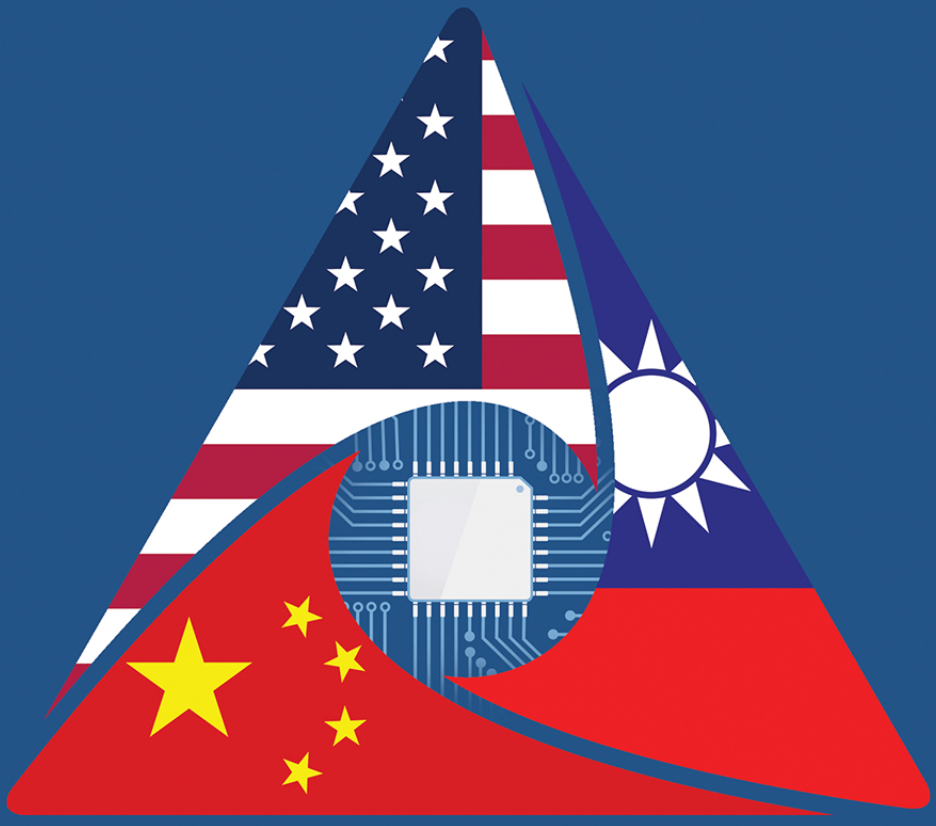

Silicon Triangle

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

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

INTRODUCTION

Washington, Taipei, and Beijing—The Silicon Triangle

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This report is the result of an eighteen-month study of the triangular relationship among the United States, China, and Taiwan as seen through the lens of the rapidly evolving and increasingly strategic global trade in semiconductors. Our Working Group on Semiconductors and the Security of the United States and Taiwan, convened by the Hoover Institution and Asia Society's Center on US-China Relations, and led by Hoover fellows Larry Diamond and Adm. James Ellis (USN, Ret.) and Asia Society's Orville Schell, drew together economists, military strategists, industry players, and regional policy experts to assess how best to enhance the economic and military security of both the United States and Taiwan, while minimizing supply chain disruptions as much as possible.

This multidisciplinary working group held numerous roundtables, dialogues, and scenario-planning exercises to track and analyze this confluence of colliding interests. The working group sought a balanced view of how US and partner policies on semiconductors can increase the resilience of semiconductor supply chains and contribute to deterrence of conflict in the Taiwan Strait.

Over the course of our study, the stakes have only increased. Both US industry and government are acting to strengthen the country's capabilities in semiconductor manufacturing and, working with partners, to reshape the global chip trade. China, meanwhile, is also focused on advancing its own domestic capabilities across the full semiconductor supply chain, both to relieve its dependence on US and other imports

and to strengthen and expand its role as a global supplier of essential semiconductors, including older legacy chips.

Taiwan excels especially at the leading edge of semiconductor manufacturing. Taiwan Semiconductor Manufacturing Company (TSMC) alone makes more than 90 percent of the world's supply of such chips and is now opening a fabrication ("fab") facility in Arizona. At the facility's December 2022 "tool-in" ceremony, TSMC founder and chairman Morris Chang described the moment as "the end of the beginning." The reference was not only to TSMC's bold move to construct its first semiconductor fab in the United States, but also to the rapidly shifting geopolitical contours of the global semiconductor supply chain.

It is also not lost on us that Chang's choice of words to describe a commercial construction project evoked those of a wartime Winston Churchill reflecting on Britain's 1942 victories in North Africa. The intersection of commerce and national security is an uneasy one, but the policy questions this intersection poses have become increasingly central on agendas in Washington, DC, and they will not resolve themselves anytime soon. One of those questions is how the United States can work with trusted partners to make the global chip supply chain and the economy it undergirds more robust and resilient, while at the same time acting to protect Taiwan, both as a crucial source of leading-edge semiconductors and as a flourishing democracy.

The Silicon Triangle

In the summer of 2022, when Speaker of the US House of Representatives Nancy Pelosi visited Taipei, Beijing retaliated by launching an unprecedented fusillade of six live-fire exercises and naval and air deployments in Taiwan's surrounding waters. Pelosi rejected China's claim that her visit was an unwarranted provocation. Instead she insisted she was simply making "an unequivocal statement that America stands with Taiwan, our democratic partner, as it defends herself and its freedom."[1] And she told Taiwan's president, Tsai Ing-wen, her visit was designed "to make unequivocally clear that we will not abandon Taiwan."[2]

What Pelosi did not explicitly mention, however, was how important Taiwan's semiconductor industry has become to the United States and to other countries, feeding a global industry valued at more than $500 billion annually.[3] Whether in kitchens, cars, offices, transportation systems, communication networks, or complex military capabilities, almost anything powered by electricity now increasingly depends on microchips. The Semiconductor Industry Association reports that global semiconductor sales in 2021 were $556 billion, a record high, and that sales in China were $193 billion, a 27 percent increase over the previous year. As a result, China is now the world's largest consumer of semiconductors, many of which find their way into products for global export. Others also become critical components in weapons systems deployed by China's rapidly expanding military.

As with the rest of the world, the United States has become deeply dependent on foreign production processes to fabricate these chips. The United States once led the world in both the design and fabrication of microchips, producing 37 percent of the global supply in 1999. Now, however, while most leading-edge logic chips, such as those featuring lithography smaller than 16nm, are still designed in the United States, the percentage of chips actually fabricated in the United States has slid to 12 percent.[4]

In fact, no country now has a completely autonomous chip supply chain. Instead, each national production cycle now involves an extremely complex, multinational collaboration. Software tools and design are largely done in the United States. Extremely sophisticated manufacturing tools, such as lithography machines, are mainly produced in the United States, the Netherlands, and Japan. Manufacturing and packaging are centered in Taiwan and Korea. Testing is largely done in China and Southeast Asia, and the assembly of finished devices is predominantly centered in China, along with some recent migration to Vietnam and India. One industry executive told our working group that the inputs and components of a typical finished chip may involve hundreds of national border crossings.

With the United States now accounting for only 4 percent of global fabrication of memory chips, it is highly dependent on other nations

such as South Korea, home to Samsung and SK hynix.[5] Meanwhile, Taiwan's ultramodern and well-run foundry system has enabled the island to produce more than 90 percent of the world's leading-edge logic chips and more than 20 percent of its legacy chips,[6] which together contribute almost 40 percent of the world's added increment of computing power each year.[7]

China's leaders have, over the past two decades, increasingly pursued greater self-sufficiency in key technologies including semiconductors. The Indigenous Innovation initiative of 2005 eventually led to the "Made in China 2025 Green Paper on Technological Innovation in Key Areas: Technology Roadmap," which came out in 2015 and was updated two years later. It highlights the urgency of supporting "national champion" firms to help China secure the technologies it needs at home and to compete more robustly abroad.[8]

The year before, the Chinese government's National Integrated Circuit Plan called on China's domestic semiconductor industry to expand capacity, so China could onshore 70 percent of its semiconductor needs by 2025 and reach design and production parity with foreign chip companies by 2030.[9] A report issued by the US Trade Representative (USTR) described the strategy as "creating a closed loop semiconductor manufacturing ecosystem with self-sufficiency at every stage of the manufacturing process—from integrated circuit (IC) design and manufacturing to packaging and testing, and the production of related materials and equipment."[10]

Ever since, President and Chinese Communist Party (CCP) General Secretary Xi Jinping has urged Chinese researchers, state enterprises, and private entrepreneurs to strive for greater chip independence, as part of his goal of "rejuvenating" China.[11] "We must take the technology lifeline in our own hands," he declared in June of 2022 while visiting a Wuhan semiconductor plant.[12]

To attain this goal, Xi's government has made an estimated $180 billion[13] available to People's Republic of China (PRC) companies, including Semiconductor Manufacturing International Corp. (SMIC), Yangtze Memory Technologies Co. (YMTC), and Huawei's HiSilicon. Fifty billion dollars came through China's National Integrated Circuit

Industry Investment Fund,[14] which became known as the "Big Fund" after its launch in 2014.[15] Success was mixed. Tens of billions of dollars flowed through the ill-fated Tsinghua Unigroup, which went heavily into debt and faced bankruptcy.[16] Other high-profile fund-backed startups landed their executives in jail for corruption.[17] Yet, tens of thousands of domestic semiconductor firms have been created across every step of the supply chain. Despite such efforts, some industry analysts predict that China will remain dependent on foreign firms for more than half of its semiconductor supply until at least 2026. Indeed, China must import hundreds of billions of dollars' worth of chips each year, with it spending twice as much on semiconductors as it spent importing oil in 2020.[18]

Meanwhile, Taiwan firms TSMC and United Microelectronics Corporation (UMC), along with South Korea's Samsung, continue to dominate the fab sector, with TSMC the clear global leader in making the most-advanced chips.[19] As of 2022, TSMC alone accounted for 54 percent of the global contract-foundry market, in which chips are produced to meet client designs,[20] with record revenues of $76 billion, up 42.6 percent from the previous year.[21]

The irony is that both the United States and China have long depended on Taiwan's semiconductor fabrication capabilities. Even in an era of increased US-China tensions, they remain each other's biggest customers, as well as their biggest competitors and threats.[22]

Many iconic US brands are still deeply dependent on China's domestic market and businesses for parts and labor. For example, because of China's superior supply lines and low costs, Apple continues to embrace complex manufacturing and assembly in China, with its iPhones and iPads mainly assembled in massive factories in mainland China—although by Taiwan companies such as Foxconn and Pegatron and powered by TSMC's chips from Taiwan. Some 90 percent of iPhones, iPads, and Macs are made in China, with China-based component suppliers now outnumbering those from Taiwan.[23]

While it is true that Apple has started to diversify, opening factories in India and Vietnam, a full disengagement from China's efficient supply chains, should one be sought, will take a long time.

The End of the Beginning

As China has ramped up military operations in disputed maritime areas over which it claims sovereignty, officials in the Obama, Trump, and Biden administrations have all focused on how to preserve stability in the Indo-Pacific. They have also pondered how they might begin to economically disentangle the United States from China, to reduce China's geopolitical leverage over the United States in a potential conflict scenario, and to mitigate economic damages should a conflict occur.

In August 2022, President Biden signed the game-changing bipartisan CHIPS and Science Act of 2022, pumping $52.7 billion into the US semiconductor industry to encourage the construction of new fabs and to support research and development within the United States.[24] At the time, Intel's CEO Patrick Gelsinger, whose firm stood to benefit handsomely from the bill's subsidies, proclaimed the legislation "the most important piece of industrial policy since the Second World War."[25]

Building on that momentum, TSMC announced in December 2022 that in addition to its semiconductor "Fab 21," which it was already building in Arizona to begin production of 4–5nm chips in 2024, it would start construction on a second fab, scheduled to begin production of leading-edge 3nm chips in 2026. TSMC said its overall investment in these two fabs would be about $40 billion, one of the largest foreign direct investments in US history. To mark the importance of this investment, President Biden flew to Phoenix for the fab's tool-in ceremony.[26]

In other efforts to build semiconductor capacity within the United States, thirty-five private companies have announced plans to invest another $200 billion in US-based chip research and manufacturing facilities.[27] And more than twenty other corporate[28] commitments have been made to locate new chip facilities across sixteen US states.[29]

Meanwhile, the Biden administration has moved to limit the sale of key US chip technologies to China, particularly for chips that could be useful for military purposes. These export controls both restrict the ability of China's chip manufacturers to use US chipmaking equipment in their most-advanced fabs and make it difficult for China's fabless

chip designers to have their most advanced products made at TSMC in Taiwan.[30] (A "fabless" company is one that designs its own microchips but, rather than owning its own factory, contracts out their production.)

Then, in December 2022, the US Department of Commerce put an additional thirty-six China-based semiconductor companies on its "Entity List." Those on this list are required to apply for special licenses to buy US-made technologies. Commerce has also applied the more stringent "foreign direct product rule" to twenty-one other entities in China, prohibiting even third parties, such as companies in other countries, from exporting US physical or intellectual property to China. Against this background, Apple quietly shelved plans to buy memory chips from Yangtze Memory Technologies Co.,[31] causing Beijing to protest that the United States was attempting to impose a "technological blockade" on China.[32]

The win-win promise of globalization—which encouraged governments to embrace cross-national supply chains that provide quality, low prices, and fast delivery without fully considering possible geopolitical risks—is now ending. So too is the US policy of "engagement," which had assumed that if China and the United States embraced each other through more trade, civil society interactions, and scientific and cultural exchanges, China would eventually become more open so that political differences become less disturbing. Engagement and globalization were win-win visions that promised a peaceful pathway forward, not only for the United States and China, but also for Taiwan and the world. But as the advent of "Xi Jinping Thought on Socialism with Chinese Characteristics for a New Era"[33] ushered in a far more antagonistic relationship with the United States and its allies, those pathways were foreclosed.

In his speeches and writings, Xi often describes a vision of a peaceful and harmonious world. However, it's one in which China is at the center and strategically positions itself by creating political leverage through trade, investments, and diplomacy. And it includes such efforts as Xi's very personalized global Belt and Road Initiative that has seen China give almost $1 trillion in loans to build infrastructure, but also

promote China's technologies, engineering, and excess commodities, as well as its preferred rules and standards.

All this is part of President Xi Jinping's grandiose effort to attain what he has called the "China Dream," not only to make China prosperous at home and powerful throughout the world, but also to compel Taiwan to become a legal, internationally recognized part of the People's Republic of China, under the direct control of the Chinese Communist Party. In attempting to make such a forced marriage more palatable to Taiwanese, China's leaders have, over the years, floated the idea that the island could enjoy a "One Country, Two Systems" deal, like the one Hong Kong was granted when it reverted from UK to Chinese control in 1997. However, after the PRC's recent crackdown on free speech and assembly in Hong Kong, few Taiwanese now have much confidence in such a formula.

With China now facing a slowing economy and a contracting workforce and population, Xi may see a finite and closing window in which to achieve the goal of bringing Taiwan into "the embrace of the motherland" before the PRC's hundredth anniversary in 2049.

Speculation has increased about whether and under what circumstances Xi would order China's military to enforce China's claim over Taiwan. The global blowback would be fierce. But Xi has said that "no one should underestimate the Chinese people's staunch determination, firm will, and strong ability to defend national sovereignty and territorial integrity" because "the historical task of the complete reunification of the motherland must be fulfilled, and will definitely be fulfilled."[34]

The Taiwanese people are hardly receptive to such a future. An overwhelming majority of them prefer a maintenance of the status quo that allows Taiwan to remain a self-governing, robust democracy that enthusiastically embraces freedom of speech and assembly. Should the People's Liberation Army move against Taiwan, they will confront an enormous challenge when they try to put boots on the ground, and a far greater challenge to ever win the hearts, minds, and allegiance of the Taiwanese people.

The United States and China are at inflection points where the policy verities of the past—such as "engagement," "win-win," and "peaceful

evolution"—no longer satisfy. As Morris Chang bluntly observed in his tool-in speech at TSMC's new Arizona plant, "Globalization is *almost* dead and free trade is *almost* dead."[35] The question is, What will replace them?

Uneasy Questions

How can the United States and its global partners manage the increasingly tense and consequential triangular US-China-Taiwan relationship, in which global supply chains and a vibrant democracy hang in the balance and military conflict is an increasingly real possibility?

As part of our working group's assessment of this question, we embarked on a multimonth strategic scenario-planning exercise that tested assumptions and provoked robust discussion about the implications of plausible futures, each playing out over a ten-year period. To create four distinctly different futures, we considered different combinations of two variables: whether global trade would remain open or become balkanized, and whether global leadership in critical technologies would come from China or from the United States and its allies.

Scenario planning helps participants understand the risks, opportunities, and other implications of different kinds of futures, while recognizing that actual events may play out in ways that move from one scenario to another, or bring in elements of several. The purpose is to actively think early on in that evolution about strategies that improve the odds of protecting one's interests and achieving one's goals. In this case, our working group considered America's interests in the US-Taiwan-China "Silicon Triangle."

Thus far, we are seeing coalescence of a world in which goods, technologies, intellectual property (IP), services, people, and capital are increasingly flowing *within* voluntary networks of like-minded nations—and less so *across* the two gathering US/China blocs. A key question we considered is: How can the United States and its like-minded partners take advantage of this shift from the "flat," rapidly globalizing world of the 1990s to one in which economic relationships are increasingly informed by strategic interests?

Our scenario work suggests that the relative attractiveness of each network—and therefore its broader economic performance, growth, and prosperity—will be shaped by the strength and sophistication of its systems and technologies, particularly of emerging critical technologies like semiconductors. The separation between commercial and security considerations is becoming murkier.

But many questions remained. For example, do Taiwan's fabs provide a "silicon shield" that makes it less likely China will attack the island? Or do they make an attack more likely because the PRC may believe that if it can take control of them, not only will China benefit from Taiwan's technical prowess, but at the same time this resource will be denied to the West? Our working group's participants did not generally accept that Taiwan's chip industry provides a meaningful "silicon shield" for Taiwan. Instead, our sense is that in assessing the risks and possible costs of an invasion, China's leaders will make their own calculations, based on goals and leadership imperatives that will go far beyond semiconductors.

As US-China trade continues, Treasury Secretary Janet Yellen stated in April 2023 that the United States seeks a "constructive and fair economic relationship with China" and that China's economic growth "need not be incompatible with US economic leadership." Nonetheless, the Biden administration has also launched policies and initiatives "to ensure that emerging technologies work for, not against, our democracies and security," as National Security Advisor Jake Sullivan said in prepared remarks at a White House briefing in September 2022.[36]

The US government has, for security reasons, already restricted the ability of US or partner firms to supply technologies to China's Huawei and ZTE given their use in establishing 5G telecom systems around the world. So, a question for our working group was: Should Washington for security reasons ban the sale of US design and manufacturing technologies that would enable China's semiconductor firms to supply its military or to displace Western firms by establishing significant global market shares?

There was disagreement on this. Many industry executives from the United States and Taiwan, as well as those in Japan, Korea, and Europe,

argue that it makes good sense to continue selling technologies and manufacturing equipment for older legacy chips (in the higher nanometer range), and to block only leading-edge chips (in the lower nanometer range). Many others insist that Washington should thwart the development of China's entire chip industry lest we feed a critical, enabling industry in a country with whom conflict is no longer unthinkable.

And, already, there is some movement in the latter direction in Washington. In December 2022, the UK chip group Arm, owned by Japan's Softbank, denied China's Alibaba use of its Neoverse V-series chip because its high performance capacity was developed by the United States.[37] And when US National Security Advisor Jake Sullivan addressed the question of export controls in a late 2022 speech, he said, "We have to revisit the long-standing premise of maintaining 'relative' advantages over competitors in certain key technologies. We previously maintained a 'sliding scale' approach that said we need to stay only a couple of generations ahead. That is not the strategic environment we are in today. Given the foundational nature of certain technologies, such as advanced-logic and memory chips, we must maintain as large of a lead as possible."[38]

Financial Times columnist Edward Luce commented in October 2022 that it was beginning to seem as if "America was now pledged to do everything short of fighting an actual war to stop China's rise."[39] A few months later, in January 2023, he wrote: "The uncertainty is no longer about whether the US-China decoupling will happen, but how far it will go. Whatever its pace over the present year, the US-China relationship is heading in an ominous direction. Businesses, countries, regions and the world are only just starting to grapple with the potential consequences."[40]

Unless China, the United States, and Taiwan find some significant new accommodation, the trend lines do not look good—either for maintaining existing microchip supply chains or for generating enough self-sufficiency for any party to stand alone.

So, given this contradiction, what is to be done? If maintaining the current global microchip ecosystem is uncertain or impossible, governments and companies alike must formulate consistent and collaborative

new rules to guide them in realigning a new global industry supply chain order. Most would, of course, prefer to maintain, or perhaps modify, the current system rather than see it completely dismantled, whether by design or by conflict. But sustaining this status quo appears increasingly out of reach, with radical change already under way. Policy choices, economic subsidies, hedging opportunities, and geopolitical realignments are all a part of the current dialogue, many occurring in an uncoordinated fashion.

The balance between national security and free markets is a matter of sensitivity and judgment, and our working group does not have a unanimous view on this matter. But this shift has profound implications for relations among US partners, and for the task of domestic governance. And these implications have not yet been fully appreciated in semiconductors or in other critical sectors where principles of economic freedom and national security intersect.

Deterrence

There are two lenses through which the United States must look at the broader problem. The first allows us to judge which policies best protect our technological competitiveness and the global supply chain of microchips. The second allows us to judge which policies best protect Taiwan's people, their autonomy, and their liberal democracy from the PRC's ambition to directly govern and control Taiwan. While these two imperatives are not in conflict, they are also not coterminous. The best preemptive policy for attaining both goals is developing an effective deterrence strategy that will discourage and, if necessary, prevent the PRC from taking military action to make China's long-standing claims of sovereignty over Taiwan a physical reality.

The former secretary general of NATO, Anders Fogh Rasmussen, described the strategy this way: "Deterring an attack by China relies on the credible belief that any invasion would come at an immense cost. . . . So spelling out the consequences of an attack in advance can act as a powerful deterrent." And, he added, "To be an effective deterrent, we should give Taiwan the weapons it needs to defend itself now. Xi Jinping

must calculate that the cost of an invasion is simply too high. . . . The best way to preserve peace is to make clear you are ready to go to war."[41]

At stake is not just the world's largest traded industry—and, moreover, Taiwan's democracy.[42] A US-China conflict in the Taiwan Strait would implicate the entire Indo-Pacific, with stakes so high that they are difficult to even imagine. Still, the implications must be considered, debated, and ultimately acted upon.

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Each chapter in this report reflects the richness of experience and expertise brought by a group of interdisciplinary contributors. While their work stands on its own, our collective thinking is informed by group deliberation, argument, and joint education over the past year and a half as we have conferred with various business, security, and policy stakeholders in the United States and in Taiwan.

In chapter 1, former China correspondent Mary Kay Magistad, now with Asia Society's Center on US-China Relations, draws from our scenario-planning exercise to examine four scenarios that may play out over the next decade, and the driving forces that underpin them, which are referenced throughout the rest of the report.

Chapter 2 takes a deep dive into the current structure of the global semiconductor industry, and underlying trends of how the core technologies are progressing. Authors H.-S. Philip Wong and Jim Plummer, Stanford professors of electrical engineering and leading technical experts on semiconductors, describe this industry as extremely dynamic and fast moving, which has implications for what policy can and cannot reasonably expect to accomplish in this space.

Chapter 3, written by international security scholar and former arms control negotiator Christopher Ford, focuses on resilience measures the United States should take, given its current reliance on fragile global semiconductor supply chains. Ford looks at measures that could reduce the cost of doing business, improve supply chain information and analysis capabilities, and provide incentives for stockpiling and/or extended inventory management.

In chapter 4, physicist and risk capital investor Edlyn V. Levine and longtime semiconductor industry leader Don Rosenberg argue that the United States should pursue security- and market-oriented industrial policy measures that are mindful of the interests of US partners. They propose a long-term US global technological competitiveness strategy that also includes building a voluntary network of like-minded nations, with US leadership in critical technologies such as semiconductors attracting participation by other countries and contributing to collective prosperity.

Chapter 5 focuses on the importance of protecting Taiwan's stability, prosperity, and democracy. Taiwan specialist Kharis Templeman and China military scholar Oriana Skylar Mastro describe how Taiwan became a trusted partner in critical supply chains despite its broader political isolation from the international community, and they offer ways in which a shared interest in semiconductors provides a rich platform for further US-Taiwan business-to-business, people-to-people, and policy exchange. They argue that deepening these relationships enhances deterrence toward those who would seek to challenge Taiwan's stability.

In chapter 6, organizational economists and global supply chain experts David J. Teece and Greg Linden explore the relative strengths and ambitions of potential global partners for the United States in the effort to ensure that US imports of semiconductors and key inputs in the supply chain come from reliable, ideologically compatible trading partners, such as the current foreign industry leaders Taiwan, Korea, and Japan, and new entrants such as India.

In chapter 7, Indo-Pacific security scholar and former deputy national security advisor Matthew Pottinger asks what the United States and its allies and partners could achieve together through a strategy that not only seeks mutual economic gains, but also recognizes the potential strategic role of critical-technology supply chains as a tool to deter China's leadership from using force or coercion to achieve its geopolitical goals.

Chapter 8, written by historian and analyst of modern China Glenn Tiffert, looks at China's historic efforts to build its semiconductor

sector, and its progress to date. He examines why China remains in a relatively weak position as a semiconductor manufacturer, despite significant efforts to emerge as a global leader in this sector.

In chapter 9, US-China policy experts Robert Daly and Matthew Turpin examine how anticompetitive behavior by semiconductor firms in China could unfairly harm those of the United States or its partners—for example, in the production of legacy chips. The authors point to ways to mitigate the risk of new dependencies on China-based chip supply chains, and thus avoid compromising future US strategic autonomy.

The concluding chapter presents our policy recommendations in five areas: US domestic resilience, the US business environment, long-term US technological competitiveness, Taiwan's stability, and dealing with China. Generally, these policy recommendations derive from the preceding chapters, which were drafted by the individual authors in consideration of our collective deliberations. But the recommendations have been extensively discussed and debated by the members of the working group, and unless otherwise noted, they represent the broad consensus of the group. As the project leaders and editors of this report, we have acted as the final arbiters and synthesizers of these recommendations.

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