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The Race for Semiconductor Supremacy: China Versus an Emerging Democratic Technology Alliance

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THE RACE FOR SEMICONDUCTOR SUPREMACY: CHINA VERSUS AN EMERGING DEMOCRATIC TECHNOLOGY ALLIANCE

CSPC GEOTECH WHITE PAPER

By: Andy Keiser¹ and Michael Lumpkin²

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¹ Andy Keiser is a Senior Advisor to the Center for the Study of the Presidency and Congress and previously served, among other positions, as a Senior Advisor to the House Permanent Select Committee on Intelligence. Mr. Keiser also conducts cybersecurity consulting and federal lobbying for several companies, including in the telecommunications and technology sectors.

² Michael Lumpkin previously served, among other positions, as Acting Under Secretary of Defense for Policy during the Obama Administration. Mr. Lumpkin also conducts defense consulting for several companies.

EXECUTIVE SUMMARY

Leading nations of the world, including the United States, have identified semiconductors as a critical national security commodity and are undertaking key actions to secure their own supply chains.

An emerging democratic technology alliance should align to push back on China's predatory economics to preserve its own economic and national security interests.

Introduction

Semiconductors are a ubiquitous component of essentially everything with an on and off switch from smart phones to the most sophisticated military weapons systems. When looking at semiconductors as a national security commodity, the importance of securing the semiconductor supply chain from disruption, potential compromise, or blackmail by hostile regimes becomes self-evident.

Industry Landscape

Given the increased reliance on semiconductors or chips in more things such as automobiles and appliances, and coupled with the world's insatiable appetite for electronics, the semiconductor industry is booming. The Semiconductor Industry Association projects the industry's worldwide sales will be \$527 billion in 2021, a 20% increase from 2020 sales. Next year the market is expected to grow another 9% on top of that.

Though fabrication of chips in the United States has decreased since its high point in the 1980's and 1990's, chip design still reigns supreme here.

The Covid-19 pandemic has led to supply chain disruptions in the semiconductor space. Increased demand for consumer technologies that enabled remote work like laptops and tablets led to chip shortages in several industries including the global automobile industry.

Strategic Threat

The United States and China are locked in a battle for semiconductor supremacy. The implications for the outcome are not just economic; our national security is also at stake as semiconductors provide the backbone of military weapons systems and communications platforms, making semiconductors a critical national security commodity.

Current projections see China becoming the top chip maker by the year 2030, while with each year that passes China increases its capacity to make high-end chips domestically.

Global policymakers also have to worry about the future status of Taiwan. Taiwan currently is responsible for more than half of the world's semiconductor production.

Strategy of the Chinese Communist Party

Under President Xi Jinping's leadership, the communist regime in China has made clear that all Chinese companies are beholden to the government. The government-led efforts forcing civil-military fusion leave no room for private companies to operate independently responding to market signals how we think of them in democratic nations.

The “Made in China 2025” plan calls for China to be by 70% reliant on domestic companies for key technologies, including semiconductors, and seeks a dominant global position by the 100-year anniversary of the Chinese Communist Party (CCP) revolution in 2049.

Threat of State-Backed Chinese Semiconductor Industry

All leading semiconductor companies in China have direct ties to the Chinese government and Communist Party leadership. Four noteworthy companies in this context are:

- SMIC

China’s largest and most important chip maker is Semiconductor Manufacturing International Corporation (SMIC). As a global foundry, SMIC’s close ties to the Chinese military and CCP landed it on the U.S. Commerce Department’s trade blacklist called the Entity List in December 2020.

- HiSilicon

HiSilicon is the fabless chipmaker and direct subsidiary of Chinese state-backed telecommunications giant Huawei. HiSilicon landed on the Commerce Entity List in August of 2019.

- YMTC

Yangtze Memory Technologies Co. (YMTC) is a CCP “national champion” advanced memory chip maker with strategic ties to the CCP leadership.

Media reporting suggests that YMTC has remained under the radar of the U.S. government, is stockpiling materials in a warehouse with SMIC and others and needs continued access to western materials – including American semiconductor manufacturing equipment (SME) – to achieve its massive growth strategy.

- CXMT

ChangXin Memory Technologies (CXMT) is the Chinese dynamic random-access memory (DRAM) market leader taking direct aim at the DRAM market per direction of CCP leadership’s division of labor.

Chinese Semiconductors Rely on U.S. Tools, Software, and Components

American companies control more than 80% of the global market share in equipment and materials for key components to advanced semiconductors manufactured around the world, including in China. In certain categories like electrochemical deposition and gate stack tools, that U.S. share is likely closer to 100%.

According to a news report in Nikkei Asia, YMTC recently conducted an 800-person review of its own supply chain with an eye toward replacing current dependence on American technology.

Fragility of the Global Supply Chain

- U.S. Manufacturing

Just 12% of chip manufacturing is done in the United States. However, Intel and TSMC have announced plans to build multi-billion-dollar fabs in Arizona.

- Global Manufacturing

The world relies heavily on Asia for semiconductors. Taiwan Semiconductor Manufacturing Company (TSMC) and Samsung in South Korea alone produce 70% of the world's semiconductors and nearly all the world's most advanced chips.

- Global Chip Shortage

As a result of several factors from the Covid-19 pandemic, beginning in 2020, dozens of key industries began seeing disruptions in their semiconductor supply chain.

- Future Demand

Market analysts predict a strong global market for semiconductors for decades to come. PWC reports that the market for artificial intelligence (AI)-related semiconductors alone will grow to more than \$30 billion by 2022, growing by 50% annually.

Structural Vulnerabilities in Microelectronics

- How We Got Here

Asia's emergence in device manufacturing traces back to 1994, when then-Defense Secretary William Perry mandated that services use "commercial specifications and standards instead of military standards." At the time and in historical context, this was a natural, even celebrated, decision given the acceleration of technological advancements.

Just 15 short years later, most chip companies outsourced their most-advanced manufacturing expertise to Asia. As we are amidst "Great Power Competition," we must fully recognize that offshoring our semiconductor supply chain created problems that seriously threaten our national security, economic liberty, and even personal freedoms.

- Layered Threat and China's Control

Though chips may be designed in the U.S., the circuit schematics are sent to foundries overseas where they are manufactured. The physical devices are tested and inspected by the designers, but the focus is on compliance to the functional specifications. Until recently, no one seriously considered the possibility that the factory itself could modify the product.

Modifications in design can be done to save costs by using substandard components resulting in reduced functional life expectancy or can be done solely for nefarious reasons.

U.S. Policy Response

The levers to protect U.S. products and companies important to national security, including in the semiconductor industry, have dramatically expanded under the prior two Administrations.

- CFIUS/FIRRMA

More resources, scope, and funding were made available for the Committee on Foreign Investment in the United States (CFIUS) thanks to legislation Congress approved in 2018 called the Foreign Investment Risk Review Modernization Act (FIRRMA).

- Entity List

At least 100 companies have been added to the U.S. Commerce Department's trade blacklist called the Entity List in recent years over national security concerns. SMIC – China's largest chip maker – was added last year during the Trump Administration. Biden Administration added seven Chinese superconductor makers in April of 2021.

- CHIPS Act

Congress approved and President Trump signed into law the Creating Helpful Incentives to Produce Semiconductors (CHIPS) for America Act as part of the Fiscal Year 2021 National Defense Authorization Act. This authorized, but did not fund, \$20 billion in new incentives for manufacturing semiconductors in the United States.

- White House Supply Chain Report

The White House issued a comprehensive review on critical supply chains in June 2021, including an entire section on semiconductor manufacturing and advanced packaging.

The thoughtful review called for seven recommendations from promoting incentives like funding the CHIPS Act, to building talent, to engaging with allies.

- Export Controls

In August of 2020, the Commerce Department's Bureau of Industry and Security (BIS) issued an advanced notice of proposed rulemaking concerning foundational technologies. The notice highlights that the export of semiconductor manufacturing equipment (SME) to indigenous military modernization efforts in China, Russia, and Venezuela may pose a national security threat.

The White House supply chain report also called for "ensuring export controls support policy actions to address national security and foreign policy concerns related to the semiconductor manufacturing and advanced packaging supply chain."

- Further Congressional/Administration Action

During recent bipartisan vote in June 2021, the United States Senate adopted the United States Innovation and Competition Act of 2021 (USICA), which included \$52 billion in funding for the CHIPS Act to encourage domestic production of semiconductors, among other things.

For Fiscal Year 2022 (FY22), the U.S. Air Force requested \$885 million for strategic microelectronics supply as part of their Strategic Microelectronic Supply Program. The White House requested this funding to Congress directly as part of its list of critical FY22 priorities.

In the FY22 NDAA, there are a series of modifications to DoD's acquisitions of printed circuit boards. That legislation is working its way through Congress and is expected to be signed into law by year's end.

Global Policy Response

- United Kingdom

In July, U.K. Prime Minister Boris Johnson announced that his government would conduct a national security review of the purchase of Newport Wafer, the U.K.'s largest producer of semiconductors, by a Chinese company called Wingtech.

- European Union

Chasing strong European financial incentives, last month U.S. chip giant Intel announced that it would spend up to \$95 billion building two new semiconductor manufacturing plants in Europe. The European Union and the United States are reportedly discussing ways to cooperate on subsidies for chip manufacturing instead of entering a subsidies race.

- Japan

Earlier this year, Japan's government announced a strategy to try to ensure Japan has enough chips to compete in the high-tech industries of the future, including AI, 5G and autonomous vehicles. The government has not, however, put in the kind of financial incentives to lure semiconductor manufacturing to its shores like competitors in the U.S., South Korea, China, and Europe.

- Netherlands

Media reports indicate that at the request of the Biden Administration, the Dutch government is continuing to block a shipment of advanced SME maker ASML to Huawei. This is a continuation of policy pursued by the Trump Administration.

- Taiwan

TSMC is no longer selling its high-end chips to Huawei or HiSilicon in accordance with U.S. regulatory restrictions.

- South Korea

South Korea's government has announced an aggressive plan to invest \$450 billion in its domestic semiconductor industry. This is currently the most aggressive announced incentive package in the world.

- The Quad

The U.S., Japan, India and Australia have reportedly agreed to focus on creating a trusted supply chain network for semiconductors.

Recommendations

- Entity Listing

BIS should build on its addition of HiSilicon and SMIC to the Entity List by adding YMTC and CXMT, among other Chinese state-backed semiconductor companies, who fit a similar profile of having ties to the Chinese military and intelligence services, ties to the Chinese Communist Party (CCP) leadership, or both.

- Export Controls, Including on U.S. Toolmakers

BIS should finalize its rulemaking for its export restrictions of foundational technologies to include the listing of high-end semiconductors and SME to state-backed enterprises of adversarial nations like China, Russia, and Venezuela, while ensuring such actions do not have the unintended consequence of undermining U.S. technological leadership in this key area.

Applied Materials, Lam Research and KLA/Teradyne ought to be subject to targeted export controls given YMTC's reported reliance on them as an SME supplier. The United States should not provide cutting-edge technology to our adversaries who may turn and use it against us even on the battlefield.

- Diplomatic Pressure / Multilateral Export Controls / Democratic Tech Alliance

In July, the North Atlantic Treaty Organization (NATO), the European Union, Japan, Australia, and New Zealand all issued statements naming Chinese state-sponsored actors responsible for a cyber-attack on Microsoft Exchange servers. This emerging, powerful democratic tech alliance should continue to collaborate on ways to share critical technologies amongst each other while working on ways to limit its' members key technologies, including advanced semiconductors and SME, from falling into the hands of adversaries like China, Russia, and North Korea.

The Quad should follow through on its promise to work together on a secure semiconductor supply chain.

- Fully Fund the CHIPS Act

Congress should fully fund the \$20 billion in domestic chip manufacturing incentives as authorized by the CHIPS for America Act approved as part of the 2021 National Defense Authorization Act in Fiscal Year 2022 appropriations.

- Increase Federal Funding for Basic R&D

Congress should approve and the President should sign into law increased investments in basic research and development.

INTRODUCTION

With the Center for the Study of the Presidency and Congress's (CSPC) 2020 paper titled "Securing the Keys to the Future: Countering the Threat from State-Backed Chinese Semiconductor Companies" as a baseline, this paper intends to provide an update on global semiconductor supply chain security and the latest international response to mitigate against that threat, particularly from untrustworthy U.S. adversaries like China.³

Semiconductors, a subset of which are integrated circuits or ICs, are a ubiquitous component of essentially everything with an on and off switch from smart phones to the most sophisticated military weapons systems. When looking at semiconductors as a national security commodity, the importance of securing the semiconductor supply chain from disruption, potential compromise, or blackmail by hostile regimes becomes self-evident. Simply put, semiconductors are the critical foundational technology upon which all of America's defense, intelligence, homeland security, and technological tools rely. Any significant disruption to the industry would have major national security and economic repercussions.

Since the publication of the last CSPC report on the topic, progress has been made on five of the six recommendations offered examined in detail below.

Updated Industry Landscape

Given the increased reliance on semiconductors, or chips, in more things such as automobiles and appliances, and coupled with the world's insatiable appetite for electronics, the semiconductor industry is booming. The Semiconductor Industry Association projects the industry's worldwide sales will be \$527 billion in 2021, a 20% increase from 2020 sales. Next year the market is expected to grow another 9% on top of that.⁴

Though fabrication of chips in the United States has decreased since its high point in the 1980's and 1990's, chip design still reigns supreme here with companies like Qualcomm, Nvidia and even Intel designing chips in the United States but having them manufactured by a third-party foundry, most often Taiwan Semiconductor Manufacturing Company (TSMC). Currently, the U.S. manufactures 12% of the world's semiconductors but designs more than half with 85% of the chip design software occurring domestically.⁵

The Covid-19 pandemic has led to supply chain disruptions in the semiconductor space as increased demand for remote work enabling consumer technologies like laptops and tablets led to chip shortages

³ Andy Keiser, "Securing the Keys to the Future: Countering the Threat from State-Backed Chinese Semiconductor Companies." *Center for the Study of the Presidency and Congress*, October 2020. <https://static1.squarespace.com/static/5cb0a1b1d86cc932778ab82b/t/5f9ae206ef715743168a96e2/1603985933848/CSPC+Semiconductor+White+Paper.pdf>

⁴ Semiconductor Industry Association, "Global Semiconductor Sales Increase 1.9% Month-to-Month in April; Annual Sales Projected to Increase 19.7% in 2021, 8.8% in 2022." June 9, 2021. <https://www.semiconductors.org/global-semiconductor-sales-increase-1-9-month-to-month-in-april-annual-sales-projected-to-increase-19-7-in-2021-8-8-in-2021/>

⁵ Asa Fitch and Luis Santiago, "Why Fewer Chips Say 'Made in the U.S.A.'" *The Wall Street Journal*, November 3, 2020. <https://www.wsj.com/articles/why-fewer-chips-say-made-in-the-u-s-a-11604411810>

in several industries including the global automobile industry, which has had to idle nearly 20 plants awaiting chip deliveries.⁶

As covered in the previous paper, there are four main categories of semiconductor computer chips: memory chips, microprocessors, standard chips, and complex systems-on-a-chip. Chips are also divided by types of circuitries: digital, analog, or mixed.⁷ Microprocessing chips serve as the central processing unit (CPU) of a computer or mobile device.⁸ Memory chips include flash, non-volatile memory (NAND), or DRAM.⁹

THE STRATEGIC THREAT

The United States and China are locked in a battle for semiconductor supremacy. The implications for the outcome are not just economic, our national security is also at stake as semiconductors provide the backbone of military weapons systems and communications platforms, making semiconductors a critical national security commodity.¹⁰

Earlier this year, President Joe Biden stated that the Chinese Communist Party (CCP) "aggressively plans to reorient and dominate the semiconductor supply chain. China and the rest of the world is not waiting, and there's no reason why Americans should wait."¹¹

Current projections see China becoming the top chip maker by the year 2030, while with each year that passes China increases its capacity to make high-end chips domestically.¹²

With increased leverage in the semiconductor market, China could decide to restrict the export of chips to countries that are not adhering to the party line on contentious issues like Hong Kong, Tibet, Taiwan or claims in the South China Sea. They could choose to use chips as geopolitical leverage in the same way that Russia uses natural gas and oil exports as geopolitical leverage. This "geotech" concern about China using technology exports as diplomatic blackmail has been explored thoroughly in previous CSPC reports.¹³

⁶ Jeanne Whalen, "Semiconductor shortage hammering automakers, costing billions in lost production and sales." *The Washington Post*, July 28, 2021. <https://www.washingtonpost.com/us-policy/2021/07/28/chip-shortage-2q-earnings/>

⁷ Investopedia, "The Main Types of Chips Produced by Semiconductor Companies." May 19, 2020. <https://www.investopedia.com/ask/answers/042115/what-are-main-types-chips-produced-semiconductor-companies.asp>

⁸ Peng Zhang, Advanced Industrial Control Technology. *Science Direct*, 2010. <https://www.sciencedirect.com/topics/engineering/microprocessor-chips>

⁹ Margaret Rouse, "DRAM (dynamic random-access memory)." *Tech Target*, November 2019. <https://searchstorage.techtarget.com/definition/DRAM>

¹⁰ Jim Lewis, "Semiconductors and Modern Defense Spending." *Center for Strategic and International Studies*, September 8, 2020. <https://www.csis.org/analysis/semiconductors-and-modern-defense-spending>

¹¹ The White House, "Remarks by President Biden at a Virtual CEO Summit on Semiconductor and Supply Chain Resilience." April 12, 2021. <https://www.whitehouse.gov/briefing-room/speeches-remarks/2021/04/12/remarks-by-president-biden-at-a-virtual-ceo-summit-on-semiconductor-and-supply-chain-resilience/>

¹² *Supra* note 5.

¹³ CSPC, "GEOTECH: FOSTERING COMPETITIVENESS FOR TECHNOLOGICAL COMPETITION." March 2021. <https://www.thepresidency.org/geotech-report>

Global policymakers also must worry about the future status of Taiwan. Taiwan currently is responsible for more than half of the world's semiconductor production.¹⁴ The CCP sees Taiwan as a renegade province it is determined to reunite with mainland China as it did forcibly, against its commitments, in Hong Kong. Should the CCP decide to cross the Taiwan strait and capture Taiwan militarily, it could potentially immediately control the majority of production of this critical component to global economic and national security.¹⁵

- *Strategy of the Chinese Communist Party*

Under President Xi Jinping's leadership, the communist regime in China has made clear that all Chinese companies are beholden to the government. The government-led efforts forcing civil-military fusion leave no room for private companies to operate independently responding to market signals how we understand capitalism in democratic nations. Every single Chinese domiciled company, including leading Chinese semiconductor companies SMIC, HiSilicon, CXMT and YMTC, is required to abide by the 2017 National Intelligence Law of the People's Republic which states: "any organization or citizen shall support, assist and cooperate with the state intelligence work."¹⁶ As American Enterprise Institute Senior Fellow Klon Kitchen wrote: "you cannot do business in China without total capitulation to the CCP — by law."¹⁷

Central planners in Beijing direct China to dominate industries like solar panels, telecommunications infrastructure, and LED display screens. They do this through intellectual property theft, forced labor, massive government investments and protected domestic markets, followed by underpriced products flooding the globe to starve international competitors so that only Chinese state-backed enterprises remain.¹⁸

The "Made in China 2025" plan calls for China to be 70% reliant on domestic companies for key technologies, including semiconductors, and seeks a dominant global position by the 100-year anniversary of the CCP revolution in 2049.¹⁹

- *Chinese Semiconductors Rely on U.S. Tools, Software, and Components*

American companies control more than 80% of the global market share in equipment and materials for key components to advanced semiconductors manufactured around the world,

¹⁴ 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>

¹⁵ John Lee and Jan-Peter Kleinhans, "Would China Invade Taiwan for TSMC?." *The Diplomat*, December 15, 2020. <https://thediplomat.com/2020/12/would-china-invade-taiwan-for-tsmc/>

¹⁶ Chinese National People's Congress Network, "National Intelligence Law of the People's Republic." *Brown University*, June 27, 2017. https://cs.brown.edu/courses/csci1800/sources/2017_PRC_NationalIntelligenceLaw.pdf

¹⁷ Klon Kitchen, "Friday Brief for 10 September 2021." *The Kitchen Sync*, September 10, 2021. https://www.thekitchensync.tech/p/friday-brief-for-10-september-2021?utm_source=substack&utm_medium=email&utm_content=share

¹⁸ Stephen Lacey, "How China dominates solar power." *The Guardian*, September 12, 2011. <https://www.theguardian.com/environment/2011/sep/12/how-china-dominates-solar-power>

¹⁹ James McBride and Andrew Chatzky, "Is 'Made in China 2025' a Threat to Global Trade?" *Council on Foreign Relations*, May 13, 2019. <https://www.cfr.org/backgrounder/made-china-2025-threat-global-trade>

including in China. In certain categories like electrochemical deposition and gate stack tools, that U.S. share is likely closer to 100%.²⁰

According to a news report in *Nikkei Asia*, YMTC recently conducted an 800-person review of its own supply chain with an eye toward replacing current dependence on American technology.²¹ The specific equipment chokepoints reportedly identified through the review found unsatisfactory reliance on the below suppliers that YMTC scored with a high level of geopolitical risk:

- Applied Materials: ion implantation, chemical and physical vapor deposition, and chemical-mechanical planarization.
- Lam Research: etching, chemical vapor deposition and wafer-cleaning equipment.
- KLA/Teradyne: testing and measuring equipment.²²

Additionally, other reporting has identified a strong reliance by the Chinese semiconductor industry on U.S. software companies like Synopsys, Cadence, and Mentor Graphics.²³

Threat of Chinese State-Backed Semiconductor Industry

All leading semiconductor companies in China have direct ties to the Chinese government and Communist Party leadership. Four noteworthy companies in this context are:

➤ SMIC

China's largest and most important chip maker is Semiconductor Manufacturing International Corporation (SMIC). As a global foundry, SMIC's close ties to the Chinese military and CCP landed it on the U.S. Commerce Department's trade blacklist called the Entity List in December 2020²⁴, as called for in our October 2020 CSPC paper.²⁵

➤ HiSilicon

HiSilicon is the fabless chipmaker and direct subsidiary of Chinese state-backed telecommunications giant Huawei. HiSilicon provides exclusive chips for all of Huawei's business units and has deep, well-known ties and founding to the Chinese military and

²⁰ Saif M. Khan, Alexander Mann, Dahlia Peterson, "The Semiconductor Supply Chain: Assessing National Competitiveness." *Center for Security and Emerging Technology*. <https://cset.georgetown.edu/publication/the-semiconductor-supply-chain/>

²¹ Cheng Ting-Fang and Lauly Li, "US-China tech war: Beijing's secret chipmaking champions." *Nikkei Asia*, May 5, 2021. <https://asia.nikkei.com/Spotlight/The-Big-Story/US-China-tech-war-Beijing-s-secret-chipmaking-champions>

²² *Supra* note 17.

²³ Che Pan, "Semiconductor shortage sees China's carmakers, chip suppliers join forces to tackle the problem." *South China Morning Post*, May 9, 2021. <https://www.scmp.com/tech/tech-trends/article/3132813/semiconductor-shortage-sees-chinas-carmakers-chip-suppliers-join>

²⁴ Bureau of Industry and Security, "Addition of Entities to the Entity List, Revision of Entry on the Entity List, and Removal of Entities From the Entity List." *Federal Register*, December 22, 2020. <https://www.federalregister.gov/documents/2020/12/22/2020-28031/addition-of-entities-to-the-entity-list-revision-of-entry-on-the-entity-list-and-removal-of-entities>

²⁵ *Supra* note 3.

intelligence service. These ties also landed HiSilicon on the Commerce Entity List in August of 2019.²⁶

➤ YMTC

Yangtze Memory Technologies Co. (YMTC) is a CCP “national champion” advanced NAND memory chip maker with strategic ties to the CCP leadership. According to Dr. James Mulvenon with SOS International, as with many other industries, the Chinese government supports YMTC’s global market position with subsidies, espionage, and anticompetitive and other illegal practices.²⁷

Media reporting suggests that YMTC has remained under the radar of the U.S. government, is stockpiling materials in a warehouse with SMIC and others, and needs continued access to western materials – including American SME – to achieve its massive growth strategy.²⁸

American Enterprise Institute Visiting Fellow Eric Sayers wrote: “YMTC should be a part of the natsec discussion the way Huawei, SMIC, ZTE and others are.”²⁹

➤ CXMT

ChangXin Memory Technologies (CXMT) is the Chinese DRAM market leader taking direct aim at the DRAM market per direction of CCP leadership’s division of labor targeting semiconductor autonomy.³⁰

Fragility of the Global Supply Chain

➤ U.S. Manufacturing

As previously stated, semiconductor fabrication in the United States has been reduced over time along with most other manufacturing. While the majority of chip design is still conducted in the United States, only 12% of the chip manufacturing is done here domestically.³¹ However, Intel and TSMC have announced plans to build multi-billion-dollar fabs in Arizona.³²

²⁶ Bureau of Industry and Security, “Addition of Entities to the Entity List, Revision of Entry on the Entity List, and Removal of Entities From the Entity List.” *Federal Register*, August 21, 2019. <https://www.federalregister.gov/documents/2019/08/21/2019-17921/addition-of-certain-entities-to-the-entity-list-and-revision-of-entries-on-the-entity-list>

²⁷ James Mulvenon, “Yangtze Memory Technologies Co. (YMTC).” *SOS International BLUE HERON*, December 2020.

²⁸ *Supra* note 18.

²⁹ Eric Sayers, *Twitter*. May 4, 2021. <https://mobile.twitter.com/DEricSayers/status/1389717940208013312>

³⁰ *Supra* note 24.

³¹ *Supra* note 5.

³² Sam Shead, “Why Intel and TSMC are building water-dependent chip factories in one of the driest U.S. states.” *CNBC*, June 4, 2021. <https://www.cnbc.com/2021/06/04/why-intel-tsmc-are-building-water-dependent-chip-plants-in-arizona.html>

➤ Global Manufacturing

The world relies heavily on Asia for semiconductors. TSMC and Samsung in South Korea alone produce 70% of the world's semiconductors and nearly all of the world's most advanced chips, while Asia alone consumes 60% of all chips.³³

➤ Global Chip Shortage

As a result of several factors from the Covid-19 pandemic, beginning in 2020, dozens of key industries began seeing disruptions in their semiconductor supply chain. Booming consumer electronic demand, Covid-19 lockdowns, fallout from the U.S.-China trade war, and weather events in Taiwan, Japan and the United States are cited factors.³⁴

➤ Future Demand

Market analysts predict a strong global market for semiconductors for decades to come. Perforce predicts "the future of the semiconductor industry is in leveraging technology trends like artificial intelligence (AI) and the internet of things (IoT). And silicon chips will still dominate into the 2040s."³⁵

PWC reports that the market for AI-related semiconductors alone will grow to more than \$30 billion by 2022, growing by 50% annually.³⁶

STRUCTURAL VULNERABILITIES IN MICROELECTRONICS

How We Got Here

Asia's emergence in device manufacturing traces back to 1994, when then-Defense Secretary William Perry mandated that services use "commercial specifications and standards instead of military standards."³⁷ At the time and in historical context, this was a natural, even celebrated, decision given the acceleration of technological advancements. There was no perceived threat with the decision at the time as China's economy was less than a tenth of ours, and their technology base was dependent upon absorption, adoption, and occasional theft from the West.

³³ Arjun Kharpal, "How Asia came to dominate chipmaking and what the U.S. wants to do about it." *CNBC*, April 11, 2021.

<https://www.cnbc.com/2021/04/12/us-semiconductor-policy-looks-to-cut-out-china-secure-supply-chain.html>

³⁴ Chris Baraniuk, "Why is there a chip shortage?" *BBC*, August 27, 2021. <https://www.bbc.com/news/business-58230388>

³⁵ Michael Munsey, "The Future of Semiconductors." *Perforce*, January 28, 2021. <https://www.perforce.com/blog/mdx/future-of-semiconductor>

³⁶ PWC, "Opportunities for the global semiconductor market." *PWC*, April 3, 2019.

<https://www.pwc.com/gx/en/industries/tmt/publications/global-tmt-semiconductor-report-2019.html>

³⁷ William J. Perry, Memorandum for the Secretaries of the Military Departments, "A New Way of Doing Business, focused on driving the Department of Defense toward commercial state of the art solution and adoption of business processes of world class suppliers." *SAE International*, June 29, 1994. <https://www.sae.org/standardsdev/military/milperry.htm>

1994 was the year after the world wide web software was put into the public domain.³⁸ There was no general awareness, never mind fear, of cybersecurity. Just 15 short years later, most chip companies outsourced their most-advanced manufacturing expertise to Asia. This was an effort to bring manufacturing prices down due to the relatively inexpensive labor markets, most notably in China.

Despite deep cultural differences and almost no intellectual property protection, the labor market and facilities made China a particularly attractive host for new factories. Their high educational standards sealed the deal for many high-tech investments, including capital-intensive semiconductor manufacturing facilities. As we are amid “Great Power Competition,” we must fully recognize that offshoring our semiconductor supply chain created problems that seriously threaten our national security, economic liberty, and even personal freedoms.³⁹

The Layered Threat & China’s Control

The implications of China’s growing supremacy in global semiconductor manufacturing goes well beyond China’s control of the global supply chain itself. By controlling the manufacturing of the semiconductors themselves, they can also control *how* chips are manufactured. In other words, even though the chips may be designed in the United States, the circuit schematics are sent to foundries overseas where they are manufactured. The physical devices are tested and inspected by the designers, but the focus is on compliance to the functional specifications. Until recently, no one seriously considered the possibility that the factory itself could change the product. Now we know the manufacturer reportedly can, and sometimes does, change the product for nefarious purposes.⁴⁰ This lack of security and control makes modification during the manufacture phase both achievable and historically undetectable.

Chip modification can be done for several reasons that can have significant operational impacts. Modifications in design can be done to save costs by using substandard components resulting in reduced functional life expectancy or can be done solely for nefarious reasons. As the former Chief Technology Officer at the Department of Veterans Affairs, Dr. Peter Levin, has stated chips that are clandestinely modified with “Trojans” can leak information (e.g., targeting coordinates), behave improperly (e.g., turn themselves off or follow inauthentic remote instructions), or be/become unreliable (e.g., erroneously compute their GPS-based position).⁴¹ While the impacts potential Trojan leaks pose significant risk to all U.S. consumers, the risk is particularly acute to the nation’s infrastructure, national security missions, and military personnel as they all rely heavily on embedded semiconductors.

³⁸ The World Wide Web Foundation, <https://www.webfoundation.org>

³⁹ The Semiconductor Industry Association in partnership with Boston Consulting Group, “Strengthening the Semiconductor Supply Chain in an Uncertain Era.” April 2021. <https://www.semiconductors.org/strengthening-the-global-semiconductor-supply-chain-in-an-uncertain-era/>

⁴⁰ Jordan Robertson and Michael Riley, “The Big Hack.” *Bloomberg*, October 4, 2018. <https://www.bloomberg.com/news/features/2018-10-04/the-big-hack-how-china-used-a-tiny-chip-to-infiltrate-america-s-top-companies>

⁴¹ Dr. Peter Levin et al, “Enabling Hardware Trojan Detection and Prevention through Emulation.” *IEEE Xplor*, October 2018. <https://ieeexplore.ieee.org/document/8574204>

Even though every conceivable misbehavior cannot be anticipated, U.S. policymakers are significantly behind in devising solutions to reduce the national security risks associated with this threat. Washington is only now starting to consider how automated tools can identify imbedded semiconductor vulnerabilities and structural threats human designers will miss.

POLICY RESPONSE

U.S. Policy Response

The levers to protect U.S. products and companies important to national security, including in the semiconductor industry, have dramatically expanded under the prior two Administrations.

- CFIUS/FIRRMA

More resources, scope, and funding were made available for the Committee on Foreign Investment in the United States (CFIUS) thanks to legislation Congress approved in 2018 called the Foreign Investment Risk Review Modernization Act (FIRRMA). CFIUS is increasingly active in preventing sales and control of significant companies of concern.⁴²

- Entity List

At least 100 companies have been added to the U.S. Commerce Department's trade blacklist called the Entity List in recent years over national security concerns. SMIC – China's largest chip maker – was added last year during the Trump Administration.⁴³ Biden Administration added seven Chinese superconductor makers in April of 2021.⁴⁴

Though HiSilicon was added in 2019 as a Huawei subsidiary, Commerce has reportedly allowed an exception to U.S. companies for Huawei to buy chips for its auto component business through limited license approvals.⁴⁵

- CHIPS Act

As called for in the 2020 CSPC paper, Congress approved, and President Trump signed into law the CHIPS for America Act as part of the Fiscal Year 2021 National Defense Authorization Act.

⁴² James K. Jackson and Cathleen D. Cimino-Isaacs, "CFIUS Reform Under FIRRMA." *Congressional Research Service*, February 21, 2020. <https://crsreports.congress.gov/product/pdf/IF/IF10952>

⁴³ *Supra* note 21.

⁴⁴ Bureau of Industry and Security, "Addition of Entities to the Entity List." *Federal Register*, April 8, 2021. <https://public-inspection.federalregister.gov/2021-07400.pdf>

⁴⁵ Karen Freifeld, "EXCLUSIVE Huawei gets U.S. approvals to buy auto chips, sparking blow back." *Reuters*, August 25, 2021. <https://www.reuters.com/business/autos-transportation/exclusive-us-approves-licenses-huawei-buy-auto-chips-sources-2021-08-25/>

This authorized, but did not fund, \$20 billion in new incentives for manufacturing semiconductors in the United States.⁴⁶

- White House Supply Chain Report

Responding to an Executive Order signed by President Biden, The White House issued a comprehensive review on critical supply chains in June 2021, including an entire section on semiconductor manufacturing and advanced packaging written by the Commerce Department.⁴⁷

The thoughtful review called for seven recommendations from promoting incentives like funding the CHIPS Act, to building talent, to engaging with allies.⁴⁸

- Export Controls

In August of 2020, the Commerce Department's Bureau of Industry and Security (BIS) issued an advanced notice of proposed rulemaking concerning foundational technologies. The notice highlights that the export of SME to indigenous military modernization efforts in China, Russia, and Venezuela may pose a national security threat.⁴⁹

The U.S.-China Economic and Security Review Commission took BIS to task on failing to enumerate what constitutes an emerging and foundational technology writing: "BIS's ongoing failure...hampers CFIUS's ability to screen foreign acquisition of potentially sensitive technologies."⁵⁰

Recently before the Senate Banking Committee, Under Secretary of Commerce for Industry and Security nominee Alan Estevez stated that his priorities would be: "Given China's malign behavior on a number of fronts, as well as to other adversarial nations, continuing and strengthening our focus on identifying and imposing appropriate controls on emerging and foundational technologies, strengthening the resiliency of our supply chains, particularly in the semiconductor area, working with our allies and friends to strengthen controls over critical technologies."⁵¹

⁴⁶ Adam Smith, "H.R.6395 - William M. (Mac) Thornberry National Defense Authorization Act for Fiscal Year 2021." *Congress.gov*, January 3, 2020. <https://www.congress.gov/bill/116th-congress/house-bill/6395/text>

⁴⁷ The White House, "Building Resilient Supply Chains, Revitalizing American Manufacturing, and Foster Broad-Based Growth." *The White House*, June 4, 2021. https://www.whitehouse.gov/wp-content/uploads/2021/06/100-day-supply-chain-review-report.pdf?utm_source=sfmc%E2%80%8B&utm_medium=email%E2%80%8B&utm_campaign=20210610_Global_Manufacturing_Economic_Update_June_Members

⁴⁸ *Supra* note 38.

⁴⁹ Bureau of Industry and Security, U.S. Department of Commerce, "Identification and Review of Controls for Certain Foundational Technologies." *Federal Register*, August 27, 2020. <https://www.federalregister.gov/documents/2020/08/27/2020-18910/identification-and-review-of-controls-for-certain-foundational-technologies>

⁵⁰ Emma Rafaelof, "Unfinished Business: Export Control and Foreign Investment Reforms." *U.S.-China Economic and Security Review Commission Issue Brief*, June 1, 2021. https://www.uscc.gov/sites/default/files/2021-06/Unfinished_Business-Export_Control_and_Foreign_Investment_Reforms.pdf

⁵¹ United States Senate Committee on Banking, Housing and Urban Affairs, "Hearing to consider pending nominations." September 21, 2021. <https://www.banking.senate.gov/hearings/09/14/2021/nomination-hearing>

The White House supply chain report also called for “ensuring export controls support policy actions to address national security and foreign policy concerns related to the semiconductor manufacturing and advanced packaging supply chain.”⁵²

- Additional Congressional/Administration Action

A recent vote in June, led the U.S. Senate to adopt the United States Innovation and Competition Act of 2021 (USICA), which included \$52 billion in funding for the CHIPS Act to encourage domestic production of semiconductors, among other things. The House is considering a more partisan version of the measure, but sponsors are optimistic that a cross-chamber agreement can be reached and the measure could be enacted into law later this year.⁵³

For Fiscal Year 2022, the U.S. Air Force requested \$885 million for strategic microelectronics supply as part of their Strategic Microelectronic Supply Program. The White House has requested this funding to Congress directly as part of its list of critical FY'22 priorities.⁵⁴

In the FY22 NDAA, there are a series of modifications to DoD's acquisitions of printed circuit boards. That legislation is working its way through Congress and is expected to be signed into law by year's end.⁵⁵

Global Response

- United Kingdom

In July, U.K. Prime Minister Boris Johnson announced that his government would conduct a national security review of the purchase of Newport Wafer, the U.K.'s largest producer of semiconductors, by a Chinese company called Wingtech.⁵⁶

- European Union

Chasing strong European financial incentives, last month U.S. chip giant Intel announced that it would spend up to \$95 billion building two new semiconductor manufacturing plants in Europe.⁵⁷ The European Union and the United States are reportedly discussing ways to cooperate on subsidies for chip manufacturing instead of entering a subsidies race.⁵⁸

⁵² *Supra* note 38.

⁵³ Chuck Schumer, “S.1260 - United States Innovation and Competition Act of 2021.” *Congress.gov*, June 8, 2021. <https://www.congress.gov/bill/117th-congress/senate-bill/1260/text>

⁵⁴ Connor O'Brien, “White House seeks extra \$2.4B to cover Afghanistan withdrawal costs.” *Politico Pro*, September 7, 2021. <https://subscriber.politicopro.com/article/2021/09/white-house-seeks-extra-24b-to-cover-afghanistan-withdrawal-costs-2083519>

⁵⁵ Adam Smith, H.R.4350 - National Defense Authorization Act for Fiscal Year 2022.” *Congress.gov*, September 10, 2021. <https://www.congress.gov/bill/117th-congress/house-bill/4350/text>

⁵⁶ Jasper Jolly, “UK to review purchase of semiconductor producer by Chinese-owned firm.” *The Guardian*, July 7, 2021. <https://www.theguardian.com/business/2021/jul/07/uk-to-review-purchase-of-semiconductor-producer-by-chinese-owned-firm>

⁵⁷ Asa Fitch and William Boston, “Intel to Invest Up to \$95 Billion in European Chip-Making Amid U.S. Expansion.” *Wall Street Journal*, September 7, 2021. <https://www.wsj.com/articles/intel-plans-investment-of-up-to-95-billion-in-european-chip-making-amid-u-s-expansion-11631027400>

⁵⁸ Laura Kayali and Laurens Cerulus, “EU, U.S. plan to ‘avoid subsidy race’ on chips.” *Politico Pro*, September 20, 2021. <https://subscriber.politicopro.com/article/2021/09/eu-us-plan-to-avoid-subsidy-race-on-chips-2085537?source=email>

- Japan

Earlier this year, Japan's government announced a strategy to try to ensure Japan has enough chips to compete in the high-tech industries of the future, including AI, 5G and autonomous vehicles.⁵⁹ The government has not, however, put in the kind of financial incentives to lure semiconductor manufacturing to its shores like competitors in the U.S., South Korea, China, and Europe.

However, former trade minister Akira Amari's latest ascent to the party Secretary General post will likely boost the new Kishida Administration's economic security policy, including potential adoption of his multi-billion-dollar proposal targeting Japan's semiconductor industry.⁶⁰

- Netherlands

Media reports indicate that at the request of the Biden Administration, the Dutch government is continuing to block a shipment of advanced SME maker ASML to Huawei. This is a continuation of policy pursued by the Trump Administration.⁶¹

- Taiwan

TSMC is no longer selling its high-end chips to Huawei or HiSilicon in accordance with U.S. regulatory restrictions.⁶²

- South Korea

South Korea's government has announced an aggressive plan to invest \$450 billion in its domestic semiconductor industry. This is currently the most aggressive announced incentive package in the world.⁶³

- The Quad

The U.S., Japan, India and Australia have reportedly agreed to focus on creating a trusted supply chain network for semiconductors.⁶⁴

⁵⁹ Reuters, "Japan worries it could be left behind as U.S. pours billions into chip industry to fend off China." *CNBC*, August 17, 2021. <https://www.cnbc.com/2021/08/18/japan-worries-it-could-be-left-behind-as-us-invests-in-chips.html>

⁶⁰ <https://www.nikkei.com/article/DGXZQQUA02DKV0S1A600C2000000/>

⁶¹ Stu Woo and Yang Jie, "China Wants a Chip Machine From the Dutch. The U.S. Said No." *The Wall Street Journal*, July 17, 2021. <https://www.wsj.com/articles/china-wants-a-chip-machine-from-the-dutch-the-u-s-said-no-11626514513>

⁶² Andrei Frumusanu, "TSMC Confirms Halt to Huawei Shipments in September." *Andantech*, July 17, 2020.

<https://www.andantech.com/show/15915/tsmc-confirms-halt-to-huawei-shipments-in-september>

⁶³ Kim Jaewon, "South Korea plans to invest \$450bn to become chip 'powerhouse.'" *NikkeiAsia*, May 13, 2021.

<https://asia.nikkei.com/Business/Tech/Semiconductors/South-Korea-plans-to-invest-450bn-to-become-chip-powerhouse>

⁶⁴ Nikkei staff writers, "Quad leaders to call for securing chip supply chain." *NikkeiAsia*, September 18, 2021.

<https://asia.nikkei.com/Politics/International-relations/Indo-Pacific/Quad-leaders-to-call-for-securing-chip-supply-chain>

RECOMMENDATIONS

- *Entity Listing*

BIS should build on its addition of HiSilicon and SMIC to the Entity List by adding YMTC and CXMT, among additional Chinese state-backed semiconductor companies who fit a similar profile of having ties to the Chinese military and intelligence services, ties to the CCP leadership, or both. Cutting-edge American technology that gives us an edge on the battlefield should not go to advance the military and intelligence capabilities of our foremost geopolitical adversary.

- *Export Controls, Including on U.S. Toolmakers*

BIS should finalize its rulemaking for its export restrictions of foundational technologies to include the listing of high-end semiconductors and SME to state-backed enterprises of adversarial nations like China, Russia, and Venezuela, while carefully ensuring actions do not have the unintended consequence of undermining U.S. technological leadership in this key area.

Applied Materials, Lam Research and KLA/Teradyne ought to be subject to targeted export controls given YMTC's reported reliance on them as an SME supplier. The United States should not provide cutting-edge technology to our adversaries who may turn and use it against us even on the battlefield.

We concur with leading China experts from the Center for a New American Security (CNAS) who wrote that "the United States should enact broad restrictions on sales of SME to China to sustain the U.S. advantage in hardware."⁶⁵

- *Diplomatic Pressure / Multilateral Export Controls / Democratic Tech Alliance*

In July, the North Atlantic Treaty Organization (NATO), the European Union, Japan, Australia and New Zealand all issued statements naming Chinese state-sponsored actors responsible for a cyber-attack on Microsoft Exchange servers.⁶⁶ The nations reportedly will also share intelligence on cyberthreats and collaborate on network defenses and security.⁶⁷ This emerging, powerful democratic tech alliance should continue to collaborate on ways to share critical technologies amongst each other while working on ways to limit its' members key technologies, including advanced semiconductors and SME, from falling into the hands of adversaries like China, Russia and North Korea.

Relatedly, we also agree with the CNAS scholars who suggested the U.S. Commerce and State Departments should work with key allies and partners, namely from the Netherlands, Japan, South Korea, and Singapore, to establish multilateral export controls on SME.⁶⁸

⁶⁵ Ely Ratner et al, "Rising to the China Challenge." *Center for a New American Security*, January 28, 2020.

<https://www.cnas.org/publications/reports/rising-to-the-china-challenge>

⁶⁶ North Atlantic Council, "Statement by the North Atlantic Council in solidarity with those affected by recent malicious cyber activities including the Microsoft Exchange Server compromise." *North Atlantic Treaty Organization*, July 19, 2021.

https://www.nato.int/cps/en/natohq/news_185863.htm

⁶⁷ Christina Wilkie, "U.S., NATO and EU to blame China for cyberattack on Microsoft Exchange servers." *CNBC*, July 19, 2021.

<https://www.cnbc.com/2021/07/19/nato-and-eu-launch-a-cyber-security-alliance-to-confront-chinese-cyberattacks.html>

⁶⁸ *Supra* note 55.

Under Secretary of Commerce for Industry and Security nominee Estevez also endorsed this concept at his recent confirmation hearing stating: “multilateral export controls are the most effective. If we don't use multilateral export controls, it's something like damming up half the river... With that said, if we need to use a unilateral export control to protect a particular... American technology from being exported, we will do that in the national security look...The follow up to that would be the to work with our allies to...hopefully bring the multilateral regimes in compliance.”⁶⁹

- *Fully Fund the CHIPS Act*

Congress should fully fund the \$20 billion in domestic chip manufacturing incentives, as authorized by the CHIPS for America Act approved as part of the 2021 National Defense Authorization Act in Fiscal Year 2022 appropriations. Though it will take years to realize results domestically, funding will help diversify the global supply chain and bring more manufacturing here to the United States where we can guarantee a greater portion of our own supply needs.

- *Increase Federal Funding for Basic R&D*

Congress should approve and the President should sign into law increased investments in basic research and development. This increase will help the United States remain competitive with adversaries like China in the critical technologies of the future like semiconductors. Congress attempted to do this via passage of legislation titled the Endless Frontiers Act, which unfortunately has become bogged down in unrelated issues and domestic politics.

CONCLUSION

Leading nations of the world, including the United States, have identified semiconductors as a critical national security commodity and are undertaking key actions to secure their own supply chains. To give a sense for the priority placed on the effort in China, the Nikkei story we referenced wrote of the extensive efforts the government is putting into the success of YMTC quoting one official as saying: “The whole country is rooting for this.”⁷⁰ The U.S. needs to be as well.

As seen in other industries like telecommunications infrastructure, solar panels, or LED display screens, when the CCP puts the full force of the Chinese government behind an industry it is usually successful to the detriment of companies in democratic nations that play by the rules.

An emerging democratic technology alliance needs to align to push back on China's predatory economics to preserve its own economic and national security interests. The democratic nations of the world cannot afford to outsource a critical national security commodity like semiconductors to untrustworthy actors like China.

⁶⁹ *Supra* note 51.

⁷⁰ *Supra* note 21.