



# Silicon Triangle

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

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## CHAPTER FOUR

# A Long-Term Competitiveness Strategy for US Domestic Semiconductor Technology

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The United States has an overriding national interest not just in maintaining a secure semiconductor supply chain, but also in pursuing leading capabilities, including in design, software tools, manufacturing equipment, materials, manufacturing, and advanced packaging—as well as the advanced products in which chips are used.

The long-term economic dynamism of the United States, its global technological leadership, and its military deterrence capability require both pushing forward semiconductor—and other critical-technology—frontiers and translating those technology breakthroughs into commercial success. US success across both realms will also accrue to its global trade and technology partners, and benefit the broader human condition.

This chapter details the steps that the US government and its partners can take to foster overall technological progress on semiconductors and the ability of the United States to benefit from those inventions.

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*The best way to predict the future is to invent it.*

—ALAN KAY

Technology is now the primary battleground of modern superpower competition. The ability of one nation to impose its will on another has expanded to include a nation's ability to wield technological assets,

control access to high-tech supply chains, and develop novel innovations that drive economic growth and impact geopolitics.

In the twentieth century, a rich ecosystem for innovation was founded in the United States on the principle of translating fundamental scientific breakthroughs into solutions to engineering problems. Liberal capitalism produced a winning formula that combined scientific research, manufacturing, free enterprise, skilled workforce, and the rule of law (including effective legal protection for intellectual property). The exigencies of twentieth-century wars further catalyzed scientific innovation and demonstrated the importance of a robust research-industrial base. For instance, the manufacturing and research institutions composing the “Arsenal of Democracy” in the United States went head-to-head against the industrial conglomerates of IG Farben and Vereinigten Stahlwerke in Nazi Germany during World War II. The United Kingdom, by contrast, had a strained manufacturing sector and had to export new inventions such as the cavity magnetron (critical to radar) to the United States to exploit their full military potential for the war effort.

By the twenty-first century, this Arsenal of Democracy had faltered. The COVID-19 pandemic exposed a crisis in US science and technology industries: they were unable to provide the necessary surge in personal protection equipment, pharmaceuticals, and respirators.<sup>1</sup> This failure was a consequence of the decades-long erosion of the US industrial base. The commercial entities that supply advanced technologies have long taken advantage of market efficiencies by outsourcing manufacturing to low-cost locations, leading to complex and geographically dispersed supply chains. We see this phenomenon clearly with semiconductors, critical materials, photonics, aerospace, biotechnology, nuclear materials, energy production, energy storage, and more.

The contraction of the US manufacturing sector and dispersal of the US supplier networks are deeply concerning. Not only does the loss of these complementary assets diminish the capability of the US industrial base to provide surge capacity during a crisis, it also subjects the United States to an outright denial of critical technologies by other nations as a means of exerting influence. The most pressing concern resulting from

the dispersal of high-tech manufacturing, however, is the loss of future technology superiority and technology-driven economic growth.

This concern is rooted in the principle that an innovative country's ability to *create* value in the form of new technology does not necessarily translate into that country's ability to *capture* value by scaling those inventions into meaningful, market-competitive products. Capturing value from innovation requires command of the "complementary assets" needed to scale innovations. These assets include capital, advanced manufacturing capabilities, supplier networks, and a highly skilled workforce. Additionally, value creation in certain advanced-technology sectors is possible only through the interplay between experimentation and manufacturing, giving an innovation edge to the countries that maintain robust manufacturing sectors.<sup>2</sup>

Today, no high-tech industry is as strategically important to US technology leadership as is the semiconductor industry. As described in chapter 2, semiconductors are produced using one of the most complex manufacturing processes ever conceived, consisting of thousands of steps to achieve near-atomic-level precision at high production volumes. The complexity of the involved physics, chemistry, and engineering epitomizes the virtuous cycle connecting inventive research to innovative manufacturing; that cycle is imperative for progress in semiconductors.

This chapter evaluates the longer-term policy options available to the United States to secure its strategic autonomy through control of critical technologies such as semiconductors in light of today's complex technological and geopolitical realities. In particular, how can we better capture the value of (i.e., commercialize) emerging technologies to ensure continued US technological superiority and economic competitiveness?

### **Defining a US Policy Objective: Strategic Autonomy via the Control of Critical Technologies**

Technologically and economically derived power shifts occur over decades, and result from progrowth policies applied consistently over

many political cycles to achieve a national purpose. China's rise is the most recent example of long-term coordination between political and industrial sectors to achieve economic and strategic aims consistent with the country's nationalistic objective of global leadership by 2049. In comparison, we have observed how US policy in recent decades has lacked purpose, instead focusing on the near-term political demands of election cycles.

For the United States to ensure that it controls its own destiny on semiconductors over the long term, a drastic pivot is required—away from short-term, reactive politics and toward an intentional, well-defined objective, accompanied by consistent policy measures sustained over a meaningful duration.

This chapter proposes that the objective of US policy over the next twenty-five years needs to be *strategic autonomy*: to protect and defend its sovereignty, liberty, and way of life—and those of its global partners—by means of technological superiority and economic leadership.

The ability of a country to control its destiny depends on its control of critical technologies. Advanced technologies are essential to life-supporting and economy-critical infrastructure (such as energy, food distribution, communications, health care, and life-support systems) and to national security and force projection (such as command and control, communications, surveillance, navigation and timing, advanced conventional weapons systems, electronic warfare, and space systems). Because semiconductors are a core enabling technology in all of these realms, controlling semiconductors is critical to achieving strategic autonomy.

Control of critical technologies implies four things. First, control requires guaranteed access to these technologies under all conditions, whether peace, international crisis, or war. No adversary should be able to impose its political will on the United States by denying or compromising access to a critical technology—either to the product itself or to its supply chain.

Second, control implies the option to deny an adversary access to the technology if that country threatens US or partner interests. Denial of access to US and partner technology, however, has costs for domestic

tech industries—so it should be used sparingly. Importantly, the prospect of denied access must be sufficiently credible and impactful to a country to be a deterrent.

Third, control includes the ability to respond to a surge in demand for a technology in a time of crisis. This ability has implications for the location of manufacturing centers: geographic access to a manufacturing center that is not located domestically or in a partner country can be more easily denied in a time of crisis. Suppliers and skilled labor are also generally colocated with manufacturing centers, and knowledge spillovers are enabled by the technology ecosystems that grow up around manufacturing centers.

Fourth, control means having the ability to lead both the development (value creation) and commercialization (value capture) of future generations of a critical technology. Both are required to realize long-term domestic economic growth and to sustain asymmetric technology leadership. Doing so for semiconductors will require new policies to improve US weaknesses in manufacturing, economies of scale, and intellectual property (IP) that account for the following:

- Manufacturing and research are closely linked for semiconductors. Without research, manufacturing is a path to obsolescence; without manufacturing, research is a bridge to nowhere. Semiconductor technology requires continual research and development for new capabilities to be manufacturable, and continuous feedback from manufacturing to inform and scale research results.
- Economies of scale are critical for commercial success in semiconductors due to the high fixed cost and barriers to entry of advanced manufacturing. Countries that create favorable environments for large, capital-intensive semiconductor companies will more easily capture the value of new inventions due to the increased efficiency introduced by the capability to manufacture at scale.
- Semiconductor manufacturing technology is highly dependent on trade secret protection and may be especially vulnerable to trade secret theft or other IP misappropriation. Today's semiconductor

innovators—whether in the United States, Taiwan, Korea, Japan, or the Netherlands—are operating in a regime of weak appropriability due to actions taken by China and others to coercively or illicitly appropriate technologies invented in other nations.

In consideration of the policies needed to achieve strategic autonomy through the control of critical technologies, we cannot ignore the reality that the next twenty-five years may not be peaceful, but marred by warfare. Russia's invasion of Ukraine and China's repeated threat of military aggression to absorb Taiwan highlight this possibility. A technological advantage and a robust economy with a domestic manufacturing base are essential for any wartime effort. Thus, long-term policies undertaken today should better position the United States for any military conflict that may emerge.

### **Why Is the United States No Longer in a Position of Assured Technology Leadership?**

The policies that should be adopted today should be informed by an understanding of industrial policies of the late twentieth and early twenty-first centuries: if we do not examine the policies responsible for the hollowing out of US semiconductor manufacturing and industry leadership, new efforts may simply perpetuate the policy failures of the past.

Recent US policy making has been dominated by near-termism. Even the novel and relatively ambitious Creating Helpful Incentives to Produce Semiconductors (CHIPS) and Science Act of 2022 is, in many respects, a victim of this malady: it provides tens of billions of dollars in government subsidies over just five years (which may be allocated as much by political motivations as by market-driven forces), as well as some time-bound tax credits—but it still does not address many of the root-cause factors, such as the overarching tax, trade, and regulatory environment that has driven the offshoring of manufacturing over decades. Reflecting the lack of long-term focus, the US Senate passed as part of the Inflation Reduction Act of 2022 (IRA) a punitive 15 percent

tax on US corporations on the same day the CHIPS Act passed both chambers. History teaches that the CHIPS Act will be insufficient and inefficient, and portions of the IRA will be counterproductive to US interests.

Today, the United States accounts for only 12 percent of semiconductor manufacturing and a mere 2 percent of outsourced assembly and testing.<sup>3</sup> These figures represent a drastic decline from its former prominence as the leader of the semiconductor industry across the industry's value chain. During the 1950s and into the 1960s, the inception, growth, and early maturation of the semiconductor industry were solely a US affair. A naïve view toward comparative advantage would conclude that, with such strong domestic capabilities initially, the US semiconductor industry would remain dominant as a point of equilibrium. This view, however, neglects the fact that nation-scale industrial policies shape global markets: other countries, realizing the strategic importance of the semiconductor industry, adopted aggressive policies to shift the global distribution of the industry in their favor. The consequent loss of the US semiconductor manufacturing base, then, was a combined result of US policy failures and others' policy successes, including in Japan, Taiwan, South Korea, and China.

The free-market landscape in which multinational companies operate is actively shaped by the actions and policies of governments around the world. China's emerging strengths in today's market are particularly concerning in this light due to China's immense scale, key role in semiconductor-dependent global value chains, and market-distorting policies.

Companies evaluate and select new manufacturing sites primarily based on the availability of infrastructure (spanning power, water sources, and telecommunications), tax policies and incentives, regulatory hurdles and permitting timelines, proximity to customers, presence of adjacent industries, local workforce, and access to distribution channels.<sup>4</sup> Additional factors—access to capital (including debt financing and foreign investment), antitrust regulation, IP protection, and the impact of restrictive measures such as export controls, tariffs,



sanctions, and visa limitations—have become increasingly important. These factors offer a rubric for policy makers as they seek to create environments favorable for manufacturers.

The reality today, however, is that the manufacture and packaging of semiconductors in the United States is economically noncompetitive—largely because US policy makers have inadvertently made the country unprofitable for such capital-intensive manufacturing. As a semiconductor industry executive stated:

I'd love to make this product in America. But I'm afraid I won't be able to. . . . Wages have nothing to do with it. The total wage burden in a fab is 10 percent. When I move a fab to Asia, I might lose 10 percent of my product just in theft. . . . [The problem is] everything else. Taxes, infrastructure, workforce training, permits, health care. The last company that proposed a fab on Long Island went to Taiwan because they were told that in a drought their water supply would be in the queue after the golf courses.<sup>5</sup>

In short, the industrial policies of both competitor and partner nations in Asia, as well as US policy failings, have hollowed out the semiconductor manufacturing environment in the United States.

### **Policies to Achieve US Strategic Autonomy through Semiconductor Leadership**

Given the above, we believe that US long-term semiconductor policy should include the following components:

- *Enhancing value capture* and commercialization of research through scaling innovation alongside the incubation of complementary domestic manufacturing activity
- *Strengthening national and economic security* by decreasing dependence on unreliable competitor nations and by diversifying geographic risk

- *Amplifying value creation* through investment in US research capacity for breakthrough technologies, which for semiconductors is strongly coupled to advanced manufacturing
- *Strengthening the global appropriability regime* by countering China's systematic theft of US and partner nation technologies

The core tenet of consistent policies across manufacturing, research, and appropriability is to ensure that the United States (together with its partners) leads in both value creation and value capture.<sup>6</sup> Success here over the next quarter century should be measured in terms of an increase in US semiconductor global market share in manufacturing and in assembly and testing; sustained market positions in design and manufacturing equipment; and the number of investments made in the United States in cooperation with partner-nation firms.

## 1. Policies to Enhance Value Capture

Capturing the value of new technologies is important for economic growth. The commercialization of new technologies leads to more domestic companies, domestic supplier and consumer networks, domestic jobs, and overall GDP growth. The United States has historically benefited from its ability to capture the value of its innovations: personal computers, cellular networks and devices, and social networks led to the creation of some of the world's largest and most valuable companies.

Recent US technology policy has focused almost exclusively, albeit parsimoniously, on value creation through research and development (R&D) funding. The resources and environment needed for breakthrough inventions, however, are very different from those needed to capture the market value of those breakthroughs—and a lack of policy focus has led to an atrophy of US ability to capture the value of new inventions.

Unsurprisingly, many US inventors lament that, although they were the first to invent a new technology, a competitor or imitator—for example, from China—has captured all of the profit. The photovoltaics

industry and lithium-ion battery industry are two prominent examples of value capture by China; during the Eisenhower era, color TVs were an example of value capture by Japan. Andy Grove—the third employee and ultimately third CEO of Intel—aptly stated that to capture value, a new technology or tech industry “needs an effective ecosystem in which technology knowhow accumulates, experience builds on experience, and close relationships develop between supplier and customer.”<sup>7</sup>

Creating these ecosystems should be the objective of policies focused on value capture. Value capture primarily depends on two factors: one, the ability to access the complimentary assets required to scale a new innovation, and two, the strength of the appropriability regime needed to protect the innovation.

Today, the semiconductor industry operates in a weak global appropriability regime, largely due to the actions of China and other countries to obtain strategic technologies. Although the United States has an imperative to counter the actions of China and other countries and strengthen appropriability as discussed below, the greatest opportunities to enhance US value capture from innovation—whether pioneered in the United States or elsewhere—come through augmenting domestic complementary assets.

Complementary assets for the semiconductor industry include advanced prototyping facilities, highly complex manufacturing facilities, packaging facilities, production and metrology equipment, digital design tools, access to electronics-grade materials, and downstream systems integrators. Without the domestic presence of these complimentary assets, US firms looking to scale production and capture the value of new innovations will increasingly be drawn abroad.<sup>8</sup> To tip the scale of value capture in favor of the United States, domestic policies favorable toward capital-intensive semiconductor manufacturing, packaging, equipment production, and materials processing are needed.

Several policy options exist to increase value capture through the augmentation of domestic complementary assets like manufacturing. These include taxes, regulation, antitrust, subsidization, immigration,

and industrial commons. IP rights, which are also vitally important, are discussed in a subsequent section on global appropriability.

### *Taxes*

Far from being globally competitive, the existing US tax code is structurally biased against capital-intensive businesses, especially manufacturers. The current tax code requires companies to spread deductions for capital investments over multiple years. For example, the capital expenditures associated with building a semiconductor foundry—which run in the billions—cannot be immediately deducted from taxable income, but instead must be spread over a thirty-nine-year period.<sup>9</sup> The reduction in the real value of deferred deductions over this time due to inflation and the time value of money causes an overstatement of taxable income for the manufacturer. The result is a tax bias in favor of service firms with high labor costs and low capital expenditures, and a tax penalty for firms requiring high capital expenditures and low labor costs. To that end, we recommend the following:

- US policy makers should eliminate the tax penalty against capital-intensive industries like semiconductor fabrication by allowing firms to deduct 100 percent of their capital expenditures in the first year of purchase.

Multinational semiconductor companies assess potential site locations for fabrication and packaging facilities based on national and local taxes. Foreign governments, including China, Vietnam, and Thailand, have offered generous income tax credits and even tax holidays to attract the high-capital-expenditure manufacturing projects of global semiconductor firms.<sup>10</sup> Tax and other incentives (land, grants, etc.) in China can account for up to 40 percent of the cost recovery of a new fab's total cost of ownership—well above that in other countries, including the United States.<sup>11</sup> We recommend the following:

- US policy makers should assess the effectiveness of the 25 percent tax credit passed in the CHIPS and Science Act of 2022 and

consider extension or expansion of the tax credit to make the US a tax-competitive environment for semiconductor fabrication and packaging facilities. Such tax incentives should also be extended to cover the domestic manufacture of semiconductor equipment needed for nanofabrication, including etch, deposition, lithography, and metrology tools.

Semiconductors are a research-intensive technology, requiring companies to invest heavily in R&D spending every year to remain competitive. The US semiconductor industry reinvested 18.6 percent of its revenue into R&D activities in 2021.<sup>12</sup> The US tax code allows for R&D tax credits to incentivize corporations to undertake expenditures necessary to support R&D activities. Claiming the R&D tax credits is complicated for firms, and thus the tax credit is often inaccessible to small firms.<sup>13</sup> Overall, US R&D benefits are not as competitive as those of other Organisation for Economic Co-operation and Development (OECD) countries.<sup>14</sup> Further, under current law, companies will be required to amortize R&D costs over five years—thereby reducing the global competitiveness of the United States as an environment for corporate R&D. We thus recommend the following:

- US policy makers should permanently eliminate the tax code's five-year R&D cost amortization and simplify the R&D tax credit system.

Finally, the overall corporate tax rate in the United States will be the strongest determinant for attracting productivity growth investments of multinational firms. Without a globally competitive business tax system, eliminating the tax bias against manufacturing, providing tax credits for fabs, and making R&D credits more generous will not be effective in the long run. Before the Tax Cuts and Jobs Act (TCJA) was passed in 2017, the United States had a statutory corporate tax rate of 38.9 percent, the highest among OECD nations. The TCJA reduced the corporate tax rate to 21 percent and eliminated the alternative minimum tax (AMT) that has been shown to disproportionately affect

mining, transportation, warehousing, and manufacturing.<sup>15</sup> Even so, less than five years after passing the TCJA, Congress passed the 2022 IRA, which reinstated the AMT and established other means such as a tax on US corporate book incomes. To raise government revenue, corporate taxes have historically proven to be the most economically deleterious, due to their chilling impact on corporate productivity-growth investments such as manufacturing and R&D.<sup>16</sup> We recommend the following:

- US policy makers should eliminate the alternative minimum tax and additional corporate tax hikes passed in the IRA because they have historically proven to disincentivize domestic manufacturing and other investments of multinational corporations. The US should create an internationally competitive corporate tax system by embracing lower statutory corporate taxes, such as the 21 percent rate introduced by the TCJA.

### *Regulations and Permitting*

The ability of the United States to remain globally competitive in semiconductor technologies requires an ability to move quickly to build manufacturing capacity for legacy technologies, as well as to construct next-generation fabrication facilities. The CHIPS Act includes federal subsidies and tax credits for fabrication and packaging—but it does nothing to alleviate the regulatory burden on domestic semiconductor manufacturers.

Today's federal and state permitting requirements are unacceptably slow. Under the federal Clean Air Act (CAA), two permitting programs are primarily of concern to semiconductor manufacturing: preconstruction permits and operation permits. These permits are generally granted at the state and local levels but are subject to Environmental Protection Agency (EPA) review. The permitting process for new facilities can take upward of eighteen months, which is prohibitive for a competitive industry where time provides a decisive advantage.<sup>17</sup> A recent study analyzing the construction of greenfield fabrication facilities

showed that the construction-to-production time of a new fab in the United States has increased by 38 percent over the last thirty years—significantly longer than in other regions, notably Taiwan and China.<sup>18</sup>

Expedited permitting and regulatory support is necessary for the United States to increase its domestic semiconductor manufacturing capacity. Doing so is especially important for attracting foreign companies to build outside of their headquartered countries where they often have ready access to policy makers to create favorable regulatory environments. And the need for reform is underscored by the fact that US firms are no longer at the leading edge of semiconductor manufacturing. We recommend the following:

- The EPA should create an expedited, simplified, and transparent permitting process for greenfield fabrication, packaging, and equipment manufacturing facilities to be constructed under the CHIPS Act, with a capped time for permitting decisions of three months. The permanent adoption of this expedited process should be considered for the construction of future facilities. Redundant federal, state, and local permitting requirements should be identified and removed.

A robust supply of chemicals, materials, and gases is essential both for domestic semiconductor fabrication and for ensuring US industry supply chain resiliency. Materials suppliers to the semiconductor industry often face even higher regulatory barriers than fabrication facilities. For example, raw materials suppliers face mining permits in addition to the construction permits faced by manufacturing facilities. A Taiwan-based supplier of specialty gases for fabrication estimated that building a factory in the United States is five to six times as expensive as in Taiwan, in part due to these regulatory barriers.<sup>19</sup> That appraisal was echoed on an earnings call in January 2023 by Taiwan Semiconductor Manufacturing Company (TSMC), whose CFO reported that their facility construction costs in Arizona exceeded those in Taiwan by four to five times.<sup>20</sup>

Additional EPA regulations may restrict the domestic production, supply, and use of certain chemicals necessary for semiconductor

fabrication. Examples of chemicals subject to EPA regulations include N-methylpyrrolidone (NMP); octamethylcyclotetra-siloxane (D4); TBBPA; hydrofluorocarbons; and phenol, isopropylated, phosphate (3:1) (PIP (3:1))—all of which are important to aspects of semiconductor manufacturing, performance, and safety.<sup>21</sup> Recent EPA evaluations under the Toxic Substances Control Act (TSCA) may increase restrictions for US manufacturers to access these and other relevant semiconductor production materials, thereby increasing domestic supply chain uncertainty and disruption. This all was recently borne out with the EPA's restriction on usage of PIP (3:1), a common chemical in semiconductor equipment.<sup>22</sup>

These regulatory restrictions have contributed to zeroing out the domestic production of the chemicals, materials, and gases needed for semiconductor fabrication—today, the United States is almost entirely import dependent.<sup>23</sup> Many countries the United States depends on for these critical minerals do not have the same environmental protections and continue to damage the environment, albeit elsewhere on the globe. It would be environmentally advantageous and beneficial to US economic and supply chain resiliency to determine a means for producing and using these chemicals, minerals, and gases in an environmentally safe manner domestically, thereby reducing the geographic externality of outsourced environmentally damaging processes. We recommend the following:

- To address acute supply chain demands and strengthen the domestic availability of critical chemicals, materials, and gases, the EPA should provide near-term exclusions or exemptions for regulated substances. In parallel, funding and incentives for the discovery and development of alternative, environmentally friendly replacement materials and processes should be prioritized.

### *Antitrust Regulation*

Size matters in the semiconductor industry. Capturing economies of scale is exceptionally important for managing the exorbitant costs



of manufacturing semiconductors—which can include up-front capital commitments of \$20 billion for a new fab. The distribution of production costs over a large number of manufactured devices is essential for driving down the cost per unit and making ownership and operation of a foundry economically viable.

Experience also matters in the semiconductor industry. The economic concept of “learning while doing” or the “learning curve” relates the reduction of unit costs to the accumulated learning needed to produce each successive unit.<sup>24</sup> This learning is particularly important for the complex high-tech manufacturing processes needed for semiconductor production. The rule of thumb is a 20 to 30 percent decline in unit cost for each doubling of experience or production volume.<sup>25</sup> The combination of size and experience can produce a decisive competitive advantage for a firm: a company with dominant market share can more rapidly accumulate experience and, consequently, perpetuate its cost advantage over rivals. Market power also enables firms to accrue the resources and capital necessary to fund their R&D.

Current antitrust regulation does not sufficiently account for the dynamic aspects of competition in evolving technology industries.<sup>26</sup> Nor does antitrust enforcement account for the importance of firms to advanced technology development, national security, and economic competitiveness.<sup>27</sup> The breakup of large technology companies leads, among other things, to the diminution of market power needed for research funding and related operational and capital expenses (e.g., owning, staffing, and operating R&D laboratories); a reduction in the learning efficiencies that benefit from economies of scale; and the loss of talent, capabilities, and assets that are often casualties of breakups. And once the scientific talent, institutional knowledge, and technology assets of a company are lost, they are virtually impossible to recover.

Antitrust enforcement against US technology companies over the latter half of the previous century and into the twenty-first century has led to a drastically reduced capacity for US firms to compete with the protected companies and industries of other countries. In no US tech sector is this more devastatingly apparent than in telecom equipment. For over a century, the United States led the world in telecom

technology development, equipment manufacture, and hardware innovation. Companies like AT&T, Western Electric, ITT, and Lucent dominated the global market. But antitrust actions by the US Justice Department to weaken these companies led to a vitiation of the domestic industry to the point of nonexistence. Some conclude that “without the aggressive antitrust policies of the US government, America would still be the world leader in telecom equipment.”<sup>28</sup> The loss of US telecom superiority has led to a loss of economic first-mover advantages in network infrastructure for 5G and 6G, and in turn has heightened the national security implications of the rise of China’s Huawei and ZTE.

More of this antitrust enforcement could destroy both the capacity of US industry to innovate and the ability of the US economy to capture the value of those innovations. The US government’s posturing to break up large Silicon Valley tech companies—some of which are at the cutting edge of semiconductor design and application—will have a similar deleterious impact on the US semiconductor industry’s global competitiveness. Just as concerning is the recent approach by competition agencies toward acquisitions and mergers. Acquisitions often serve as the vehicle for moving the results of R&D to commercial practice. Indeed, a significant share of start-ups look forward to an established firm acquiring them for just that reason. We recommend the following:

- US antitrust policy should take into account a firm’s impact on US economic competitiveness, national security, and innovation capacity by recognizing the importance of a firm’s market power on its ability to invent and scale new technologies, as well as its ability to compete with the protected industries of other nations. Innovation-based antitrust evaluation requires improved methods and metrics for regulators to effectively assess global markets and downstream impacts on US technology leadership.

It is worth considering the chilling effect that antitrust enforcement can have on technology collaboration between firms. The National Cooperative Research Act (NCRA), passed by Congress in 1984, allowed companies within the same industry to form consortia to

collaborate in precompetitive R&D. But the NCRA does not extend to the R&D required to scale differentiated products to the competitive market when in fact such collaboration may be necessary. In Japan, by contrast, liberal antitrust enforcement and the exemption of the computer and semiconductor industries contributed to the rise of Japan's industry in the 1970s and 1980s.<sup>29</sup> Ultimately, the United States passed its own antitrust exemption for the industry R&D consortium SEMATECH, which was formed in response to Japan's advances. We thus recommend the following:

- The US Congress should pass a similar antitrust exemption for semiconductor industry collaboration that may be undertaken in response to the CHIPS Act. This exemption should extend beyond the limiting scope of precompetitive R&D, and Congress should consider permanently adopting this exemption.

### *Subsidization*

The provision of heavy government subsidies to preferred companies is a standard tactic of the mercantilist playbook to grow domestic champions, including in China. This approach has succeeded in creating Chinese technology juggernauts such as Huawei. Even so, it is massively inefficient and often corrupt, having led to a catastrophic waste of Chinese public funds—indeed, government subsidies are all too often distributed on the basis of political favoritism rather than market competition.<sup>30</sup> Historically, the United States' embrace of free-market competition has dampened the appetite for government subsidies to industry. Current budget considerations also contribute to a total lack of political will to compete with China on the magnitude of industrial subsidies—what might be termed a subsidy “race to the top.”

Given this context, the US government must carefully consider the best means to provide taxpayer subsidies to the industry in a manner that avoids the market-distorting impacts of political favoritism and the artificial propping up of noncompetitive organizations at the expense of taxpayers.

Effective subsidies require assurance that taxpayer dollars are awarded in a market-competitive manner, which can be achieved by having the US government act as a customer. Creating market-competitive programs involves the US government buying down the demand risk for industry—enabling industry to focus on the technical risks needed to develop its desired services, infrastructure, or capabilities. In this way, subsidies can catalyze the building of complementary assets that are needed for future value capture of semiconductor innovation.

This demand-side method was used by NASA during the Commercial Orbital Transportation Services (COTS) program, which has encouraged the burgeoning of a globally competitive commercial space industry in the United States. COTS also made raising private financing a requirement for firms to receive NASA dollars—the understanding being that private capital would be loath to invest in a noncompetitive business.<sup>31</sup> Considering this, we recommend the following:

- Subsidies to incentivize onshoring of semiconductor manufacturing capabilities and other complementary assets—such as those of the CHIPS Act manufacturing incentives program—should be awarded on a market-competitive basis. This can be done by requiring firms competing for the subsidies to raise additional private capital to supplement taxpayer dollars. The US government can further reduce private investment risk by acting as a customer of some capabilities developed under the subsidy program, for example through commercial purchase agreements for chips needed in defense, energy, or other critical-infrastructure modernization needs.

The CHIPS Act subsidies also include a significant amount of funding for research infrastructure. Most proposals for the research-related CHIPS Act subsidies to date have focused on onshoring semiconductor fabrication facilities that already exist elsewhere in the world. Going forward, however, subsidies should also be directed toward building next-generation prototyping infrastructure that will be needed to

overcome significant innovation barriers. Today, the cost and time associated with the invention and scaling of new semiconductor devices have drastically increased, and in many cases are prohibitive to innovators. The US government can use subsidies to derisk the development of novel, cutting-edge infrastructure that would give an asymmetric advantage to US innovators in capturing the value of their inventions domestically. We recommend the following:<sup>32</sup>

- Rather than invest taxpayer dollars in copying existing prototyping facilities that have proven to be cost-prohibitive for US innovators and startups, the US Department of Commerce should use CHIPS Act funding for the National Semiconductor Technology Center to build a next-generation network of digital and physical infrastructure needed to scale novel semiconductor devices. This new infrastructure should take the form of a network of new pathfinder fabs and facilities across the United States that leverage technical advances, such as cloud-native, full-chip simulation environments, AI-enabled design capabilities, and the digital twins of process flows with high-throughput experimentation. The goal of that spending should be to lower the cost of chip design and prototyping for US companies of all sizes.

Subsidies will have limited impact over time if the underlying industry economics remain uncompetitive. Beyond tax and regulatory issues, high labor costs in the United States are also particularly important for the competitiveness of the semiconductor packaging portion of the supply chain due to its high labor content. The United States is now home to only 5 percent of global semiconductor packaging compared to approximately 44 percent in China and 29 percent in Taiwan.<sup>33</sup> Funding the development of technologies to increase automation of packaging facilities is thus another effective use of CHIPS Act subsidies that have already been earmarked for packaging. Advanced packaging technologies will also be a key driver of semiconductor device performance enhancement over the next decade as two-dimensional scaling of transistors slows, as discussed in chapter 2. Making packaging

an economically viable manufacturing activity in the United States is therefore a strategic imperative. We recommend the following:

- The Department of Commerce should use funding for the National Advanced Packaging Manufacturing Program of the CHIPS Act to fund the development of technologies that boost automation of manufacturing, effectively increasing the output efficiency per employee by one to two orders of magnitude. US packaging facilities built in response to the manufacturing incentives program should be incentivized to adopt these advances to ensure economically sustainable operation is achieved over the long term.

### *Skilled Labor*

A skilled workforce is an essential complementary asset needed for effective value capture. And there is some concern that the United States currently suffers from a workforce shortage in the semiconductor industry.<sup>34</sup> In market economies like that of the United States, however, perceived workforce shortages are often a result of the compensation and perceived opportunities that an employer can offer.<sup>35</sup>

As noted in chapter 2, the US semiconductor industry competes with high-paying US internet technology hyperscalers (e.g., Amazon, Google, Meta), other tech firms, and Wall Street financial firms for engineering talent. This tough competition—combined with accessible and increasingly skilled low-cost labor in other countries—has led to the offshoring of US semiconductor jobs. A lack of demand for this type of employment domestically has led to a diminished workforce. Until the demand side for a domestic semiconductor workforce is addressed, putting more money into the supply side to increase the “pipeline”—for instance, more electrical engineers and materials scientists, the typical policy recommendation for workforce development—will not effectively build a domestic workforce, because these skilled workers will just migrate to higher-paying jobs.

Thus, if the United States wants to have a domestic industry with the requisite skilled labor force, it is going to have to pay for that labor

force with higher wages. Expecting semiconductor companies to pay substantially higher salaries to US engineers is not a market-competitive option, given the availability of low-cost labor elsewhere in the world. Rather, the US government can provide direct means to boost remuneration in the form of individual tax incentives for workers in strategic industries. This approach is similar to the tax incentive provided by the government in the Netherlands, under their “knowledge migrant” visa program: highly skilled immigrants who emigrate with this visa are eligible to receive 30 percent of their income free of tax, allowing Netherlands technology companies to offer higher take-home pay.<sup>36</sup> We recommend the following:

- The US government should provide worker-oriented tax incentives for the semiconductor industry and other strategic sectors to boost take-home income.

That tax example highlights another aspect of the US labor market that needs to be fixed: high-skilled immigration. Today, the United States could do more to retain the talent that comes to our shores for education. US universities are among the best in the world and naturally attract the highest-achieving science and engineering students globally. Many of these international students seek advanced degrees with associated research training that is funded by government grants—in the field of electrical engineering in particular, 61 percent of graduate students studying in US universities are temporary visa holders.<sup>37</sup> Yet these students are all too often forced to return to their countries of origin after a brief postgraduation Optional Practical Training (OPT) work period if they cannot secure a long-term employer visa sponsorship. More of these skilled students want to stay in the United States than are able to.

The United States should provide pathways for these international students to stay after graduation, ensuring that US industry has access to the most innovative young technical talent in the world. Despite bipartisan support, the politics surrounding broader immigration policy continually sabotage efforts to pass legislation enabling such high-skilled immigration. For example, an amendment to exempt science

and technology graduate degree holders from numerical visa caps was excluded from a revised version of the 2023 National Defense Authorization Act. We recommend the following:

- H1-B visas should be made available to all international students completing a graduate program in science or engineering at an accredited US university, and exempted from numerical visa caps.

### *Industrial Commons and Technology Hubs*

The rise of Silicon Valley as a technology and innovation hub was serendipitous and unplanned by the US government. But Silicon Valley has served as a model for other nations to replicate through government planning and programming. Technology hubs consist of geographically concentrated tech companies that pursue cutting-edge innovation in close proximity to one another. These hubs have well-known benefits to enhancing a firm's productivity as well as the efficiency with which new technologies are invented and scaled.<sup>38</sup>

Hubs often benefit from favorable government policies, draw from leading R&D universities and trade schools, and attract upstream suppliers and downstream consumers to colocate. The result is a concentration of technical exchange, supplier linkages, skilled labor, and knowledge spillovers that turn technology hubs into powerful engines of wealth generation. For example, Taiwan's Hsinchu Science Park has evolved into one of the most productive hubs in the world: by one measure, firms located inside the hub are estimated to be 66 percent more productive than other Taiwanese firms operating outside of it.<sup>39</sup> Another successful example is the Saigon Hi-Tech Park in Vietnam, which succeeded in attracting an Intel packaging facility in 2006; fifty-eight other companies followed suit, bringing \$2.03 billion in capitalization to the site.

Unsurprisingly, the creation of technology hubs is a result of a confluence of many value-capture policies. Most successful technology hub policies adopted by Taiwan, Singapore, South Korea, Vietnam, and China have focused on creating favorable business environments for large tech firms to move in, paving the way for smaller firms to



relocate. These policies include favorable tax and regulatory environments, common infrastructure development, and public-private workforce development programs to train local talent.

The US federal government, by comparison, has adopted few policies focused on creating technology hubs. When such policies are considered, subsidization—rather than creating favorable business conditions—is often the method chosen by Congress. For example, the CHIPS Act authorized \$10 billion in taxpayer dollars to create twenty technology hubs, but did not address creating the underlying business environments that would make those hubs more desirable. Targeted subsidies have not historically been successful in upgrading local economies and are subject to distribution based on political (rather than economic) factors.<sup>40</sup> Instead, the US government should adopt an approach that focuses on creating favorable business environments, including via accessible tax, regulatory, and legal reforms that reduce entrepreneurial barriers and increase commercial and manufacturing activity. Such an approach could be seen as analogous to the special economic zones that have been used to good effect in other parts of the world—including by China, whose government in the 1980s pragmatically and selectively compromised on its value of state control in order to achieve the broader goal of economic growth. To that end, we recommend the following:

- The US federal government should coordinate with state and local governments to create opt-in technology hubs through the implementation of policies that engender favorable business environments. These geographically limited hubs would adopt the beneficial tax and regulatory reforms needed for effective value capture that may not be possible to pass at the national level, such as expedited environmental review or permissible worker visas. Ongoing fine-tuning of legislation establishing such hubs should be encouraged through experimentation and pilot projects.

### *Global Technology Standards*

Global standards organizations play a critical role in defining the evolution of certain technology industries that are downstream consumers of

semiconductors. These organizations select amongst various technological choices and define paths for global interoperability. Because the selection of a particular technology can create favorable conditions for a supplier with existing market leadership, engagement in these standards-setting activities is thus commercially important for private firms.

Increasingly, coordinated engagement in global standards organizations is also becoming a national security matter—it is important that US and partner companies therefore maintain their participation in this process. In recent years, companies in China have been encouraged, and often directed, by their government to dramatically increase their participation in global standards setting. Using this coordinated approach, those companies and individuals can constitute the majority of standards body members and, as such, play an outsized role—often selecting technology paths that are favorable to China-based suppliers.

The telecommunications standards network 3rd Generation Partnership Project (3GPP) provides a notable example of China's heavy engagement in international standards setting. 3GPP has recently focused on 5G and 6G telecom standards, with implications for upstream semiconductor suppliers. The number of China-based companies participating in 3GPP as voting members, having more than doubled in recent years, is now twice that of US-based voting members.<sup>41</sup> This growing influence enables China to guide the direction of future technology development in the worldwide telecommunications industry. If the United States and partners do not respond, companies in open societies around the world will effectively have to comply with China's technology standards. Alternatively, as considered in the scenario work of chapter 1, two separate global technology ecosystems could develop, but that would eliminate the seamless interoperability that has been so critical to global communication and trade.

Multiple policy options exist to enhance coordinated US and partner participation in global standards setting. We recommend the following:

- Policy makers should consider incentivizing R&D investment to develop and patent next-generation technologies to incorporate in future standards; encouraging standards participation as a prerequisite to receiving subsidies and tax credits; eliminating or

making exceptions to export controls that restrict US participation in standards bodies when China-based companies are active participants; providing antitrust exemption to US companies engaged in collaboration with other companies in recognized global standards bodies; and strengthening the rights of patent owners to demand a reasonable, market-based return on investment for contributions of essential technology to a global standard.

## **2. Policies to Strengthen National and Economic Security**

Onshoring complementary assets to enhance US value capture and commercialization is important, but additional considerations are required to strengthen US national and economic security. In contrast to the minimal economic ties between the West and the Soviet bloc during the Cold War, today's liberal democracies are heavily intertwined with autocracies: one-third of democracies' imported goods originate in autocracies, democracies trade over \$15 billion per day with autocracies, and autocracies account for 31 percent of global GDP, with 17 percent contributed by China alone.<sup>42</sup>

These numbers reflect significant economic dependencies on authoritarian nations that the United States and other open societies have developed. Further aggregation of critical supply chains by China has created choke points for which alternate suppliers are not available. For example, China is a near-monopoly producer of many chemicals, critical minerals, and metals—many of which are important for semiconductor devices and in other tech sectors such as aerospace, pharmaceuticals, and energy.<sup>43</sup> These dependencies strengthen China by exposing democracies to retaliation, in times of war as well as peace—as experienced by Japan during the 2010 Senkaku boat-collision incident and by Australia in 2020 over a request for an independent inquiry into the origin of COVID-19.

Ameliorating economic dependence on China will require skillful navigation. China has undertaken a program to asymmetrically decouple from the Western world, investing billions to achieve autonomy in

semiconductors and other technologies. China's asymmetric decoupling is characterized by increasing Western and US dependency on China while simultaneously weaning China off economic dependencies on the West.<sup>44</sup> To achieve strategic autonomy, then, the United States must simultaneously reduce its critical economic dependencies on China while maximizing resilience in overall global trade. In addition to the value-capture policies of the previous section—which will reroute global supply chains to the United States in the long run—the United States must leverage additional policies of global trade, investments, economic access, and partnerships to strategically and selectively decouple from China on its own terms. In doing so, it is credible that such decoupling can be done in such a way as to reduce US critical dependencies on China, while maintaining some degree of trade (and codependence) with the West.

### *Incentivizing US Industrial Alignment*

Actions of individual corporations can have significant impact on the competition between liberal democracies and authoritarian states. Companies benefit from the free-market environment, the rule of law, and the democratically accountable systems of government embraced by liberal democracies.<sup>45</sup> Firms in return comply with law and regulations and pay taxes on profits, but otherwise typically do not view themselves as being in service to the nation. The policies of democratic governments, meanwhile, have historically been ambivalent to encouraging globalization and offshoring of corporate assets to authoritarian nations, including to the People's Republic of China (PRC).

The enmeshing of the PRC and US economies was driven by years of aggressive PRC policies to attract foreign companies. To gain access to its large and lucrative economy, US corporations were more than willing to comply with China's policies of transferring intellectual property, relocating manufacturing, and forming joint ventures with PRC firms. Accessing the China market has made many US companies extremely prosperous while simultaneously making inexpensive technology products available to US consumers. As a result, China's economy has grown significantly in importance, further augmenting the incentives for US corporations to have a presence in China.

Throughout the 1980s, 1990s, and 2000s, the actions of US corporations to increase economic integration with China had the blessing of US policy makers. It was widely believed that Deng Xiaoping's market reforms were a harbinger of political reforms that would ultimately lead to China's liberalization. Thus, the financial interest of US firms to enter China's market aligned with overarching US policy objectives.

Only relatively recently has it become more widely accepted that free markets do not necessarily lead to free societies. Rising authoritarianism ushered in by Xi Jinping since 2012 has led to a drastic contraction of individual liberties, including enslavement of Uyghurs, suppression of democratic Hong Kong, brutal COVID-19 lockdowns, crackdowns on the Chinese tech sector, and threatening of Taiwan's self-determination. Rather than increase freedom, the West's fueling of China's economy has empowered China to emerge as the greatest existential threat to open societies around the world.

The rapid realization of the threat posed by China has led to a policy pivot by the US federal government. Now US priorities are to reduce economic exposure to the PRC market and halt the flow of US technology and industry to China. The rapidity of this policy shift—over the past six years—has left in its wake a misalignment of US policies with the financial interests of US companies. After decades of permissive US policies, it is not surprising that US businesses have built up extreme exposure to and dependency on China, and that China itself has now become a significant part of global market share. In semiconductors alone, China buys over 50 percent of the world's semiconductor components,<sup>46</sup> and fabs in China now constitute about one-third of total revenue of US semiconductor equipment manufacturers.<sup>47</sup> This exposure will take years to reduce and will require skillful crafting and handling of policies to move US business activity away from China in a way that does not cripple US corporations in the process.

Aligning US corporate financial interests with US policy objectives is paramount. In particular, conditions must be created such that to make the most money, US corporations will want to build capacity and business ties domestically rather than abroad. Policies should move assets that contribute to value capture (manufacturing) and value creation

(research) out of China and back to the United States while simultaneously increasing market leadership of US companies. Global market leadership requires that policies enhance penetration of US technologies into China's market as well as the rest of the world. To be sure, China will still attempt to misappropriate and reverse engineer US technology—but their attempts to do so will be curbed by the fact that this type of activity is economically inefficient, and in any case should be deterred by active US trade and appropriability policies, as discussed later in this chapter.<sup>48</sup>

Today's US policies seem to be doing the exact opposite: cutting off the demand side from China via export controls while subsidizing capital-intensive building of overcapacity on the supply side is a dangerous policy mix that may overheat the US semiconductor industry and ultimately lead to its contraction. In 2022 alone, \$1.5 trillion in market value of US semiconductor firms was wiped off the global markets due to a combination of slowing sales and tightened US export controls.<sup>49</sup> Additional antitrust sentiment by the Federal Trade Commission, the Department of Justice, and Congress against big US internet and consumer technology hyperscalers—some of which are the largest US consumers of US semiconductors—may further chill the demand for US semiconductor technologies.

Rather than antagonize US business interests, policy makers and industry in the United States should work together to incentivize the alignment of corporate activity with national security goals. Instead of threatening to break apart US hyperscalers, the US government should create a partnership with these companies, leveraging their significant market power to onshore manufacturing. This approach takes advantage of the priority placed on customers by semiconductor firms and the power large US customers have in shaping their supply chains. This was exemplified during a 2022 TSMC earnings call where its chairman, Mark Liu, stated that plans to build TSMC fabs in the United States and Japan were driven by demand from customers.<sup>50</sup> In light of these considerations, we recommend the following:

- Create incentives to align US corporate activity with US national security. For example, rather than threaten to break up big tech

companies, the US government should partner with them, leveraging their market clout to encourage diversification of their supplier base.

Countering China's forced requirements for market entry is also an important measure. The US government should review and, if necessary, deem illegal the types of investments China demands from US firms, including forced joint ventures, financial commitments, and research and manufacturing commitments in China. US firms to date have evaluated the known loss of IP and technology to China in the context of near-term profits from operating in China—that is, whether the upside of doing business in China in the near term outweighs the significant and known downsides of forced technology transfer over the long term. By strictly regulating or making such activity illegal for US companies to engage in, the US government can prevent US firms from having to play by coercive rules set by Beijing in order to do business in China. The objective of such measures should be to ultimately force Beijing to allow commercial activity (e.g., the sale of US technology products in China) without requiring accompanied joint ventures, forced IP transfer, and buildup of complementary assets like manufacturing. We recommend the following:

- The interagency Committee on Foreign Investment in the United States (CFIUS) should review and restrict outbound investment—such as the building of manufacturing centers, research centers, joint ventures, and financial investment—in China and other authoritarian nations, especially when such outbound investments are required by those countries for entry into their domestic markets.

Finally, additional changes to the corporate tax system can be used to achieve better alignment between the long-term interests of the US government and the actions of US industry through incentives strong enough to encourage investment over the long durations needed for

research and manufacturing activities at the leading edge of technology. To that end, we recommend the following:

- US policy makers should differentiate within the R&D tax credit those companies that are focused on critical and emerging technologies such as semiconductors versus technologies that lack a national security purpose. Additionally, US policy makers should differentiate the capital gains tax to provide better incentives for truly longer-term investment, for example over five or ten years versus simply the current single-year qualifier.

### *Export Controls*

In this chapter, we make a countervailing argument to other voices in this volume: we believe that the use of export controls to restrict access to US technology should be applied sparingly. Recent use of export controls has been widely applied by the US government in an attempt to cut off China's access to critical technologies. These controls are often targeted at choke point technologies—that is, those technologies without which China cannot make progress on achieving specific, advanced capabilities. Extreme ultraviolet (EUV) lithography is one such choke point: EUV is needed to commercially fabricate semiconductors below 7nm at scale.<sup>51</sup> Controlling access to EUV has to date successfully prevented China from developing the capability to fabricate at the leading edge. However, there are very few technologies in the same class of uniqueness and complexity as EUV to justify application of export controls. Thus, although use of export controls to slow China has been widely lauded, it does not generally align US business interests with US policy objectives. And although it may create near-term strategic advantage for the US, this approach could ultimately weaken the United States' economic position over the long term—for three primary reasons.

First, the use of export controls today will weaken the effectiveness of any export controls or sanctions needed to counter PRC military



action in the future. The United States does not have a monopoly on advanced technologies and savvy engineers. Parallel supply chains will grow in response to export controls—both within China and with its other trading partners—to replace technologies that were formerly sourced primarily from US firms. China’s decoupling in response to US export controls is well under way: after being placed on the US Department of Commerce’s Entity List in May of 2019, Huawei rapidly pivoted its supplier base, introducing a new cell phone with no US components by December of that year.<sup>52</sup>

It would be more advantageous for the United States to consider a strategy that maximizes penetration of US technologies into China’s market while simultaneously taking measures to prevent the appropriation of that technology by PRC companies (discussed below). This approach would strengthen the position of the United States to impose export controls and sanctions as a means of last resort to deter belligerent PRC actions in the future. Some might argue that this future is now. The near-term strategic advantage from US export controls, however, is in conflict with long-term projection of US economic power. In contrast, China has been successful at building US dependency by penetrating its technology into US consumer, technology, energy, and defense markets, including for rare earths, batteries, magnets, and solar panels. The near-termism of export controls may very well accelerate an asymmetric decoupling scenario where China is less dependent on US technologies but the United States still heavily relies on Chinese exports.

Second, export controls could weaken the market position of US semiconductor firms and damage the United States’ reputation as a reliable technology supplier. The size of China’s market, discussed previously, is applicable here: by cutting off revenue from sales to China, the US government is curbing cash flow to US companies that is essential for maintaining competitive advantage in both technology development and economies of scale.

The unilateral nature of the current export control laws will also enable foreign suppliers to capture market share from US firms. Such capture occurred in the decade following the 1979 Export

Administration Act: in the wake of export control enforcement, the market position of US capital equipment suppliers dropped from 90 percent of global market share to only 50 percent by 1980, having lost 40 percent of the market to Japan-based suppliers.<sup>53</sup> The inefficient administration of export control laws in the United States exacerbated this market loss and led to a reputation that US technology was unreliably accessible and subject to lengthy, arbitrary licensing decisions.<sup>54</sup> History will repeat itself—unless countries such as Japan, South Korea, Taiwan, Singapore, and the Netherlands are willing to join the United States in locking China out of accessing the entire global semiconductor ecosystem.

Third, the concept of a choke point technology is ultimately an artificial one, bounded temporally by the evolving sophistication of a country's scientists, engineers, equipment, and technology ecosystem. This point is not to say that replication of existing complex technologies is easy—it is a prodigious task and exceedingly inefficient from an economic perspective. More than any other country, however, China has advantages that make it plausible that they will, eventually, be able to re-create technologies denied to them under export controls. One advantage is that re-creating existing technologies—no matter how complex—is easier than pioneering new capabilities. China has also benefited from tremendous technology transfer from the West and will continue to learn from Western technology, illegally if necessary. China is well known for cyber theft of intellectual property, reverse engineering hardware, and hiring Taiwan and Western talent. Finally, China is willing to stomach the heavy financial cost needed to gain technology independence—and with the imposition of export controls, China has ample motivation to do so.<sup>55</sup>

The use of export controls to restrict access to US technology should therefore only be applied as a last resort to impose political will. Economic analysis should be conducted to determine the long-term impact of export controls on a US technology sector before export controls are applied. In particular, if a technology is deemed to be easy to copy, it should *not* be controlled lest the targeted nation simply appropriate or otherwise rapidly indigenize the controlled technology,

to the detriment of US industry's market share. In sum, we recommend the following:

- Use export controls sparingly. Rather, undertake policies recommended in this chapter that promote maximal penetration of US technologies into the global market and promote a strong appropriability regime to protect theft of those technologies. If export controls are used, apply them only to the most sensitive and difficult-to-appropriate technologies that directly pertain to security use.

### *Foreign Investment*

As the scenario analysis in chapter 1 illustrated, the United States benefits from being a part of the larger global economy no matter what form global trade flows take in the future. Foreign direct investment (FDI) augments US economic activity through both greenfield investments—such as building facilities and operations from the ground up—and mergers and acquisitions (M&A). Through FDI, foreign companies contribute to creating domestic jobs, upskilling the labor force, funding R&D, and growing domestic industries and services sectors. Approximately 7.9 million Americans are employed by foreign companies that had invested \$5 trillion cumulatively by the end of 2021—\$405 billion of which was invested in 2021 alone.<sup>56</sup>

FDI in the form of greenfield investments has the potential additional benefit of increasing the resiliency of the global economy by on-shoring critical nodes of the supply chain. A recent example is TSMC's construction of its 5nm Fab 21 in Arizona. This facility's projected capacity is comparatively small, at a planned twenty thousand wafer starts per month.<sup>57</sup> Its presence in North America, however, diversifies geographic access to leading-edge logic fabrication for the global economy. Such diversification is especially important given that, today, 92 percent of leading-edge (sub-10nm) capacity is located in Taiwan.<sup>58</sup> TSMC's FDI represents the surest near-term approach to advancing US domestic manufacturing capacity at the leading edge.

The United States should also collaborate with Taiwan's other semiconductor firms, such as United Microelectronics Corporation (UMC), Advanced Semiconductor Engineering (ASE Group), and MediaTek, to diversify their geographic holdings of fabrication and research facilities. This partnership starts, however, with providing a commercially attractive environment for investment in terms of capital efficiency and regulatory expediency. Today the opposite is more likely to be true. TSMC recently confirmed that "a range of construction costs and project uncertainty in Phoenix makes building the same advanced-logic wafer fab in Taiwan considerably less capital intensive." Some of those factors include "federal regulatory requirements that increase project scope and cost; . . . additional site prep and new infrastructure expense; and . . . state and local taxes on construction, facility, and utility use."<sup>59</sup> Unless these cost factors change, the United States will remain uncompetitive for FDI even as semiconductor firms may look to diversify their geographic holdings globally.

Attracting greenfield FDI from partner countries should, then, be a priority, especially for advanced technological and manufacturing capabilities that the US is lacking domestically.<sup>60</sup> And the many policies recommended elsewhere in this chapter also serve to attract greenfield FDI, including minimizing tax burdens for capital expenditures, implementing targeted fiscal incentives, improving domestic infrastructure, promoting skilled workforce development, and improving the regulatory environment. We recommend the following:

- Policy measures to enhance the fiscal environment, improve infrastructure, augment workforce development, and streamline the regulatory environment should be pursued to enhance greenfield foreign direct investment into the United States from partner countries. This is particularly necessary for attracting FDI from global semiconductor firms.

Through the Obama and Trump administrations, concerns grew about the security implications of FDI in the form of investments into and M&A of US companies. China in particular has invested in US

companies to gain control of company boards, and has even outright acquired US companies to obtain a foothold in a new technology or to deepen strength and control of a strategic technology.<sup>61</sup> To counter these efforts, in 2018 Congress passed the Foreign Investment Risk Review Modernization Act (FIRRMA), which strengthens the process by which the interagency CFIUS process reviews FDI.<sup>62</sup> Although this legislation has led to a decrease in requests from China-based acquirers, its overall effectiveness in protecting US interests is, as yet, to be determined.<sup>63</sup>

Ultimately, the CFIUS review process has the difficult task of protecting US national security interests while simultaneously enabling the traditionally open US investment climate that leads to business opportunity for US companies and their employees. CFIUS' denial of foreign investment into US technology startups limits the capital available for those companies to scale and perhaps achieve successful exits in the form of acquisitions. Moreover, the CFIUS review process is opaque, leading to uncertainty when foreign companies from friendly jurisdictions—for example, Taiwan—seek to acquire a US company as part of broader US investment activity. Providing more transparency, increasing negotiation opportunities, and providing more certainty for foreign investors from partner nations would enhance the ability of US technology startups to attract the capital necessary to scale their innovations. We thus recommend the following:

- CFIUS inbound investment review should be a more transparent process with active engagement and negotiation with prospective foreign investors from partner nations. FDI into the United States from partner countries should be encouraged, whereas foreign investment from authoritarian countries that pose a national security risk should be strictly limited.

### *Armaments and Defense Acquisitions*

All modern weapons systems contain semiconductor devices. Many defense programs of record develop complex and expensive platforms with

long service lifetimes. While these platforms are often essential for modern warfighting capability, the Department of Defense (DoD) should complement them by acquiring large numbers of new classes of small, modular, inexpensive, and expendable systems that can be quickly and cheaply produced. Autonomous to semiautonomous drones for aerial or maritime operation or soldier-launched, sensor-equipped missiles are examples of modular, inexpensive systems that can be produced in large numbers. The acquisition and service lifetime of such systems would better match the rapid innovation cycles of the commercial semiconductor and consumer technology industries, allowing the DoD to benefit from economies of scale and cutting-edge innovation elsewhere in the economy.

The near-term focus should be to rapidly ramp up weapons production, especially in the wake of recent stockpile depletion needed to supply Ukraine's war effort—because currently, US arms makers are languishing.<sup>64</sup> Ukraine's war effort against Russia has further demonstrated the importance of semiconductor-enabled technologies to advanced warfighting capabilities and the effectiveness of adopting a strategy of deploying a large number of small, inexpensive weapons and precision guidance missiles. Ukrainian forces have depended on Switchblade drones, Stinger anti-aircraft missiles, NLAWs (next-generation light anti-tank weapons), and Javelin missiles to fight Russia's forces. Each of these weapon systems contains a plethora of semiconductors.<sup>65</sup> Meanwhile, Russia has reportedly been struggling to equip its forces: without a domestic semiconductor manufacturing capability, Russia has been unable to gain access to semiconductors needed to replenish its precision-guided munitions due to export bans imposed by the United States and its partners.<sup>66</sup>

The lesson for the United States in the context of Taiwan is to take advantage of today's supply of semiconductors. Not only should the United States stockpile its own arsenal, Taiwan should also be equipped to defend itself with advanced capabilities today, in the manner that Ukraine has been only after invasion. Arming Taiwan with advanced, semiconductor-powered weaponry would be a true "silicon shield" for the Taiwanese people (in contrast to how the silicon shield is often

described: the mere presence of the semiconductor industry in Taiwan, which will neither deter an invasion by Party General Secretary Xi Jinping nor be the decisive factor in a US defensive posture). Many in both the United States and Taiwan advocate for a “porcupine” strategy, which takes advantage of advanced, semiconductor-enabled weapons.<sup>67</sup> Crucially, given US supplier backlogs, doing so should include partnering with Taiwan’s defense, electronics, and semiconductor firms to scale up advanced weapons coproduction, weapons codevelopment, and weapons deployment within Taiwan, as discussed in chapter 5. We recommend the following:

- Create a real “silicon shield” for Taiwan by partnering with its firms to scale up advanced weapons deployment, coproduction, and codevelopment on the island to make an invasion of Taiwan as costly as possible to potential aggressors. Partner with TSMC and Taiwan’s significant semiconductor industry to supply state-of-the-art semiconductor devices for these new defense systems.

### **3. Policies to Amplify Value Creation**

Value creation is the discovery of new scientific principles and the invention of new technologies that lay the foundation for future industries and enhanced human welfare. Policies to enhance value creation in semiconductors include increasing R&D funding in basic and applied sciences, building and maintaining R&D infrastructure, and educating the next generation of pioneering scientists and technologists. To improve return on investment to the taxpayer, this should be strongly coupled to the advanced-process and fabrication-oriented value-capture activities described above.

#### *R&D Funding*

Federal R&D funding as a percentage of GDP in the United States has been declining for several decades. The US government spent only 0.62 percent of GDP in 2017 on R&D (down from a peak of

1.86 percent of GDP in 1964), even as absolute federal funding has increased.<sup>68</sup> This diminution of the federal budget's R&D intensity has long been a point of concern, due to the recognition of the fundamental role that curiosity-driven R&D in basic and applied sciences has in value creation and future GDP growth.

In the context of the twenty-first-century great-power competition with China, the emphasis on funding value-generating R&D has never been more important. Yet the federal budget—of which more than 73 percent goes to various kinds of social insurance—does not reflect the importance of such a vitally important GDP-growing activity.<sup>69</sup> This neglect will ultimately lead to an economic and geostrategic death spiral: an ever-increasing portion of GDP allocated to social services, with ever-decreasing funding allocated toward value creation, will lead to economic stagnation and the demise of the innovation engine that has brought such vast prosperity to so many Americans. As one study put it, the US federal budget “is not the investment strategy of a focused superpower . . . competitor.”<sup>70</sup> We recommend the following:

- The US Congress should increase and sustain federal R&D funding in basic and applied research, spanning established fields (e.g., conventional semiconductors) as well as frontier fields, such as beyond-CMOS (complementary metal-oxide semiconductor) devices that could someday complement today's predominant logic chips.

### *R&D Infrastructure*

Increased funding for R&D in semiconductor devices is necessary but not sufficient for US value creation. Pure R&D programs will enable the US research community to explore trends in future computing, including the use of emerging devices that exploit physical phenomena such as spin, ferroelectricity, ferromagnetism, and phase transformations, as well as new materials such as oxides, nitrides, carbon, and chalcogenides for semiconductor transistor channels. Without access to fabrication facilities capable of integrating these emerging devices and materials with advanced CMOS architectures, however, US



innovations will either fail to transition to commercial settings or be sent to offshore facilities for testing and scaling.

Today, the United States has no such facilities for exploratory research at foundry-relevant dimensions and scales. Previous US government-funded facilities have proven their importance, for example, in the Metal Oxide Semiconductor Implementation Service (MOSIS) program in the 1980s and the National Science Foundation's National Nanotechnology Coordinated Infrastructure (NNCI) in 2015, but they cannot address today's research needs in advanced and exploratory semiconductor technology.<sup>71</sup>

A national facility (or network of facilities) whose construction and operation are supported by the federal government is a key ingredient for US value creation and ultimately value capture.<sup>72</sup> Such facilities encompass capabilities at leading-edge fabrication, legacy nodes, and packaging capabilities, with the mission of enabling rapid, high-throughput experimentation. The construction of such facilities should be colocated with industry in technology hubs, and should leverage established infrastructure and methods, such as the use of a 300mm (i.e., modern commercial-scale wafer size) research pilot line, as well as advances that will drastically reduce cost and increase experimental learning cycles. Possible advances include simulating digital twins of process flows to create virtual environments for experimentation that are coupled to experimental facilities; using machine learning to identify novel experiments and process flows; and developing advanced, customizable tool sets with a wide range of operating conditions.<sup>73</sup>

This chapter has already recommended the use of CHIPS Act subsidy funds to build such infrastructure to enhance value capture. Even so, further R&D funding should be allocated to the building and operating of commonly available semiconductor research infrastructure—and not just specific research programs themselves—to ensure that the United States has indigenous research capabilities. We recommend the following:

- Allocate a portion of R&D budgets to the building and operating of new capabilities and research infrastructure rather than research programs alone.

## *Education*

Training the next generations of scientists, engineers, and technicians will be vital to the United States' continued capacity to create value through new inventions.

Education in the quantitative sciences must start early. All too often, the US public education system fails to adequately prepare students in the K–12 system to be sufficiently competent in sciences and mathematics to seriously entertain pursuing careers in those fields at the collegiate level and beyond. Rectification of the dire state of scientific illiteracy and unpreparedness in the K–12 system should not be the responsibility of universities. Rather, solutions should be found to reform the US public education system and expose students in K–12 schools to high-tech industries that will drive the future economy and national security. Specific reforms are beyond the scope of this chapter, but acknowledging the importance of adequately preparing the next generation is not. We recommend the following:

- Enhance exposure to high-tech industries, including for semiconductors, in K–12 education and reform K–12 education to ensure students have sufficient training in mathematics and sciences to compete with global peers upon entry into universities or trade schools. For those pursuing collegiate degrees in semiconductor-relevant fields, increase the number of pathways to jobs as well as the industry's demand-side pull, for example, a semiconductor-focused version of the DoD SMART Scholarship program—which requires recipients upon graduation to work for a set number of years for the scholarship funder, and for whom a job is already in place upon graduation—financed in partnership with industry.

## **4. Policies to Strengthen the Global Appropriability Regime**

Value capture is enhanced under a strong appropriability regime, defined as the efficacy by which knowledge and innovations can be

protected from imitators.<sup>74</sup> The strength of appropriability is a function of the effectiveness of legal protections and the nature of the innovation (tacit or codified; easy or difficult to replicate). Today's global appropriability regime is weak, largely due to the unenforceable nature of legal protections for technology and innovation in the global setting. Transfer of US technologies to companies in other countries by both legal (but coercive) and illicit means has been rampant over the past few decades. China in particular has implemented an array of practices and policies that have resulted in a systematic transfer of US intellectual property to China. Beijing's support of IP theft by means of intrusions into US commercial networks is also well documented.

US innovation and value creation should not ultimately fuel China's economic growth and military-industrial complex. And yet, transitioning technologies to China (e.g., for production) is the paradigm under which US innovators operate today. Many US companies do not raise the issue of unfair trade practices for fear of retaliation and loss of business opportunities.<sup>75</sup> High-profile examples of technologies invented in the United States that are now produced by PRC firms include batteries, telecom equipment, photovoltaics, and, increasingly, semiconductors. China has repeatedly violated bilateral and multilateral trade agreements, and disputes brought by the United States and other countries via formal trade-resolution mechanisms have been slow and ineffectual.

Countering China's systematic theft of US technology and establishing a strong global appropriability regime is an imperative to ensure future technology leadership and strategic autonomy. The United States must also ensure that it does not continue to erode its domestic IP-rights strengths that incentivize innovators to undertake the risk and years of hard work needed to pioneer technologies.

### *Trade*

The United States has increasingly taken unilateral action to counter technology theft by China. More often than not, unilateral action takes the form of restrictive measures, including export controls, the Department of Commerce's Entity List that restricts business with

specific foreign firms, stricter CFIUS oversight of acquisitions, and expanded application of the International Emergency Economic Powers Act (IEEPA). For example, the Biden administration adopted sweeping export control measures to curb semiconductor technology and capability transfer to China.<sup>76</sup>

Ultimately, rectifying global trade will require bold action and determined leadership on the part of the United States. World Trade Organization (WTO) principles embrace free trade and disallow trade barriers that discriminate against countries of origin. The United States has no recourse to halt unfair PRC technology transfer practices under this system. The United States, therefore, must take action to build significant leverage over China, including a unified front of global partners, to force Beijing to change its behavior. Rather than act responsively and tactically, the United States should comprehensively reform global trade rules to respect and enforce strong appropriability, the rule of law, and other economic norms.

Once a clear objective for global trade is defined, the United States should act strategically, proactively, and persistently to reshape the international trading system as a whole, ensuring strong coordination with partner nations. We recommend the following:

- This and subsequent administrations should build a coalition of partners who share the US vision for a reformed global trade agenda; this coalition should then strategically shape international trade and counter China's market-distorting actions. As discussed in chapter 5, the United States should start by focusing on signing trade deals with partners—including Taiwan—to establish stronger trade relationships.

The United States has never put requirements on foreign firms for access to the US economy, yet this is routine practice in China: if a foreign company wants to sell a product in China, some fraction of that product must be manufactured in China, joint ventures must be established with China-based companies (often state-owned), and IP is forcibly transferred. The use of reciprocal policies by the United States would

be counter to the free-market principles adopted after World War II, and serious economic analysis is necessary to evaluate what, if any, qualifications on access to the US economy should be enforced to protect US interests and to encourage foreign and domestic investment in the United States and like-minded partners. In the wake of recent PRC actions, however, there are several reasons to consider such policies.

The first concern is the predatory behavior of China to capture technology industries. For example, PRC government subsidies, its protected domestic market, and state-directed access to capital have directly contributed to China's domination of the photovoltaic industry. These policies allowed China's emerging photovoltaics manufacturers to sustain tremendous losses while contributing to a global supply glut and dumping product into export markets, crushing global competition. China's global share of photovoltaic cell production grew from 14 percent to 60 percent between 2006 and 2013 alone.<sup>77</sup> Sanctions imposed by the United States in response proved to be too late and rife with loopholes that rendered them useless.

The second concern is the national security implications of certain PRC products sold in the United States or in partner markets. This concern has led to banning Huawei and ZTE equipment in the United States and other countries. For example, the Secure Equipment Act, signed into law in November 2021, prohibited Huawei, ZTE, and any other company considered a national security threat from obtaining licenses for network equipment in the United States.<sup>78</sup> Even so, China is still allowed to export its illiberal vision to the rest of the world in the form of other products. National security experts and policy makers, for example, have raised concern over millions of US teenagers freely providing data to China-based social media platform TikTok.<sup>79</sup> The United States' ability to address these concerns can be described as muddled at best.

### *Tacit Knowledge*

Although forced IP transfer and theft are of great concern, it is often the tacit knowledge of highly skilled scientists and engineers that is key to technology progress. The United States and other Western countries

have trained Chinese students in STEM fields for decades. Originally, China was concerned that systematic brain drain would occur as the most talented Chinese youth would be lost to foreign countries.<sup>80</sup> But the lack of concerted effort by the United States to retain Chinese and other international students has quelled this fear.

The presence of foreign students from competitor nations studying critical technologies in US universities—or foreign nationals from competitor nations working for US critical-technology companies—is now viewed by some as a national security risk.<sup>81</sup> But crude steps (such as a ban on student visas for Chinese scholars and work visas for highly skilled Chinese scientists and engineers) will cut off the United States from a massive talent pool. Instead, the United States should consider how to accommodate those Chinese students and workers it accepts within its universities and companies, and give opportunities to those who wish to escape an increasingly authoritarian and illiberal regime under General Secretary Xi—as happened with scientists fleeing the Soviet Union.<sup>82</sup> We recommend the following:

- An evidence-based process should be adopted to screen for those with demonstrable ties to PRC military, security, or influence organizations. Otherwise, individuals permitted entry for studies or work should be allowed—and encouraged—to permanently relocate to the United States. Doing so will enable the United States to continue to be the greatest attractor of global and Chinese talent and fulfill Beijing’s fears of brain drain to the West.

Meanwhile, China has established its Thousand Talents program to provide strong incentives to attract talented foreign nationals to its shores,<sup>83</sup> and it has aggressively recruited from international technology companies such as TSMC despite such recruitment being in violation of Taiwan’s laws.<sup>84</sup> The tacit knowledge of US experts and leading researchers is of high value and is leveraged by Beijing and PRC firms for technology transfer—from high-profile cases of faculty members at leading US universities participating in the Thousand Talents program<sup>85</sup> to US corporations collaborating with universities in China that

are closely tied to China's defense industrial base.<sup>86</sup> In consideration, we recommend the following:

- The United States should control the flow of tacit information to China by requiring a broader set of US citizens involved in critical technologies and sectors to obtain outbound visitation or training before travel to China. A similar measure was recently implemented in the new export controls implemented by the Bureau of Industry and Security: they require US citizens to obtain a license “to support the development, or production, of [integrated circuits] at certain PRC-located semiconductor fabrication facilities.”<sup>87</sup>

### *Incentivizing US Innovators*

A strong global appropriability regime will not be meaningful to US innovators if domestic intellectual property rights are eroded. The US government must therefore also ensure healthy and competitive domestic IP policies that incentivize US innovators to undertake the risky, difficult, and time-consuming work needed to invent new technologies.

The United States has been on a steady path for the past two decades to limit and devalue patents, progressively weakening US IP policies in almost all areas. Among the notable changes are limiting the availability of injunctive relief for infringement of IP rights, particularly by entities that are involved in licensing, not manufacturing; weakening IP rights in software-enabled inventions; and weakening the role of the US federal courts in patent cases through more extensive reviews of their decisions.

The Supreme Court decision in *eBay Inc. v. MercExchange, L.L.C.* and subsequent related rulings have all but eviscerated the foundational core of a patent right: the right to exclude. That line of cases now makes it almost impossible for a patent owner to enjoin the continued infringement of a patent by a proven infringer. These judicial rulings have encouraged what has been coined “efficient infringement” by companies that bet on the expense, disruption, resource drain, and uncertainty of outcome inherent in patent litigation and take the chance

that if and when they are called to task, they will have to pay only the royalty that the noninfringers were willing to pay from the start.

The scope of patentable subject matter in the United States has also been limited to exclude abstract ideas by cases such as *Alice Corp. v. CLS Bank International*. This narrowing has made important inventions that previously would have been protected from theft or appropriation freely available. This limitation is in stark contrast to the situation in China, which issues patents for inventions that are far less novel and significant. China's approach to determine patent eligibility is much more pragmatic than the US approach: rather than test for abstractness (a vague concept), China's patent authority, the China National Intellectual Property Administration (CNIPA), encourages examiners to review a proposed invention as a whole and to focus on the technical solution. The result is a more favorable patent environment in China than in the United States: a recent study showed "more than 12,000 cases that had been granted in China and Europe but denied in the United States on statutory subject-matter grounds."<sup>88</sup>

Further erosion of IP protection in the United States has taken many forms. Antitrust law in the United States has been employed to preempt the legitimate statutory power granted to patents by treating them as monopolies, rather than as constitutionally mandated limited rights to exclude. The courts have further diminished patent rights by finding them exhausted by the sale of a product that embodies it, thereby restricting the patent owner's freedom to choose the means of recovering the expense of investment. Congress has spent years focusing on concerns about so-called patent litigation abuse, eventually passing amendments that favored infringers over inventors and placing even higher burdens on efforts to enforce patent rights. Of particular concern has been the trend to try to diminish the value and rights associated with standard essential patents, risking technological leadership in mobile communications and ceding control of standards to China. Congress also created a new patent review board that allows anyone to challenge a patent that is already issued, thereby prolonging the patent owner's effort to stop infringement. This body has overwhelmingly invalidated patents even when a district court has found them valid.



The weakening of US support for IP has only accelerated during the Biden administration, which supported waiving obligations under the WTO's Trade-Related Aspects of Intellectual Property Rights (TRIPS) during the COVID-19 pandemic, over the objection of our trading partners. This has sent a strong signal that US support for strong IP protections is on the decline.

Trade secret protection has also been diminished in the United States as an effective tool against misappropriation. This diminishing is of particular concern to companies that rely on trade secrets to protect against access to and use of their innovations. Semiconductor development and manufacturing is a prime example. The know-how and years of experience required to succeed in such a complex and capital-intensive field is not something one can describe in a patent application; this type of intellectual property is most appropriately treated as a trade secret. Yet, the law in the United States now favors very limited protection of trade secrets and largely prohibits such things as non-compete provisions previously employed to prevent employees from jumping ship and taking trade secrets to a competitor.

All of these changes and more have contributed to an attendant perception of instability and have had the effect of discouraging traditional investors from promoting new technology development—thereby stifling innovation in the United States. Many valuable innovations are simply no longer patentable in the United States but are patentable elsewhere in the world, including in China.<sup>89</sup>

Meanwhile, China has recognized that strengthening its patent system and the ability of its courts to enforce patent rights is essential to encouraging domestic innovation. Since 2000 alone, Beijing has also undergone massive reforms of its IP system, including four major revisions to its patent law and two major revisions to its trade secret law, as well as significant revisions to its technology transfer laws and contract laws. In contrast to the United States, PRC courts provide injunctive relief in nearly 100 percent of all successful cases; China has strengthened protections of software-enabled inventions, as well as in other fields; and China has established four national appellate IP courts and one national IP court of final instance. PRC companies are now among

the top ten patent filers globally. China's patent office, CNIPA, has hired tens of thousands of examiners and has expedited time-to-grant for patent applications. Specialized IP courts in China provide rapid rulings and readily issue injunctions. In fact, US companies often now sue in PRC courts when they have a choice of jurisdictions in order to obtain the injunctive relief no longer available in the United States.

There is no lack of irony in the fact that IP rights have been weakened in the United States while being strengthened in China over the last two decades. The erosion of IP rights in the United States has contributed to the rise of economic and technological power in China and will continue to vitiate US capacity to develop new technologies. To reclaim leadership in technology innovation, the United States must embrace laws and policies that incentivize innovators by valuing and protecting IP rights, ultimately creating a more integrated and strategically focused approach to IP that better promotes US strategic interests. To that end, we recommend the following:

- The US IP regime should be modernized and made more efficient, competitive, and stable. This will require (a) clarifying and stabilizing patent eligibility criteria, to promote a range of high-tech industries and ensure that the United States is not placed at a competitive disadvantage; (b) making injunctive relief readily available in IP infringement cases of all types; (c) creating a team within the US Patent and Trademark Office to address the relationship between intellectual property and strategic competitiveness; (d) appointing US IP officials in a timely manner; and (e) ensuring that countries with which the United States forms deeper relationships through trade and “friend-shoring” have robust IP regimes, to avoid a repetition of the types of problems that US companies have faced in protecting IP in China.

## **Achieving Strategic Autonomy**

Around the time of the founding of the United States, Alexander Hamilton stated that “it is impossible to foresee or define the extent

and variety of national exigencies.”<sup>90</sup> The United States is now facing an unprecedented challenge from a rising China that seeks to reshape the world order in its favor. China’s vigorous pursuit of science and engineering—including a preeminent and self-sufficient semiconductor industry—exemplifies the tenet that technological superiority is the means of shifting the global balance of power. If the United States desires to ensure the continued liberty and prosperity of its people, it must continue to lead. To continue to lead globally, it must outcompete China, and thus it must augment its ability to predict the future—or, more precisely, to invent it and to own it.

In his book *On China*, Henry Kissinger presents an analogy to the differences between Western and Chinese strategic doctrine by comparison to the games of chess and *weiqi* (Go). Whereas chess values total victory, *weiqi* seeks to patiently accumulate strategic advantage. He writes:

The players take turns placing stones at any point on the board, building up positions of strength while working to encircle and capture the opponent’s stones. Multiple contests take place simultaneously in different regions of the board. The balance of forces shifts incrementally with each move as the players implement strategic plans and react to each other’s initiatives. At the end of a well-played game, the board is filled by partially interlocking areas of strength. The margin of advantage is often slim and to the untrained eye, the identity of the winner is not always immediately obvious.<sup>91</sup>

Our future will be characterized by the evolving and interlocking strengths of the United States and China. Achieving strategic autonomy over the long term will require the United States and its partners to patiently accumulate relative advantage over China—in the manner of a *weiqi* player, rather than seeking decisive victory in the manner of a chess player. This is possible through the persistent application of policies consistent with the growth of the US economy, technology development, and enhancement of national security. The policies recommended

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