor vulnerabilities to a range of natural and geopolitical disaster scenarios could reveal supply chain weaknesses that need to be addressed, and facilitate planning for recovery from potential incidents. These evaluations could include tabletop exercises of supply chain disruption and recovery, with US and Taiwan industry participation. A partnership between TSRI and NSTC would be a potential institutional structure for conducting such evaluations. TSRI would have access to sensitive information from the Taiwanese industry about vulnerabilities of semiconductor facilities in Taiwan (and facilities of Taiwanese firms in the United States and elsewhere) to earthquakes and other natural disasters, and about vulnerability to disruption of supplies of components, materials, and services. It would have access to contingency plans for recovery as well. The NSTC would have access to comparable information about vulnerabilities of US facilities and supply chains and access to the analytic capabilities of US industry and academia. Such supply chain disruption simulation and mapping exercises have already begun in earnest within the private sector; they would be made stronger with broader and shared participation.

Partnerships on Energy Supply Resilience

Any energy policy must balance the energy system's environmental impacts with its affordability and broader economic implications, and with the security and reliability of the architecture. This need is no different in Taiwan.

On the environment, Taiwan's people are as interested in climate issues as are those elsewhere in the world, and they also are very active regarding the local environmental impacts, for example, that of infrastructure development. As a democracy, Taiwan's civil society sector is extremely influential in the path of energy policy. Meanwhile, US chip buyers and other original equipment manufacturers (OEMs) are also increasingly concerned with the emissions profiles of their suppliers abroad, which impact the clean-energy purchase needs of producers in Taiwan.

On the economy, energy costs and the competitiveness of Taiwan's industries are major concerns—the electricity rate structure can be considered to be subsidizing the island's semiconductor sector today. Taiwan still has monopoly state ownership of its oil and gas and power sectors; as is common in such scenarios, each is generally loss-making given political concerns, and this can make sufficient capital inflows for new investment a concern, especially when attempting to transform the sector to a cleaner profile, as Taiwan wishes to do today.

Security, meanwhile, has emerged as an area of increasing importance for Taiwan—as it has in other parts of the Indo-Pacific (including the United States) and in Europe as well. The year 2022 and the Russian invasion of Ukraine have proved that the world is more dangerous than we had thought or hoped. Energy import–dependent Taiwan now faces three dimensions of energy security concern: (1) resource adequacy, and the balancing of energy supply with energy demand, such as in the power sector to meet demand growth (as this chapter has described, with rapid demand growth from the IT industry, blackouts can still be a problem despite somewhat improved adequacy margins)[60]; (2) traditional energy import security concerns, such as the reliability of one's suppliers abroad (mitigation of this risk generally involved diversification of global suppliers to avoid potential disruptions, and Taiwan has done well on this account over the past few decades, including through new liquefied natural gas [LNG] imports from the United States); and (3) special existential concerns, which add a whole new layer to Taiwan's other, more typical energy security problems (this has implications for electric grid robustness needs, resiliency planning

and investment, distributed generation, contingency of operations or even planned rationing and selective service degradation under duress, hardening of supply lines, and energy storage capacity across fuels—according to Taiwan's Ministry of Economic Affairs' Bureau of Energy, while Taiwan maintains a roughly 130-day supply of oil and 40-day supply of coal, it mandates only an 8-day supply of natural gas).[61]

Taiwan is now making concerted efforts across each of these dimensions of its energy needs. But its policy has also been contradictory in places. For example, on the one hand, the current government has pledged to phase out both nuclear power and coal and to replace them with renewables and natural gas generation, while also aiming to reach net-zero carbon dioxide emissions by 2050. On the other hand, the government has failed to meet its renewables targets, and has been hamstrung even in its efforts to improve its LNG import infrastructure. Meanwhile, Taiwan's semiconductor industry is already consuming vast amounts of electricity, and consumption is set to rise dramatically over the next decade. The development of greater energy reserves, new electricity generation capacity, and greater grid resiliency is both an economic and security imperative. The choice to phase out nuclear power, for example, may have to be revisited (as it was in California), given evolving energy system dynamics.

Moreover, that challenge takes place against the injustice of Taiwan's isolation from what has elsewhere become an increasingly international energy and climate discussion. Taiwan lacks International Energy Agency (IEA) membership, which means that it is not well represented in international energy and emissions statistical sharing or policy modeling, and it has no United Nations Framework Convention on Climate Change (UNFCCC) membership, which means that it does not participate in global climate gatherings such as 2022's UNFCCC Conference of the Parties (COP 27). This exclusion points to great potential for increased bilateral as well as civil and academic US-Taiwan, Japan-Taiwan, or Australia-Taiwan cooperation on energy issues.

Climate, resource adequacy, and broader electric grid security issues are a fertile area for US-Taiwan technical collaboration in improving supply chain resiliency. The US Department of Energy and US national

labs should increase their energy statistical and technical collaborations with Taiwan. Climate and energy also constitute a good area for subnational collaboration, for example with California, which already pursues such policy and technical memoranda of understanding with China; it should do so with Taiwan as well, given its jurisdictional freedoms for international collaboration in this sector.

Smoothing US-Taiwan Economic Frictions

Taiwan's government has made significant overtures to opening its domestic market to US exports; Taiwan is the sixth-largest US agricultural product export market, for example, with consumption levels of US agricultural products such as beef among the highest per capita globally. And Taiwan is a major US LNG export market. Overall, only Mexico and Canada have higher overall per capita trade relationships with the United States.

And as this and other chapters have discussed, Taiwan's firms have also made significant investments in the United States, including in different parts of the semiconductor supply chain.

But more can be done—specifically, to borrow the words of Taiwanese economic affairs minister Wang Mei-hua, the timely conclusion of a "real free-trade agreement" with Taiwan, something the island has sought for more than a decade.[62] Indeed, the Tsai administration has already spent considerable political capital reversing a ban on, and then campaigning against and winning a referendum on, the importation of US pork containing the feed additive ractopamine. That issue had been a long-running source of contention in the US-Taiwan economic relationship; Tsai's ability to face it down and resolve it is a strong indicator not just that her government is a willing partner in US economic initiatives, including semiconductor supply chain management, but also that the Taiwanese people perceive the broader security and stability benefits to Taiwan of deeper business and people-to-people ties with the United States.

Securing Taiwanese government and business cooperation on critical-technology supply chain management—a key US goal—is influenced by the political goals of the administration in power. Taiwan is, after

all, a vibrant democracy. The KMT's previous approach, exemplified by the many cross-strait agreements signed by the Ma administration in the early 2010s, had been to seek economic prosperity by going to the world through China. This approach has now clearly become obsolete. Tsai's DPP has instead favored an alternative of economic agreements with other, friendly countries in the region to gradually rebalance Taiwan's economy away from the PRC. This strategy now looks increasingly appealing, and even urgent, to many Taiwanese. And with Taipei facing an implacably hostile regime in Beijing that has repeatedly sought to use economic leverage for political ends in the cross-strait relationship, President Tsai has signaled that she is eager to strike economic agreements with friendly countries that exclude the PRC. In the revived regional Comprehensive and Progressive Agreement for Trans-Pacific Partnership (CPTPP) trade mechanism, to which neither the United States nor China is a party (but to which Beijing has applied for membership), Beijing is nonetheless likely able to use its influence over some of that group's members to block Taiwan's accession. It will also be hard for Taiwan to negotiate trade deals with other countries that fear Beijing's reaction.

Thus, Taiwan's government, for the time being, will have to focus on bilateral partnerships, particularly with the United States. It is important that Tsai's counterparts in the United States also recognize, as she does, that free-trade negotiations are not just about lowering tariffs. They are strategic, and they are a deterrent to conflict. This should be evident in a US administration whose leader has at least four times offered his "commitment" to militarily defend the island from invasion. Why not a trade deal first? As of the spring of 2023, reports are that the US Trade Representative has concluded approximately one-third of the articles that would be necessary to complete such an agreement and is actively pursuing the rest. But it needs to move even faster.

In the meantime, the US Treasury can take a straightforward step that would remove another source of economic friction that will become more important as the items outlined here—including the success of TSMC's fab investments in Arizona—are pursued. Under current US law, Taiwanese nationals working in the United States—at TSMC's

new plant or elsewhere—are going to face double income taxation, because Taiwan and the United States do not have a bilateral tax treaty.[63] Resolving this issue requires the United States to conclude an agreement with Taiwan, a jurisdiction that it does not recognize as a sovereign state. An agreement on taxation would require overcoming that diplomatic hurdle, and risk condemnation from the PRC, but it would improve one of the cost considerations for TSMC, GlobalWafers, MediaTek, and other Taiwanese semiconductor firms for doing more business in the United States. (The United States does have such an agreement with another likely CHIPS and Science Act beneficiary, Korea, and thirty-six other jurisdictions globally, including the Vatican.) The US Congress has offered bipartisan signals in support of the Biden administration taking such steps, including a July 2022 resolution by Senators Ben Sasse (R-NE) and Chris Van Hollen (D-MD) that stressed Taiwan's role as a crucial defense ally and key part of the global technology supply chain.[64] It encouraged the president to begin negotiations on an income tax agreement with Taiwan and encouraged further increased trade, technology, and investment ties with Taiwan.

Defense Industry Cooperation

While a treatment of US-Taiwan defense strategy and coordination is beyond the scope of this chapter, we generally endorse the writings elsewhere on the need for a "porcupine" strategy of both deterrence by denial and deterrence by resilience involving "a large number of small things" and the need for more concrete US-Taiwan cooperation on defense planning and large-scale training.[65] One specific defense opportunity does, however, relate more directly to Taiwan's electronics and advanced manufacturing sectors.

The war in Ukraine has exposed the fragility and limited capacity of the US defense industrial base. The invasion has contributed to multiyear backlogs in the delivery of US weapons systems to Taiwan that would materially improve its deterrence posture. At the same time, Taiwan's capabilities in precision manufacturing, electronics, and defense-grade semiconductors make it—if given a green light—a promising contributor to the manufacture of key weapons systems

and munitions for both its own defense and even for export. This is a concept that has been endorsed by both the Taiwanese and US defense industries, and at least tacitly by the Taiwanese government. It is also important for US interlocutors to appreciate that, just as in the United States, Taiwanese leaders face political considerations in their defense budgeting systems, something that has led to some seemingly nonsensical domestic weapons program outcomes. It would be better to channel that political need into the most productive possible domestic weapons programs and, in doing so, help sustain Taiwanese public support for the recent substantial increases in defense spending—up to 2.1 percent of gross domestic product (GDP) in 2022, and likely heading higher.[66]

The best way to achieve that coproduction is not necessarily for members of Congress or prominent individuals to further debate the pros and cons of specific weapons. Rather, we need a process. The US government could materially improve regional deterrence by partnering with Taiwan's manufacturing firms to rapidly scale up local production of a large number of mobile, distributed, resilient weapons. Because these efforts will necessarily include the authorization of IP transfer and other use provisions of the US International Traffic in Arms Regulations (ITAR), bureaucratic inertia is the main enemy. To that end, the Biden administration should sponsor a joint industry task force of Taiwanese and US defense firms charged with identifying opportunities—and then working together to remove interagency barriers—for coproduction, followed by codevelopment, and possible later indigenization of US weapons systems within Taiwan, at scale. Doing so would most closely align the Taiwanese people's will to deter—and, if needed, win—a war with their own ability to deliver.

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The PRC threat to Taiwan is becoming more acute, and the challenge of deterring a PRC invasion is becoming more difficult. The existential nature of the threat to Taiwan's autonomy and security will continue to grow and must be addressed on an urgent basis. But the Taiwanese

people are impressively resilient. They possess a vibrant democracy, and they are served by talented and dedicated individuals across the political spectrum, in both the private and public sectors. At the same time, Taiwan is increasingly isolated from the broader international community. Reversing this trend is critical to deterring the PRC from using force, and this requires both symbolic and substantive assistance on the part of the United States and other countries.

Taiwan's leaders are thoughtfully threading their way through a treacherous geopolitical situation. In fact, as this chapter argues, we can learn from their experiences in doing this. They now grasp the seriousness of the challenge Taiwan confronts, and they are trying to move the public toward a more robust and resilient response. What Taiwan most needs from the United States is a clear demonstration of commitment, independent of the rhetorical debate over strategic clarity or ambiguity. Other governments and opinion leaders in the region would likely appreciate this as well. And through semiconductors, the United States has an opportunity to demonstrate aspects of this commitment through the variety of deeper bilateral government, business, academic, and people-to-people interactions outlined here—while not formally announcing a shift to "strategic clarity." Words are important, but actions will speak louder than words.

NOTES

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A report of the Working Group on
Semiconductors and the Security of the
United States and Taiwan, a joint project of
the Hoover Institution and the Asia Society
Center on U.S.-China Relations