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14. ABSTRACT
As the world's fourth-most traded product, semiconductors underpin modern daily life and are critical components of everything from consumer electronics to the world's most advanced weaponry. Access to advanced semiconductors can give a nation's military a competitive advantage. The semiconductor industry supply chain is considered one of the world's most complex, inhibiting a country from domesticating the production process. Production often requires more than 1,000 steps, fostering a web of interdependencies across nearly 100 international borders. Existing interdependencies include U.S. semiconductor software, U.S., Japanese, and Dutch manufacturing equipment, and Korean and Taiwanese fabrication. The U.S. maintains an assessed 39% of the global semiconductor industry's market share and is uniquely postured to exploit its positions of strength to gain a relative adventive over its competitors. This paper recommends the application of a balanced strategy to achieve this advantage and discusses the application and effectiveness of a geoeconomic policy. This paper further discusses key areas that the U.S. can invest to revitalize the domestic semiconductor industry, including human capital and the reshoring and domestication of semiconductor manufacturing and fabrication operations.

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Weaponized Exports:

America's Geoeconomic Gamble in an era of Great Power Competition

Introduction

As the world's fourth-most traded product, semiconductors underpin modern daily life. [1] From microwaves to military applications, semiconductors are components of consumer electronics, smartphones, and cars. They are integral components of autonomous weapons, cyberweapons, hypersonic missiles, nuclear weapons technology, and artificial intelligence (AI) integrators. Access to advanced semiconductors can give a nation's military a competitive advantage. But the inherent complexity of the semiconductor industry supply chain inhibits a country from domesticating the production process, causing a dependency on industry leaders. Only a handful of countries dominate the global industry's market share. These countries, each with a strategic hold on portions of the industry, are uniquely postured to leverage existing supply chain choke points to limit access to sensitive capabilities that may undermine their national security. The U.S. maintains an assessed 39% of the global industry's market share and is the leader in semiconductor design and the development and export of semiconductor manufacturing equipment (SME).[2] As a byproduct of its relative position of strength within the supply chain, the U.S. is postured to gain an opportunistic advantage over its competitors.

The Strategic Context

The U.S. sees the People's Republic of China (PRC) as its pacing threat. Especially telling, the Biden Administration's 2022 National Security Strategy specifically states that the "PRC is the only competitor with both the intent to reshape the international order and,

[1] "The Semiconductor Supply Chain Visualized," Advanced Semiconductor Engineering, Inc., Accessed January 15, 2023, https://ase.aseglobal.com/en/solution/semiconductor-supply-chain.
[2] Kahn, *The Semiconductor Supply Chain,* 5.

increasingly, the economic, diplomatic, military, and technological power to do it."[3] The Chinese Communist Party (CCP) has published an industrial policy called "Made in China 2025" and developed a national strategy of military and civil fusion (MCF). Through this MCF, the PRC envisions decoupling from foreign dependencies, including the semiconductor industry on which it is heavily reliant. The PRC plans for its military to be the most technologically advanced and become the global leader in AI.[4] Beijing's industrial policies aim to achieve semiconductor design and manufacturing dominance by 2030.[5] To do this, Beijing must first nationalize a domestic semiconductor industry. Chinese subsidies, annualized at $15 billion, are helping to make this a reality.[6]

The semiconductor industry supply chain is considered one of the world's most complex. Semiconductor production encompasses three main stages (Figure 1): design (1), fabrication (2), and assembly, testing, and packaging (ATP) (3). Production often requires more than 1,000 steps, fostering a web of complex interdependencies across nearly 100 international borders.[7] Existing interdependencies include U.S. semiconductor software, U.S., Japanese, and Dutch manufacturing equipment, and Korean and Taiwanese fabrication. Though China's existing semiconductor manufacturing industry tails industry leaders, its increased efforts to gain market share parity are helping to erode existing U.S. positions of strength. A 2002 Government Accounting Office (GAO) report found that China is gaining parity as its efforts to improve its

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[3] "National Security Strategy," White House, accessed November 2023, https://www.whitehouse.gov/wp-content/uploads/2022/10/Biden-Harris-Administrations-National-Security-Strategy-10.2022.pdf.
[4] "Military-Civil Fusion and the People's Republic of China," Department of State, accessed January 23, 2023, https://www.state.gov/wp-content/uploads/2020/05/What-is-MCF-One-Pager.pdf.
[5] Congressional Research Service, *Semiconductors: U.S. Industry, Global Competition, and Federal Policy*, (October 26, 2020), https://crsreports.congress.gov/product/pdf/R/R46581/5.
[6] Congressional, "Semiconductors".
[7] Saif M. Kahn, Alexander Mann, and Dahlia Peterson, *The Semiconductor Supply Chain: Assessing National Competitiveness* (Center for Security and Emerging Technology, 2021), 5.

domestic semiconductor manufacturing capability have narrowed the U.S.-PRC capability gap from >7 years to <2 years (Figure 2).[8]

Since 1949, the United States Government (USG) has applied economic sanctions to further its national interests.[9] Increasingly, the USG leverages economic instruments of power and restricts trade to deny sensitive scientific know-how and technologies deemed vital to national security; tactics driven in many ways by its top global economic standing and dominant key market position.[10] U.S. policymakers contend that control of "the transfer of design and manufacturing know-how is of overwhelming importance."[11] The USG continues to pursue policies of national economic competition with the PRC to enhance the state's competitive position.[12] It is important, however, to recognize the existing trade dependencies between the two powers. As of 2020, China was the U.S.'s top trading partner, ranking as the top import country and the third largest export destination. Integrated circuits are the top U.S. export and often account for one of the top export commodities to China. For example, in 2020, integrated circuits were the U.S.'s second-highest export to China (8.5%), while finished computers accounted for the U.S.'s top Chinese import (11.2%).[13]

Reason exists for the U.S. to be judgmental of the PRC's MCF and weary of asserted end-use applications. MCF blurs the delineation between the open and restricted end-use of a

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[8] "Export Controls: Rapid Advances in China's Semiconductor Industry Underscore Need for Fundamental U.S. Policy Review," Government Accounting Office, April 19, 2002, https://www.gao.gov/products/gao-02-620.
[9] Haoyang Li, Di Wu, Jingwei Chen, and Kam C. Chan. "The impact of technology export regulations on corporate R&D investments." *Borsa Istanbul Review* (2022).
[10] Gary Clyde Hufbauer, *Economic Sanctions Reconsidered* (Washington, D.C.: Peterson Institute for International Economics, 2007), 92.
[11] United States Defense Science Board. Task Force on Export of United States Technology. *An Analysis of Export Control of US Technology-a DoD Perspective*. Office of the Director of Defense Research and Engineering, 1976, 1.
[12] James Lee and Richard Maher, "US economic statecraft and great power competition," *Business and Politics* 24, no. 4 (2022): 338.
[13] "Country to Country Comparison," The Observatory of Economic Complexity, accessed January 23, 2023, https://oec.world/en/profile/bilateral-country/usa/partner/chn.

piece of technology and has caused the U.S. to question the foreign application of its most sensitive domestic exports. In support of foreign policy objectives, the U.S. recently implemented export controls on the PRC that limit the export of sensitive advanced computing technology and SME.[14] Specifically, this rule imposes restrictive export controls on advanced computing semiconductor chips, new controls on SME, transactions for integrated circuit and supercomputer end-uses, and transactions involving certain commodities on the Entity List.[15]

The intended consequence of the recently imposed US export controls is to offset the PRC's MCF strategy and to impair its military potential by stifling the ability to procure chips that may lead to the advancement of Chinese military capabilities. This effort to maintain overmatch demonstrates a national security strategy grounded in geoeconomics.[16] In pursuing U.S. interests, the debate has hinged on how, then, "to keep the U.S. tech superior to any adversary in weapons and defense while maintaining a proper balance with the sometimes-competing interests of scientific and technological excellence and economics strength."[17] It is important, therefore, to understand the likeliness of the policy's intended outcome by analyzing the general effectiveness of targeted sanctions.

The Case for Geoeconomics

[14] "Commerce Implements New Export Controls on Advanced Computing and Semiconductor Manufacturing Items to the People's Republic of China (PRC)," Bureau of Industry and Security, October 7, 2022, https://www.bis.doc.gov/index.php/documents/about-bis/newsroom/press-releases/3158-2022-10-07-bis-press-release-advanced-computing-and-semiconductor-manufacturing-controls-final/file,1.
[15] "Commerce Implements", 2.
[16] Cindy Whang, "Trade and Emerging Technologies: A Comparative Analysis of the United States and the European Union Dual-Use Export Control Regulations." *Security and Human Rights* 31, no. 1-4 (2021): 26.
[17] Roland W. Schmitt, "Export Controls: Balancing Technological Innovation and National Security." *Issues in Science and Technology* 1, no. 1 (1984): 117–26. http://www.jstor.org/stable/43308858.

The motive behind a government or international regime's use of trade or financial sanctions as economic instruments of power are to punish, deter, or rehabilitate.[18] Focusing on trade sanctions, a 'sending' country can inflict costs on a target by restricting imports, exports, or a combination of both. Heavy trade restrictions increase the relative distance between countries by slowing the target country's economic growth and limiting development in that sector. These impacts on the target country hopefully assure a long-term competitive advantage for the sender. Through a narrower lens, the strategic intent of export control is to restrict an adversary's access to domestic technologies.[19]

The overall level of geoeconomic policy effectiveness is difficult to assess, but a fair argument can be made for using sanctions. In a comprehensive analysis of over 200 case studies of international sanctions since WWI through the beginning of the 21st century, 34% were found to be at least partially successful.[20] When measuring the effects of sanctions on a target's gross national product (GNP), successful impairment cases inflicted a negative loss of over 2%. Narrowing the scope to cases involving the impairment of a target's military potential, which accounted for 14% of all cases studied, 31% achieved a positive outcome.[21] International cooperation and the imposition of companion policies accounted for more than two-thirds of those cases with a successful outcome. Economic and political variables also impact success rates. A larger percentage of positive outcomes were noted when higher levels of trade existed between the sender and target countries and the political climate was stable. In successful cases,

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[18] Gary Clyde Hufbauer, *Economic Sanctions Reconsidered* (Washington, D.C.: Peterson Institute for International Economics, 2007).
[19] Michael J. Noble, "Export Controls and United States Space Power," *Astropolitics*, 6:3 (2008): 277, OI: 10.1080/14777620802469798
[20] Gary Clyde Hufbauer, *Economic Sanctions Reconsidered* (Washington, D.C.: Peterson Institute for International Economics, 2007).
[21] Hufbauer, *Economic Sanctions*, 71.

a target's trade with the sender usually accounted for one-third of the country's trade balance.[22] Considering the bilateral trade balance between the U.S. and China, financial and trade sanctions can be powerful.

Advocates of non-proliferation defend unilateral action contending that any potential collateral impact is a necessary risk to discourage and prevent the share of sensitive technologies.[23] Proponents of non-proliferation further argue that unilateral action on the international stage can help to rally for stronger multilateral measures. Those favoring export controls argue that the policies message "the values of the sender country and that declaration of national values serves important purposes in and of itself."[24] This was exemplified by the European and Russian adoption of International Atomic Energy Agency safeguards for nuclear-based exports after a decade of the U.S.'s unilateral insistence.[25] A study examining the adverse effects of sanctions on a target country's gross domestic product (GDP) found that the imposition of unilateral (U.S.) sanctions impacted the target's growth over 7 years by an average of only -.5-1%. Sanctions supported multilaterally by an international regime such as the UN, however, have an increased and longer-lasting effect, impacting growth over 10 years by -2.5-3.5%.[26] Multilateral policies can also yield compounding results if the international regime escalates the policy's severity.[27] The ongoing Russian-Ukraine conflict will soon provide new data on the

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[22] Gary Clyde Hufbauer, *Economic Sanctions Reconsidered* (Washington, D.C.: Peterson Institute for International Economics, 2007), 90.
[23] Robert Johnston, "U.S. Export Control Policy in the High-Performance Computer Sector," *The Nonproliferation Review*, 5:2 (1998): 44-59, DOI: 10.1080/10736709808436706, 52.
[24] Gary Clyde Hufbauer, *Economic Sanctions Reconsidered* (Washington, D.C.: Peterson Institute for International Economics, 2007).
[25] Robert Johnston, "U.S. Export Control Policy in the High-Performance Computer Sector," The Nonproliferation Review, 5:2 (1998): 44-59, DOI: 10.1080/10736709808436706, 52.
[26] Matthias Neuenkirch and Florian Neumeier, "The Impact of UN and US Economic Sanctions on GDP Growth," *FIW Working Paper, No. 138, FIW - Research Centre International Economics, Vienna* (2015)
[27] Neuenkirch, "The Impact".

topic, but the impact of multilateral sanctions imposed with increased severity is seemingly impairing Russia's military-industrial base. It is evident that multilateral export controls have limited Russia's ability to produce weapons and replenish war stock such as precision-guided munitions.[28]

Trade Restrictions, A Zero-Sum Game

Critics argue, however, that economic sanctions rarely yield the intended effect. For example, attempts by the USG in the late 1990s to restrict the PRC and Russia from access to high-powered computers were circumvented and thwarted by unethical trade practices. High-powered computer systems within the Chinese Academy of Sciences were found to be of capability grade higher than domestic export authorizations allowed, raising concern that the systems could be or were used for weapons development instead of the asserted academic use.[29] U.S. systems sold to Russia under the assertion that they would be used for environmental science end-use applications were found in the country's nuclear weapons laboratory.[30]

Seemingly, sanctions hurt domestic interests and have a greater collateral impact.[31] It is estimated that U.S. export controls on supercomputers in the early 1990s cost the domestic industry $640 million in sales and over 12,000 jobs.[32] In 2006 the Aerospace Industries Association (AIA) credited trade restrictions and policies driven by the Buy American Act, which required 50% of the makeup of domestic products to be of U.S. origin, as the leading

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[28] Sheelah Kolhatkar, "The Money War." *The New Yorker* XCVIII (2022): 35.
[29] Robert Johnston, "U.S. Export Control Policy in the High-Performance Computer Sector," *The Nonproliferation Review*, 5:2 (1998): 44-59, DOI: 10.1080/10736709808436706.
[30] Johnston, "U.S. Export".
[31] Yang Chunmei and Mai Wenyi, "The US high technology export control towards China." *Journal of Business* 1, no. 2 (2016): 13-16.
[32] Robert Johnston, "U.S. Export Control Policy in the High-Performance Computer Sector," *The Nonproliferation Review*, 5:2 (1998): 44-59, DOI: 10.1080/10736709808436706.

cause for higher-priced and lower-quality products for U.S. homeland security programs.[33] In 2018, the USG imposed a 25% tariff on imported Chinese semiconductors under the auspice that unfair Chinese trade practices hurt U.S.-based companies. The U.S. domestic semiconductor industry, strongly opposed to this action, argued that the tariffs were "counterproductive and fail(ed) to address intellectual property theft or industrial policy concerns."[34] The USG's action resulted in a tariff war that, by the end of 2019, covered over $450 billion in bilateral trade.[35] Economists suggest that support payments to the affected domestic agricultural industry exceeded 130% of tariff revenue and that the trade war will amount to hundreds of billions lost to the U.S. economy.[36]

Free-trade advocates argue that unilateral dual-use export controls are effective only when the technology is unavailable in another country. If the technology is pervasive and exists elsewhere, the target country can circumvent any imposed sanction, as was the case when the U.S. imposed sanctions against Pakistan's nuclear program following the Soviet invasion of Afghanistan.[37] In the contemporary environment, allied democracies with a controlling stake in SME have stated that they would sell to China even if the U.S. applies limitations on similar technologies. This would undermine unilateral action and thwart any attempt to unify imposition efforts. Consequentially, this could accelerate the growth of the foreign market and drive competition by creating opportunities for other state actors to compete for market share. For

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[33] Michael J. Noble, "Export Controls and United States Space Power," *Astropolitics*, 6:3 (2008): 277, OI: 10.1080/14777620802469798

[34] SIA. 2018. "SIA Statement on Trump Administration Tariff Announcement." Semiconductor Industry Association. June 15, 2018. https://www.semiconductors.org/sia-statement-on-trump-administration-tariff-announcement/.

[35] Chad P. Bown, "How the United States marched the semiconductor industry into its trade war with China." *East Asian Economic Review* 24, no. 4 (2020): 349-388.

[36] Daniel W. Drezner, "Economic Statecraft in the Age of Trump", *The Washington Quarterly*, 42:3 (2019): 7-24, DOI: 10.1080/0163660X.2019.1663072.

[37] Gary Clyde Hufbauer, *Economic Sanctions Reconsidered* (Washington, D.C.: Peterson Institute for International Economics, 2007), 130.

example, in the 1980s, the U.S. domestically maintained six of the world's top ten leading semiconductor firms. But competition with the Japanese semiconductor industry drove domestic protectionist advocates to promote an interventionist trade policy. The USG signed into action the 1986 Semiconductor Trade Agreement that enforced tariffs on Japanese technology, providing South Korea, and Taiwan an opportunity advantage to gain a foothold in the market. Taiwan and South Korea now dominate the fabrication sector of the market, with semiconductors making up nearly one-third and one-fifth of the country's exports, respectively.[38]

Unilateral export controls have generally been found to be sub-optimal given that the targeted country may be able to decouple and equally weaponize its economic sector.[39] Restrictions on trade force the target country to find a competitive edge, which can lead to escalatory retaliation. As the most globally rich region for rare earth metals, China could also threaten the control of raw material exports like gallium or germanium in a tit-for-tat scenario. While this could disrupt the manufacturing of gallium-based wafers and the manufacturing of transistors, the resulting economic impact has yet to be studied and bears consideration.[40]

Export controls and domestic uncertainty over access to foreign markets also create barriers to entry and lead to offshoring. In a 2007 Department of Commerce survey of the U.S. space industry, 58% of those polled reported export controls as the primary barrier to entry into the foreign market.[41] Even the Center for Security and Emerging Technology (CSET), which

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[38] Chad P. Bown, "How the United States marched the semiconductor industry into its trade war with China." *East Asian Economic Review* 24, no. 4 (2020): 351.
[39] "Washington's Multilateral Export Control Impasse." n.d. China-US Focus. Accessed January 9, 2023. https://www.chinausfocus.com/finance-economy/washingtons-multilateral-export-control-impasse.
[40] OECD, *The Economic Impact of Export Restrictions on Raw Materials,* (OECD Publishing, 2010), http://dx.doi.org/10.1787/9789264096448-en.
[41] Michael J. Noble, "Export Controls and United States Space Power," *Astropolitics*, 6:3 (2008): 277, OI: 10.1080/14777620802469798

believes export controls on advanced SME is integral in assuring China's sustained dependence on foreign-produced chips, argues that America's unilateral controls have led to an increase in offshoring.[42] While multilateral actions have been deemed more effective than unilateral efforts, especially through international regimes like the UN, cooperation is difficult.

Legacy international regimes like the League of Nations or the Coordinating Committee for Multilateral Export Controls (CoCOM) have not been without their limitations. The CoCOM existed to coordinate export control policies to restrict Soviet access to military technologies. Even in the mid-1980s, the U.S. proposed to multilaterally restrict the Soviet acquisition of SME such as photolithography machines and chip design software, but these efforts had limited effect.[43] In the contemporary environment, regimes such as the Australia Group, Missile Technology Control Regime, and the Nuclear Suppliers Group have a limited focus on weapons non-proliferation. Only the Wassenaar Arrangement (WA) currently encompasses dual-use technologies such as semiconductors within its scope of consideration. The WA, established in 1996 as a CoCOM byproduct of the post-Cold War era, exists as the current international avenue to control the export of conventional weapons and dual-use goods and technologies. As a conglomerate of 42 voluntary member states, the WA demonstrates similar symptoms to its predecessor. Because participation and the exchange of information is voluntary, information on export licensing agreements or controls is only sometimes shared and to a questionable extent. Furthermore, there is currently no consensus among members regarding what constitutes

[42] Andre Barbe and Will Hunt, "Preserving the Chokepoints: Reducing the Risks of Offshoring Among U.S. Semiconductor Manufacturing Equipment Firms" (Center for Security and Emerging Technology, May 2022). https://doi.org/10.51593/20210045

[43] Gary Clyde Hufbauer, *Economic Sanctions Reconsidered* (Washington, D.C.: Peterson Institute for International Economics, 2007), 71.

countries or states of concern and the WA has also failed to limit China's ability to procure SME.[44]

Policy Recommendations

The U.S. must find a balance that effectively limits the proliferation of sensitive material and intellectual property without stifling creativity and hurting economic growth. The government must continue to exploit its competitive advantage abroad by limiting the transfer of sensitive science and technology. While economic sanctioning is only marginally impactful, this tool is still effective one-third of the time.[45] At home, the USG must consider subsidization packages to incentivize and revitalize the domestic chip industry. The CHIPS and Science Act is a superb first effort. The USG's bipartisan CHIPS and Science Act, introduced in 2020 and passed in 2022, is intended to enhance domestic semiconductor manufacturing capacity and the country's position in the semiconductor value chain. What is vital to the U.S. maintaining its leadership, however, is the promotion of three domestic areas of influence: an investiture in human capital, a reshoring of SME operations, and an enhancement of chip manufacturing capabilities.

1. For the U.S. to maintain its leadership in the science and technology sector, it must focus on human capital.[46] The CHIPS act has the anticipated effect of creating 200,000 new jobs across the domestic semiconductor industry. To fill these jobs the U.S. must incentivize, recruit, and retain a highly skilled workforce. The U.S. should increase its access to the international

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[44] "Export Controls: Rapid Advances in China's Semiconductor Industry Underscore Need for Fundamental U.S. Policy Review," Government Accounting Office, April 19, 2002, https://www.gao.gov/products/gao-02-620.
[45] Gary Clyde Hufbauer, *Economic Sanctions Reconsidered* (Washington, D.C.: Peterson Institute for International Economics, 2007), ix.
[46] "U.S. Semiconductor and Software Industries Increasingly Produce in China and India," United States Government Accountability Office, Accessed December 15, 2023, https://www.gao.gov/assets/gao-06-423.pdf, 44.

STEM talent pool while actively attempting to retain those educated within its borders. U.S. academic institutions are awarding two-thirds of advanced degrees to foreign nationals.[47] Only 6% of U.S. undergraduates pursue engineering degrees compared to 40% of Chinese undergraduates.[48] The USG could offset the loss of foreign talent by restructuring its visa program to offer securities to foreign nationals. Examples include preemptively approving green cards for those pursuing STEM-based advanced degrees with the intention of gaining U.S. employment or decoupling visas from employers to protect employees between jobs.[49] The development of a highly skilled workforce must start at the bottom. The USG must start developing talent earlier through the subsidization of K-12 STEM-based educational programs with a targeted emphasis on the extension of opportunities to the financially disadvantaged and underrepresented.

2. The U.S. has benefited from its leadership in semiconductor chip design and accounts for 50% of the highly specialized global workforce.[50] To maintain its standing in the chip design and SME space, the domestic industry must continue to develop and export these technologies. While most U.S. SME exports are produced onshore, the top three domestic firms either have or are investing in and building offshore manufacturing capacity.[51] If U.S. firms continue offshoring their operations, the country will lose its relative position. The CHIPS Act already

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[47] Government Accountability Office, "U.S. Semiconductor".
[48] Michael J. Noble, "Export Controls and United States Space Power," *Astropolitics*, 6:3 (2008): 277, OI: 10.1080/14777620802469798
[49] Semiconductor Industry Association, *2022 State of the U.S. Semiconductor Industry,* (Semiconductor Industry Association, 2022), https://www.semiconductors.org/wp-content/uploads/2022/11/SIA_State-of-Industry-Report_Nov-2022.pdf
[50] Semiconductor, *2022 State*.
[51] Andre Barbe and Will Hunt, *Preserving the Chokepoints: Reducing the Risks of Offshoring Among U.S. Semiconductor Manufacturing Equipment Firms* (Center for Security and Emerging Technology, May 2022), https://doi.org/10.51593/20210045.

boasts $13 billion for R&D, but further government subsidies may be needed to incentivize SME firms to remain onshore. I also advocate for liberalized restrictions on more pervasive and mature equipment in a combative effort against the offshoring of U.S. SME firms. Since this is a position of U.S. strength and leadership, the USG must continue to restrict the export of SME but the restrictions should be narrowed to 'advanced' SME. Specifically, the USG should limit the export of technologies to one to two generations behind pacing technology. For this to be effective, the USG must forge a common understanding with the Netherlands and Japan, the two other countries that dominate this sector. While current international bodies have proven ineffective in curbing proliferation, the USG should pursue bi and trilateral arrangements to restrict the exchange of these sensitive technologies.

3. Should the U.S. desire to shore up its position within the supply chain and increase the relative distance between itself and China, it must also reinvigorate the domestic chip fabrication industry. The U.S. maintains only a 10% market share of the semiconductor fabrication industry[52] and zero advanced semiconductor fabrication firms.[53] There is growing discussion among U.S. national security officials about using export controls to pressure Taiwan's TSMC to roll out its newest fabrication technologies simultaneously within U.S. borders. Consequentially, bullying Taiwan into choosing between Beijing and Washington will only further strain bilateral relations. Intel Corporation is America's best chance to cover lost ground in the fabrication space, given its experience in this sector. Intel has plans to launch a new chip foundry and is slated to acquire the next-generation extreme ultra-violet (EUV) machine from Dutch

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[52] Saif M. Khan, *Securing Semiconductor Supply Chains* (Center for Security and Emerging Technology, January 2021), https://doi.org/10.51593/20190017.

[53] Will Hunt, *Sustaining U.S. Competitiveness in Semiconductor Manufacturing* (Center for Security and Emerging Technology, January 2022), https://doi.org/10.51593/20210024.

lithography equipment maker ASML.[54] Though the U.S. may be years away from being able to manufacture the most advanced logic chips, the country will still have a competitive advantage over the PRC in the chip manufacturing space. The CHIPS Act boasts $39 billion in government subsidization for advanced semiconductor manufacturing, but how much has been sidelined for advanced fabrication start-up initiatives is unknown. A portion of the CHIPS act should immediately be secured for this initiative. Should the USG delay action, the perceived costs 10 years from now are estimated to be three times as much.[55] Should the USG completely fail to act to improve its position within the fabrication space, the U.S. will undoubtedly concede its position within the supply chain.

Conclusion

The USG struggles to balance a foreign policy that effectively combats the proliferation of sensitive technologies but also promotes an interdependent and globalized free market. The U.S. maintains a position of relative strength within the global semiconductor industry as a leader in semiconductor design and a key exporter of SME. Because of the semiconductor supply chain's globally integrated manufacturing complexities, the U.S. is uniquely postured to exploit its advantage. With the goal of keeping the PRC at least two generations (three to four years) behind leading semiconductor technologies, the U.S. must leverage economic instruments to limit the transfer of its most sensitive technologies. Export controls are proven to be marginal to moderately effective and can impact a nation's GNP over a seven-to-ten-year span. With consideration to any potential collateral impact due to unilateral economic action, the U.S. must combine geoeconomics with domestic initiatives. Novel ways to reinvigorate the domestic

[54] Chris Miller, *Chip War: The Fight for the World's Most Critical Technology* (Simon and Schuster, 2022).
[55] Miller, *Chip War.*

semiconductor industry, such as the CHIPS and Science Act, will help to ensure the U.S. remains a key stakeholder in the industry and within the supply chain.

In concert with domestic initiatives, the USG must do a better job of compelling other nations to consider the potential global impact of the proliferation of similar dual-use technologies. This cooperative engagement is necessary to ensure export control effectiveness. The USG must look beyond the WA to improve cooperation between the four leaders in the semiconductor supply chain. The Netherlands, Japan, Taiwan, and the U.S. should develop a unified security strategy that focuses on hardening the security of the semiconductor supply chain to curb the proliferation of their intellectual property, fabrication hardware, integrated circuits, and advanced semiconductors. In acknowledging that collective government involvement may affect industry-wide revenues, this unified strategy will ensure that those democracies maintain a competitive advantage against potential adversaries.

Modern semiconductor manufacturing is a globally integrated, multi-stage process

The stages and examples of companies involved in the semiconductor design and manufacturing supply chain

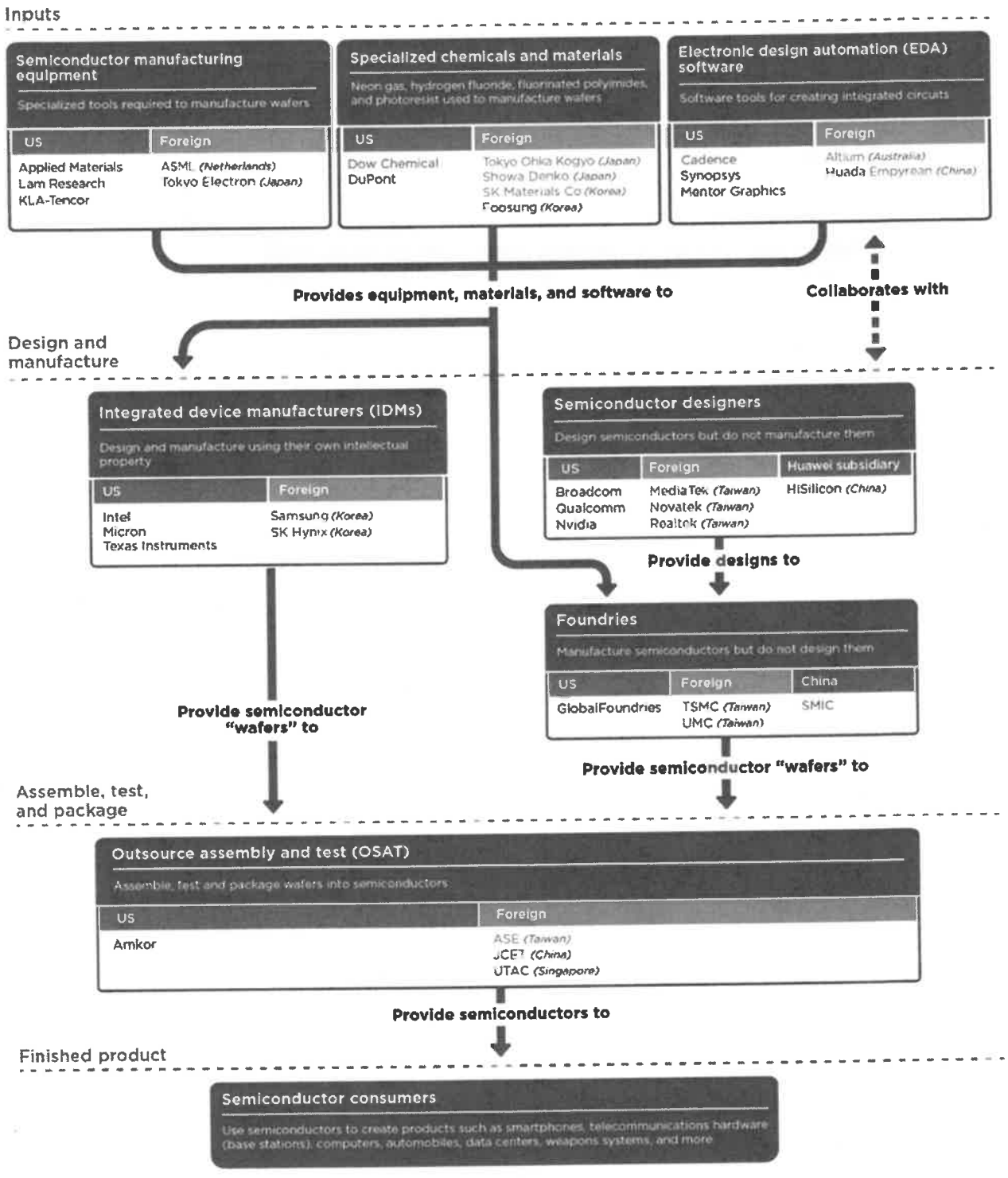
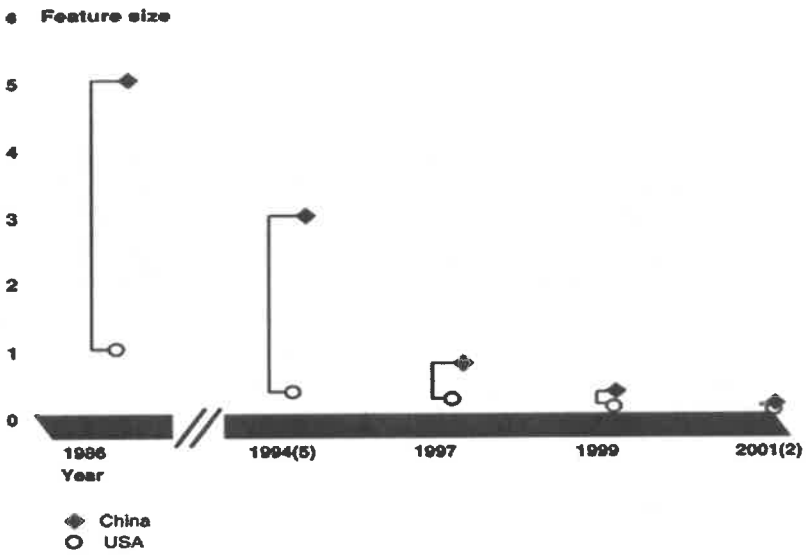


Figure 1: Semiconductor Supply Chain



The gap between U.S. and Chinese semiconductor manufacturing technology, as measured in the feature size of the semiconductors produced, rapidly diminished in recent years. A semiconductor's feature size is measured in microns and is used to define the current level of technology.

Figure 2:

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