HOW DOES THE U.S. EXPORT CONTROL ON ADVANCED COMPUTING SEMICONDUCTORS IN CHINA ENSURE U.S.-TAIWAN TECH SUPPLY CHAIN PARTNERSHIP

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EXECUTIVE SUMMARY

Semiconductor chips play an indispensable role in the world's social infrastructure. From consumer electronics to medical device networks, these advanced chips make up a foundational mainstay of everyday life. Much of the manufacturing occurs overseas particularly in Taiwan, a self-governing democracy that has recently faced growing military aggression from Beijing in recent months.

In August, former U.S. House Speaker Nancy Pelosi visited Taiwan and met with President of Taiwan Tsai Ing-wen, as part of Pelosi's congressional delegation visit in Asia. In response, Beijing launched live-fire rockets, ballistic missiles, and a volume of cyber-attacks "23 times higher than the previous daily record"[1] against the Taiwan Strait. Pelosi's visit came at a tenuous moment amid tensions between Washington and Beijing reaching levels unseen in nearly thirty years. On a phone call with U.S. President Joe Biden a week prior, Chinese President Xi Jinping accused the U.S. of "play[ing] with fire" over Taiwan.[2] Beijing has also raised tacit support for Russia's invasion of Ukraine.[3]

Despite the controversial visit, Pelosi has routinely underscored the island's crucial role in the global chip supply chain, particularly on the world's biggest chipmaker, Taiwan Semiconductor Manufacturing Co. (TSMC). Additionally, in a meeting with TSMC Chairman Mark Liu, Pelosi underlined the importance of semiconductors on U.S. national security.[4]

The COVID-19 pandemic and the Russian invasion of Ukraine have introduced further uncertainties to the semiconductor supply chain. Demand for semiconductors in 2020 and 2021 exceeded prepandemic forecasts in almost all industries.[5] High-tech sales volumes have increased during the pandemic, partly wrought by greater reliance on wireless connectivity and computers.

Experts have warned that any interference to Taiwan's chip manufacturing industry could "paralyze production of key equipment, impacting almost everyone in the world."[6] The risks for supply chain disruption, whether that be a natural disaster, global pandemic, or political

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[1] "Tracking the Fourth Taiwan Strait Crisis," Center for Strategic and International Studies (CSIS) China Power Project, October 13, 2022, https://chinapower.csis.org/tracking-the-fourth-taiwan-strait-crisis/; Sarah Wu and Eduardo Baptista, "From 7-11s to train stations, cyber attacks plague Taiwan over Pelosi visit," August 4, 2022, https://www.reuters.com/technology/7-11s-train-stations-cyber-attacks-plague-taiwan-over-pelosi-visit-2022-08-04/.

[2] Ministry of Foreign Affairs of the People's Republic of China, "President Xi Jinping Speaks with US President Joe Biden on the Phone," July 9, 2022, https://www.fmprc.gov.cn/eng/zxxx_662805/202207/t20220729_10729593.html.

[3] Phelim Kine, "China sees strategic advantage in Russia's Ukraine invasion," Politico, February 26, 2022, https://www.politico.com/news/2022/02/26/china-sees-strategic-advantage-in-russias-ukraine-invasion-00012032.

[4] Arjun Kharpal, "Pelosi's Taiwan trip puts the world's biggest chipmaker back in the spotlight of U.S.-China rivalry," August 3, 2022, CNBC, https://www.cnbc.com/2022/08/04/pelosi-taiwan-visit-puts-tsmc-back-in-spotlight-of-us-china-rivalry.html.

[5] Ondrej Burkacky, Johannes Deichmann, Philipp Pfingstag and Julia Werra, "Semiconductor shortage: How the automotive industry can succeed," McKinsey & Company, June 10, 2022, https://www.mckinsey.com/industries/semiconductors/our-insights/semiconductor-shortage-how-the-automotive-industry-can-succeed.

[6] Eric Cheung, "Tensions with Beijing throw spotlight on Taiwan's unique role in global tech," CNN, April 7, 2022, https://www.cnn.com/2022/04/06/tech/taiwan-china-conflict-impact-tsmc-chips-hnk-intl/index.html.

deliberation on armed conflict, are particularly acute. Exposing existing vulnerabilities in the U.S. — due in part of recent shortage of automotive chips and the geopolitical uncertainty of Taiwan — is firstly necessary to composing a proper recommendation.

This report is intended to examine the semiconductor supply chain as a crucial nexus of U.S.-Taiwan partnership with financial market and national security interests at its core. To address resulting findings in the report, I will offer policy recommendations for the U.S. government and companies to consider strategies for rebuilding domestic resilience in chip fabrication and defending Taiwan's chip infrastructure from the PRC. Such proposals fall into three main categories: (1) ensuring innovation and funding to reshoring U.S. chip supply chain, (2) commiting to U.S.-Taiwan partnership in economic resilience, and (3) erasing the PRC of its strategic leverage to produce advanced microchips for malign operations. By taking these steps, the U.S. government and companies can more effectively safeguard the semiconductor supply ecosystem in case of geopolitical disruption to the supply chain and ensure that Taiwan remains a close ally proper to its democratic and bilateral ties.

INTRODUCTION

On October 7, 2022, the U.S. Department of Commerce launched a new export control policy on advanced computing semiconductors to the People's Republic of China (PRC or China).[7] These new policies would restrict the PRC's ability to obtain and manufacture advanced computing chips and supercomputers for military purposes, including weapons of mass destruction, automated military systems, and human rights abuses. While tensions have existed between the two countries for decades, these rules make clear that technology has emerged as the new center stage of competition.

This policy did not emerge without a notable precedent. In June, a bipartisan group of senators unveiled the Facilitating American-Built Semiconductors (FABS) Act, which purpose was to grant tax-based incentives towards the making and expansion of semiconductor fabrication factories (or 'fabs') in the U.S.[8] Two months later, in August, the Biden administration signed a bipartisan Creating Helpful Incentives to Produce Semiconductors (CHIPS) for America Act 2022 with the intention of improving American technological supply chains and creating new manufacturing jobs in the semiconductor and advanced computing industry, all while "ensuring that what is invented in America is made in America."[9] Yet, a tertiary goal belies the domestic

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[7] Bureau of Industry and Security (BIS), "Commerce Implements New Export Controls on Advanced Computing and Semiconductor Manufacturing Items to the People's Republic of China (PRC)," 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.

[8] The Senate, "The Facilitating American-Built Semiconductors (FABS) Act," https://www.finance.senate.gov/imo/media/doc/FABS%20Act%20-%20One%20Pager.pdf.

[9] The White House, "FACT SHEET: CHIPS and Science Act Will Lower Costs, Create Jobs, Strengthen Supply Chains, and Counter China," August 9, 2022, https://www.whitehouse.gov/briefing-room/statements-releases/2022/08/09/fact-sheet-chips-and-science-act-will-lower-costs-create-jobs-strengthen-supply-chains-and-counter-china/.

rationale of the act, and that is the $52.7 billion subsidy is part of a targeted attempt to "counter China" and increase American competitiveness in the global technology market.[10]

It follows that a month later the Biden administration disclosed its first round of export control on the U.S. top two computing and artificial intelligence (AI) chipmakers, Nvidia and Advanced Micro Devices (AMD), to China in an effort to "address the risk that the covered products may be used in, or diverted to, a 'military end use' or 'military end user' in China and Russia."[11] Following the passage of the new export control and The CHIPS and Science Act, the U.S. is firmly intent on retaining a chokehold over China's military-technology pipeline.

Indeed, the PRC has made it clear that it will implement its vast technological resources to achieve leadership in artificial intelligence by 2030.[12] Additionally, in the Annual Threat Assessment of the U.S. Intelligence Community in April 2021, the Bureau of Industry and Security (BIS) at the Commerce reported that China will follow through its scheme to at least double the size of its nuclear warhead stockpile in the next decade.[13] By issuing an end-use control of advanced computing semiconductor technology and AI, the Biden administration intends to disrupt China's modernization ambitions and challenge the legitimacy of the Chinese Communist Party.

So, to what extent do U.S. efforts to suppress Beijing's rapid expansion in military-technology and malign influence in the geopolitics succeed? How effective are U.S. efforts to forestall China of high-end technology access and establish bilateral trade talk with Taiwan in favor of its robust semiconductor supply chain model? This paper focuses on Taiwan's semiconductor industry as a critical role in the U.S. and China technological competition and considers the outcome of a U.S.-Taiwan technological supply chain partnership.

HISTORY AND IMPORTANCE OF THE U.S.-TAIWAN RELATIONSHIP

Sealocked at the junction of the East and South China Sea, roughly 100 miles away from China, is Taiwan, officially the Republic of China (ROC). Taiwan holds a unique position in foreign policy. The island is sovereign by international law; effectively, it asserts the right to self-govern freely within the confines of its territory, yet the United Nations (UN) does not recognize Taiwan as a member state. Only 13 countries and the Vatican City/Holy See grant Taiwan's independence, and it faces a growing existential threat from the PRC that claims "effective jurisdiction" and demands the prospect of "forceful unification" if diplomacy fails.

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[10] Ibid.
[11] Stephen Nellis and Jane Lanhee Lee, "U.S. officials order Nvidia to halt sales of top AI chips to China," Reuters, September 1, 2022, https://www.reuters.com/technology/nvidia-says-us-has-imposed-new-license-requirement-future-exports-china-2022-08-31/.
[12] BIS, "Implementation of Additional Export Controls: Certain Advanced Computing and Semiconductor Manufacturing Items; Supercomputer and Semiconductor End Use; Entity List Modification," October 13, 2022, https://www.federalregister.gov/documents/2022/10/13/2022-21658/implementation-of-additional-export-controls-certain-advanced-computing-and-semiconductor.
[13] Office of the Secretary of Defense, "Military and Security Developments Involving the People's Republic of China 2020," 2020, https://media.defense.gov/2020/Sep/01/2002488689/-1/-1/1/2020-DOD-CHINA-MILITARY-POWER-REPORT-FINAL.PDF.

Since the normalization of diplomatic relations with China in 1979, the U.S. relationship with Taiwan has remained unofficial under the auspices of The American Institute in Taiwan (AIT) and the Taipei Economic and Cultural Representative Office (TECRO) in the United States.[14] Decades after, Taiwan has continually received long-standing U.S. bipartisan support for its shared democratic, leadership, economic, and technological interests.

TSMC AND TAIWAN'S SEMICONDUCTOR SUPPLY CHAIN

Indeed, so much depends on Taiwan's global and strategic leverage, which, in 2021, has become the U.S. eighth largest trading partner and 18th largest economy in the world.[15] In 2020, the Observatory of Economic Complexity (OEC) at MIT published a ranking Intensity Index measuring the relative knowledge intensity and economic performance of a country. Between 2000 to 2020, out of 147 countries, Taiwan's ranking rose from 22nd to 2nd whereas China's standing grew from 54th to 29th, despite being the world's second largest economy.[16]

Taiwan houses the world's biggest microchip maker, Taiwan Semiconductor Manufacturing Co. (TSMC), which accounts for 92% of all advanced semiconductor chips in the U.S. and has supplied microchips to top U.S. companies like Apple, Google, Intel, Qualcomm, AMD, and Nvidia.[17] The TSMC business model is dedicated entirely to chip manufacturing rather than design, which has primarily led to the emergence of the "fabless model" in the United States where semiconductor engineering firms no longer depend on internal chip-manufacturers or -fabricators but would rather license their manufacturers to contractors like TSMC.

This model has reduced the American semiconductor manufacturing capacity from about 40 percent of global market share in 1990 to 12 percent in 2020.[18] Yet, according to a 2020 report by the Center for Security and Emerging Technology, the U.S. semiconductor engineering firms' sales have totaled more than $200 billion, covering 45% of the global market.[19]

The Taiwanese technological supply chain is at peril given that the core manufacturing facility is located at a geopolitical security risk. Without a doubt, Taiwan's strategic dominance in the semiconductor industry has refurnished an unprecedented order among the U.S.-China-Taiwan

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[14] National Development Council, "The American Institute in Taiwan (AIT) and the Taipei Economic and Cultural Office in the United States (TECRO) Joint Statement on the 2nd Digital Economy Forum," October 13, 2016, https://www.ndc.gov.tw/en/nc_8455_26393.

[15] International Trade Association, "Taiwan - Country Commercial Guide," September 15, 2022, https://www.trade.gov/country-commercial-guides/taiwan-market-overview.

[16] Richard Cronin, "Semiconductors and Taiwan's 'Silicon Shield.'"

[17] Yimou Lee, Norihiko Shirouzu, and David Lague,"Taiwan Chip Industry Emerges as Battlefront in U.S.-China Showdown," Reuters, December 27, 2021, https://www.reuters.com/investigates/special-report/taiwan-china-chips; Jason Matheny, "The U.S. Has a Microchip Problem Safeguarding Taiwan Is the Solution," The Atlantic, October 3, 2022, https://www.theatlantic.com/international/archive/2022/10/taiwan-microchip-supply-chain-china/671615/.

[18] Congressional Research Service (CRS), "Semiconductors: U.S. Industry, Global Competition, and Federal Policy," October 26, 2020, https://crsreports.congress.gov/product/pdf/R/R46581.

[19] Will Hunt and Remco Zwetsloot, "U.S. Strengths and Priorities for the High-End Semiconductor Workforce," Center for Security and Emerging Technology, September 2020, https://cset.georgetown.edu/publication/the-chipmakers-u-s-strengths-and-priorities-for-the-high-end-semiconductor-workforce/.

relation, notably granting Taiwan a "silicon shield" that is key to thwarting the communist state from invading Taiwan. After all, a Chinese invasion against Taiwan would be disastrous for China's economy — not to mention, the global economy — given its reliance on the Taiwanese manufacturing industry. About 70% of TSMC chip products are processed into China's leading consumer electronics industry.[20]

As a result, the U.S. has poured in billions of dollars into the CHIPS Act to expand its own semiconductor ecosystem by reshoring the industry from the ground up. About 72% of the funding would be directed to the making of "fab" equipment and factories in the U.S.[21] The remaining $11 billion funding will be appropriated to R&D and $2.7 billion to other sectors. In all, the legislation's billion-dollar investment in domestic chip manufacturing aims to boost U.S. international economic competitiveness in high-tech sectors and preserve its chip market resilience in case of supply chain disruptions abroad. While offshoring the industry may provide long-term resilience to the U.S., relocating supply chains may reduce profitability and productivity, and result in overcapacity in chip manufacturing.

ADVANCING U.S.-TAIWAN PARTNERSHIP IN THE CHIP "FAB" SUPPLY CHAIN

There are four key reasons why Taiwan has earned its place as the world-leading supplier of chips: (1) engineering talent pipeline, (2) government leadership, (3) investment in Research and Development (R&D), and (4) advanced technological development. In the 1970s, the Taiwanese government recruited a talented workforce of managers and engineers who are now spearheading the world's top semiconductor manufacturing and Integrated Circuit (IC) design companies, including Morris Chang of TSMC, Minn Wu of Macronix, and Nicky Lu of Etron. Taiwan's advanced technological powerhouse is, in large part, due to government funding and support, and the installment of the Taiwan Semiconductor Research Institute (TSRI).[22] TSMC has also allocated plans to invest in R&D work, specifically "beyond-2nm node and on areas such as 3D transistors, new memory and low-R interconnect," by 2025.[23]

For this reason, Taiwan has recently attracted major multinational investments in R&D. This year, R&D exceeded NT $24 billion (US $786 million) in foreign business investments, which is an eight-fold increase since 2018.[24] The R&D model has been attractive for decades in the U.S.,

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[20] Richard Cronin, "Semiconductors and Taiwan's 'Silicion Shield,'" Stimson Center, August 16, 2022, https://www.stimson.org/2022/semiconductors-and-taiwans-silicon-shield/.
[21] White House Briefing Room, "FACT SHEET: CHIPS and Science Act Will Lower Costs, Create Jobs, Strengthen Supply Chains, and Counter China," August 9, 2022, https://www.whitehouse.gov/briefing-room/statements-releases/2022/08/09/fact-sheet-chips-and-science-act-will-lower-costs-create-jobs-strengthen-supply-chains-and-counter-china/.
[22] Hung-Yi Wu, I-Shuo Chen, Jui-Kuei Chen, and Ching-Fan Chien, "The R&D efficiency of the Taiwanese semiconductor industry," *Elsevier* 137 (2019): 203-213. https://doi.org/10.1016/j.measurement.2019.01.053.
[23] Taiwan Semiconductor Manufacturing Company (TSMC), "Future R&D Plans," https://www.tsmc.com/english/dedicatedFoundry/technology/future_rd.
[24] "R&D investment in Taiwan by multinationals exceeds NT$24 billion," Focus Taiwan CNA English News, September 1, 2022, https://focustaiwan.tw/business/202209010032.

rather not so much in the semiconductor industry. U.S. chip production dropped from 37% in 1990 to 12% in 2022 as U.S. semiconductor R&D share experienced a severe decline.[25]

The National Security Commission on Artificial Intelligence uncovered in a report that the U.S. relies on Taiwan and other foreign manufacturers to produce AI-powered semiconductors "that power all the AI algorithms critical for defense systems and everything else."[26] TSMC chips also power F-35 fighters and a host of "military-grade" equipment for the U.S. Department of Defense (DOD), as well as defense systems like field-programmable gate arrays (FPGA).[27]

The U.S. is not alone in the industry's emerging talent shortage. While the Taiwanese government had taken advantage of the semiconductor talent boon early on since the 1980s, Taiwan reportedly lost over 30,000 chip-manufacturing workers in the fourth quarter of 2021, a 77 percent growth in deficit since the second quarter of 2020 around the time when the COVID-19 virus hit the globe.[28] Cultivating a talent pipeline in the industry would be commercially viable both in the U.S. and Taiwan, according to leading experts of the Semiconductor Industry Association, as the two governments work to rebuild regional and cross-continental clusters of high-technology.[29]

The latter kind is crucial to maintaining democratic ties with Taiwan, primarily as the geopolitics of the Taiwan strait continue to grow more tense. Ever since the election of President Tsai Ing-Wen of Taiwan in 2016, Tsai has carried out her promise to toughen her stance on China's reunification plans, asserting that Taiwan will maintain its democratic standing and refuse to comply with Chinese demands for unification.[30] However, Xi has not backed down on his

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[25] Dylan Patel, "Why America Will Lose Semiconductors," SemiAnalysis, June 13, 2022, https://www.semianalysis.com/p/why-america-will-lose-semiconductors; President's Council of Advisors on Science and Technology, "REPORT TO THE PRESIDENT Revitalizing the U.S. Semiconductor Ecosytem, "September 2022, https://www.whitehouse.gov/wp-content/uploads/2022/09/PCAST_Semiconductors-Report_Sep2022.pdf.

[26] National Security Commission on Artificial Intelligence, "Final Report," March 19, 2021, https://www.nscai.gov/wp-content/uploads/2021/03/Full-Report-Digital-1.pdf.

[27] Sujai Shivakumar and Charles Wessner, "Semiconductors and National Defense: What Are the Stakes?", Center for Strategic & International Studies (CSIS), June 8, 2022, https://www.csis.org/analysis/semiconductors-and-national-defense-what-are-stakes#:~:text=All%20major%20U.S.%20defense%20systems,defend%20itself%20and%20its%20allies.

[28] Sujai Shivakumar and Charles Wessner, "Reshoring Semiconductor Manufacturing: Addressing the Workforce Challenge," CSIS, October 6, 2022, https://www.csis.org/analysis/reshoring-semiconductor-manufacturing-addressing-workforce-challenge#:~:text=Talent%20Shortage%20and%20Competition%3A%20A%20Global%20Concern&text=Taiwan%2C%20which%20has%20the%20most,the%20second%20quarter%20of%202020.

[29] Antonio Varas, Raj Varadarajan, Jimmy Goodrich, and Falan Yinug, "Government Incentives and US Competitiveness in Semiconductor Manufacturing," Semiconductor Industry Association (SIA), September 2020, https://www.semiconductors.org/wp-content/uploads/2020/09/Government-Incentives-and-US-Competitiveness-in-Semiconductor-Manufacturing-Sep-2020.pdf.

[30] Tsai Ing-Wen, "Taiwan and the Fight for Democracy," Foreign Affairs, November/December 2021, https://www.foreignaffairs.com/articles/taiwan/2021-10-05/taiwan-and-fight-democracy?check_logged_in=1&utm_medium=promo_email&utm_source=lo_flows&utm_campaign=registered_user_welcome&utm_term=email_1&utm_content=20220306.

rhetoric of "reunification," instead reiterating in the latest 20th Party Congress that China reserves the right to use force when necessary.[31]

Were China to invade Taiwan, two scenarios may likely occur, according to experts at large: Taiwan's semiconductor manufacturing enterprise would fall into China's control, or the industry would be destroyed in combat.[32] In both cases, the outcome would certainly crush the regional and global economy and put the U.S. at a grave national security threat, largely unprotected from the open waters of the pacific.[33]

Following intensifying naval and air force exercises by the Chinese military near the coasts of Taiwan, on September 2, the Biden administration approved its sixth arms sales package for Taiwan, which exceeded $1.1 billion in military supplies.[34] U.S. and Taiwanese officials are also endorsing a "porcupine defense strategy" such that the island remains insulated within a stockpile of weapons, largely furnished by the U.S. government, in case the Chinese military blockades and attacks Taiwan.

The U.S. has already ramped up subsidy efforts to supporting oversea business partnerships, particularly to TSMC. In 2020, the company announced its plans to construct a $12 billion chip-fabrication plant in Arizona with intentions of fabricating its first-generation 3 nm chips and potentially has plans for 1 nm chip production.[35] So it follows that the semiconductor and emerging technology challenge is not so much strictly economic but is rather, strategically and dangerously, chipping away the guardrails of U.S. and Taiwanese national security.

U.S. RELIANCE ON TAIWAN'S CHIP PRODUCTION FOR DEFENSE

In the 2021 report by the National Security Commission on Artificial Intelligence (NSCAI), the chair and vice chair writes, "We do not want to overstate the precariousness of our position, but given that the vast majority of cutting-edge chips are produced at a single plant separated by just 110 miles of water from our principal strategic competitor, we must reevaluate the meaning of supply chain resilience and security."[36]

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[31] Damien Cave and Amy Chang Chien, "On Taiwan, Xi Jinping warns against international 'interference,'" The New York Times (NYT), October 16, 2022, https://www.nytimes.com/2022/10/16/world/asia/on-taiwan-xi-jinping-warns-against-international-interference.html?smid=url-share.

[32] Gregory Arcuri and Samantha Lu, "Taiwan's Semiconductor Dominance: Implications for Cross-Strait Relations and the Prospect of Forceful Unification," CSIS, March 22, 2022, https://www.csis.org/blogs/perspectives-innovation/taiwans-semiconductor-dominance-implications-cross-strait-relations.

[33] Wang Mouzhou, "What Happens After China Invades Taiwan?" The Diplomat, March 24, 2017, https://thediplomat.com/2017/03/what-happens-after-china-invades-taiwan/.

[34] Edward Wong and John Ismay, "U.S. Aims to Turn Taiwan Into Giant Weapons Depot," NYT, October 5, 2022, https://www.nytimes.com/2022/10/05/us/politics/taiwan-biden-weapons-china.html.

[35] Katie Schoolov, "Inside TSMC, the Taiwanese chipmaking giant that's building a new plant in Phoenix," CNBC, October 16, 2021, https://www.cnbc.com/2021/10/16/tsmc-taiwanese-chipmaker-ramping-production-to-end-chip-shortage.html; Lianne Frith, "TSMC to Make 3 nm Semiconductors at Arizona Fab, Looking to 1 nm," All About Circuits, November 28, 2022, https://www.allaboutcircuits.com/news/tsmc-to-make-3-nm-semiconductors-at-arizona-fab-looking-to-1-nm/.

[36] Eric Schmidt and Bob Work, "Final Report," National Security Commission on Artificial Intelligence, 2021, https://www.nscai.gov/wp-content/uploads/2021/03/Full-Report-Digital-1.pdf.

Meeting the security needs of the U.S. defense establishment is critical to building safeguards against potential adversaries. Technological advances have primarily been driven by commercial electronics, reducing the government of its access to leading edge technology.[37] The demand for "legacy" (or "feature-rich") microelectronics required by the DOD — notably, the chip lifespan exceeds that of commercial chips — remains high.[38] The lack of unitary strategy across the U.S. defense agency fails to account for that level of demand.

While electronic components used for complex military application follow the same logic as consumer semiconductors, there are specialized requirements that guide the durability, high heat-tolerance, and radiation-resistance features in military-specific chips.[39] In response, the DOD launched the Trusted Foundry Program between 2003 and 2004, which aimed to source chip production for military purposes to a domestic fab base.[40] The program secured a contract with IBM's Microelectronics Group to deploy microchip foundry services for the DOD and has now contracted out to other trusted U.S. fabs such as Raytheon and Northrop Grumman that do testing and packaging. Yet, as of 2021, the foundry program only provided about 2 percent of the chips purchased by the DOD and other military complexes, primarily radiation-hardened chips used in secret operations in space or a nuclear war.[41]

However, there are various defense applications that call for commercial-off-the-shelf (COTS) devices — including but not limited to computer processing units (CPUs), graphics processing units (GPUs), and advanced-node memory chips — which Taiwan notably dominates. In 2020, TSMC accounted for 54 percent of global foundry revenue while the largest U.S. semiconductor fab accounted for only 7 percent.[42] As such, Taiwan has underwritten a substantial portion of the U.S. commercial and defense complex.

POLICY IMPLICATIONS

REBUILDING DOMESTIC "FAB" BASE AND SUPPORTING TAIWAN'S SEMICONDUCTOR INDUSTRY & DEMOCRATIC-DRIVEN IDEALS

While the Biden administration and members of Congress appear to be worrisome about the U.S. growing reliance on the Taiwanese semiconductor manufacturing industry, transitioning to absolute self-sufficiency is unfeasible in the decades that follow, as the U.S. remains one to two

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[37] Sujai Shivakumar and Charles Wessner, "Semiconductors and National Defense: What Are the Stakes?," CSIS, June 8, 2022, https://www.csis.org/analysis/semiconductors-and-national-defense-what-are-stakes.
[38] Tim Culpan, "A 'legacy' chipmaker may be key to solving the global shortage," The Detroit News, June 23, 2021, https://www.detroitnews.com/story/business/autos/2021/06/23/legacy-chipmaker-may-key-solving-global-shortage/5326515001/.
[39] Eric Lee, "How Taiwan Underwrites the US Defense Industrial Complex," The Diplomat, November 9, 2021, https://thediplomat.com/2021/11/how-taiwan-underwrites-the-us-defense-industrial-complex/.
[40] Mark Lapedus, "A Crisis in DoD's Trusted Foundry Program?" Semiconductor Engineering, October 22, 2018, https://semiengineering.com/a-crisis-in-dods-trusted-foundry-program/.
[41] John M. Donnelly, "Pentagon Races to Shore Up Supply Chain Security," Government Technology, April 9, 2021, https://www.govtech.com/security/pentagon-races-to-shore-up-supply-chain-security.html.
[42] Yen Nee Lee, "2 charts show how much the world depends on Taiwan for semiconductors," CNBC, March 15, 2021, https://www.cnbc.com/2021/03/16/2-charts-show-how-much-the-world-depends-on-taiwan-for-semiconductors.html.

generations behind TSMC.[43] Additionally, TSMC relies on the U.S. for holding the most downstream customer group, including Apple, AMD, and Qualcomm, in the semiconductor supply chain.[44] This unrealized dependence can go a long way, as TSMC, or Taiwan so to speak, becomes the focal point of the U.S.-China technological conflict. Beyond the additional proposed governmental actions needed to compensate for the limitations of the CHIPS Act, there are several policy recommendations that ought to be addressed for U.S. government and companies.

Ensure policymakers are judicious about the allocation of the $39 billion in CHIPS Act subsidy to fabrication and assembly, testing, and packaging (ATP). Rebuilding a domestic fab base is just as critical to sustaining and diversifying a narrow chipmaking supply chain that is largely centralized in Taiwan and South Korea. It is necessary to ensure that the U.S. remains resilient in response to any supply chain disruption overseas, such as a natural disaster, global pandemic, or political deliberation on armed conflict. While Washington aims to reduce its chipmaking reliance on East Asia via the CHIPS Act, the act outlined its $39 billion in manufacturing incentives towards the building, expanding, and modernizing of "domestic facilities and equipment for semiconductor fabrication, assembly, testing, advanced packaging, or research and development."[45]

> It is crucial to endorse an equitable allocation of grants, ensuring that overfunding and underfunding certain sectors (followed by overproduction and underproduction) are improbable. In so doing, such an imbalance undercuts the flow of supply. Thus, policymakers ought to consult with leading tech experts, economists, and data engineers to devise a proper allocation of funds that may well determine whether the U.S. leads or falls short of its competitors in the next decade.

Building a broader talent pipeline through educating and training a national microelectronics training network. The talent pipeline goal seeks to create educational hotspots for youths. However, the U.S. and Taiwan continue to battle with the decline of students pursuing a career in the semiconductor industry and high-level degrees in science, technology, engineering and mathematics (STEM), respectively.[46] Maximizing scholarship incentives and targeting K-12 students early on may be paramount to producing the necessary number of future engineers and technology leaders. Growing talent horizontally (that is, broadening resources in commercial and military-use semiconductors, AI research, data engineering, geophysics, and

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[43] Graham Allison, Kevin Klyman, Karina Barbesino, Hugo Yen, "The Great Tech Rivalry: China vs the U.S." The Belfer Center for Science and International Affairs, December 2021, https://www.belfercenter.org/sites/default/files/GreatTechRivalry_ChinavsUS_211207.pdf.

[44] 陳玉娟, "英特爾有望成台積電獲利主力　2023年躍升前三大客戶," DigiTimes, December 14, 2021, https://www.digitimes.com.tw/tech/dt/n/shwnws.asp?cnlid=1&id=0000625425_L8Z3RFTC3NA4WG4CGJ2BL; Kawakami Momoko, "Taiwan's TSMC as a Focal Point of US-China High-Tech Conflict," Asia-Pacific Review 29, no. 1 (2022), https://doi.org/10.1080/13439006.2022.2055407. As of December 2021, Apple is the leading customer base of TSMC; out of all TSMC's earnings, Apple holds 25.83% of the share, followed by AMD in third place with 4.39% and Qualcomm in fourth with 3.90%.

[45] "The CHIPS Act of 2022," Department of Commerce (2022), https://www.commerce.senate.gov/services/files/592E23A5-B56F-48AE-B4C1-493822686BCB.

[46] Jason Hsu, "Ensuring a stronger US-Taiwan tech supply chain partnership," Brookings Institution, April 12, 2022, https://www.brookings.edu/blog/order-from-chaos/2022/04/12/ensuring-a-stronger-us-taiwan-tech-supply-chain-partnership/.

more, as well as extending the talent pipeline to Taiwan) will nurture smart innovation from the present to the future.

Maintain U.S.-Taiwan Global Semiconductor Supply Chain Partnership. As the U.S. maintains a chokehold on China's high-end technological supply chain through export controls and investments in robust democratic allies, it is foreseeable that U.S.-Taiwan partnership continues to grow stronger. TSMC has already completed its construction of its 5 nm semiconductor fab — Fab 21 — in Phoenix in July 2022. The company is now looking to manufacture chips as compact as 3 nm and has plans to downsize it to 1 nm.[47] With added support from TSMC and plans to rebuilding a domestic "fab" base via the CHIPS Act, the U.S. may see a positively horizontal growth in both the chip "fab" and "fabless" American supply chain in the long run.[48]

Accelerate bilateral trade agreements with Taiwan
The U.S. and Taiwan formalized bilateral negotiations on the U.S.-Taiwan Initiative on 21st Century Trade on August 17 this year. This agreement follows the Biden's Administration decision to not include Taiwan in the Indo-Pacific Economic Framework (IPEF), which aims to advance economic partnership in trade, supply chains, clean energy, among other pillars.[49] Despite that, the commencement of negotiations notably grants U.S. a stronger strategic commitment to supporting Taiwan's free market system and economic resilience. The announcement further strengthens strategic benefits between two democracies that determine the most critical sectors in the chip supply chain: U.S. design and Taiwan's manufacturing. Prioritizing bilateral trade talk with Taiwan, a self-governing state that has prided itself on having a "vibrant and competitive democratic system" — combined with long-term intentions to rebuild U.S. self-sufficiency on manufacturing chips — is essential. [50]

CONCLUSION

The semiconductor industry has underwritten a multitude of critical infrastructures in the U.S., including the economy, national security, and clean energy. For decades, Taiwan has continued to preside over the microchip ecosystem. The U.S. relies on the island for much of its commercial and military-application semiconductors. Indeed, Taiwan's most influential microchip fab, TSMC, accounts for 92% of all advanced semiconductor chips in the U.S. and has furnished its leading-edge microchips to top U.S companies like Apple, Google, and Intel. Faced with growing pressure from Beijing against Taiwan's self-governing status and deepening U.S. -

[47] Frith, "TSMC to Make 3 nm Semiconductors."
[48] Mary Saunders and Giulia Neaher, "Beyond CHIPS: Prioritizing standardization is critical for US competitiveness," Atlantic Council, August 22, 2022, https://www.atlanticcouncil.org/blogs/geotech-cues/beyond-chips-prioritizing-standardization-is-critical-for-u-s-competitiveness/.
[49] "U.S.-Taiwan Initiative on 21st Century Trade," Edelman Global Advisory, August 24, 2022, https://www.edelmanglobaladvisory.com/insights/US-Taiwan-Initiative-on-21st-Century-Trade#:~:text=Issue,in%20the%20U.S.%20(TECRO); Office of the U.S. Trade Representative, "Indo-Pacific Economic Framework for Prosperity (IPEF)," May 2022, https://ustr.gov/trade-agreements/agreements-under-negotiation/indo-pacific-economic-framework-prosperity-ipef.
[50] "Taiwan," Freedom House, https://freedomhouse.org/country/taiwan.

China tensions, the U.S. is ramping up onshoring efforts to incentivize companies such as TSMC and Samsung to construct advanced wafer fabrication in the U.S via the CHIPS Act.

Revitalizing a semiconductor supply chain partnership with the U.S. and Taiwan has also grown more strategic and beneficial for the two democracies. While domestic onshoring may be advantageous for the U.S. in the long run, the report has shown that more needs to be done to encourage semiconductor growth in the U.S., including (1) endorsing an equitable framework to allocate funds provided by the CHIPS Act, (2) building a broader talent pipeline in the U.S. and abroad, (3) ensuring U.S.-Taiwan global semiconductor supply chain partnership, (4) accelerating bilateral agreements with U.S. and Taiwan.