Marcellus
POLICY ANALYSIS

Spring 2023 - Marcellus Policy Analysis

CHIP-ing Away: The CHIPS Act and US-China Tech War

By Benie Kwarteng

EXECUTIVE SUMMARY

The United States must change its strategy in its technology competition with China. At the core of the US-China tech war and geopolitical tensions are advanced semiconductor chips. Since the invention of integrated circuits (commonly known as semiconductors), the United States has been a global leader in the industry for decades. However, since the 1990s, the American share of global manufacturing capacity has declined from 37 percent to 12 percent today. As the chip-making process became more complex and expensive, fabless manufacturers– companies without fabrication plants (or fabs)- emerged as an alternative. Influenced by foreign direct investment (FDI) and cheap labor, U.S. companies in the 1960 and 1970s took advantage of incentives offered by manufacturing companies in East Asia and outsourced the manufacturing and assembly process.

Currently, semiconductors are the fifth-largest export of the United States, accounting for 48 percent of the global market share. At the same time, the United States remains very dependent on East Asia for manufacturing. This reliance led the Biden Administration to spearhead the CHIPS Act of 2022 to revitalize onshore manufacturing in an effort to attain supply chain resilience.

However, this paper argues that the CHIPS Act of 2022 is not enough to revitalize manufacturing and obtain supply chain resilience. In fact, relying solely on the CHIPS Act detracts from the main U.S agenda behind supply chain resiliency. The CHIPS Act of 2022 focuses mainly on boosting the supply of chips for critical sectors such as defense, health care, and telecommunications, but it does not address the demand side of the market, which is driven by consumer electronics, cloud computing, and artificial intelligence (AI). Given the ubiquitous nature of semiconductors, the CHIPS Act greatly ignores national security concerns and broader US-China competition. This paper suggests the U.S. should employ the following measures to mitigate the weaknesses of the CHIPS Act:

1. Address the industry's talent shortage

2. Remove unnecessary barriers and conditions on CHIPS Act incentives
3. Introduce parallel policies in demand market sectors like AI and consumer electronics
4. Increase the investment budget for the CHIPS Act to gain industrial capacity
5. Allyshore with industrial giant economies like the Netherlands, Taiwan, and South Korea

Introduction

The CHIPS Act of 2022 is a bipartisan statute that aims to revitalize the U.S. semiconductor industry and enhance its competitiveness in the global market. The authority provides funding for research and development, tax incentives, and supply chain guardrails to promote onshore domestic manufacturing. The US-China tech war is a strategic rivalry between the two superpowers over the control of emerging technologies such as artificial intelligence, quantum computing, and biotechnology. This paper examines the effectiveness of the CHIPS Act 2022 on the U.S.-China tech war.

What is the CHIPS ACT of 2022?

The CHIPS Act 2022 is the second part of the 2020 CHIPS for America Act which was included in the National Defense Authorization Act (NDAA) for the 2021 fiscal year.[1] The purpose of the CHIPS Act is to structuralize and provide funding for implementing the CHIPS for America Act. The Act allocates $54.2 billion to authorities within the U.S. Department of Commerce, U.S. Department of State, and the U.S. Department of Defense to pursue activities that develop onshore domestic manufacturing of semiconductors critical to U.S competitiveness and national security. Over 70 percent of the appropriated funds, approximately $39 billion, is designated for manufacturing incentives to draw foreign entities to build fabrications in America. About $11 billion is designated for research and development (R&D) which includes the construction of the National Semiconductor Technology Center (NSTC), a public-private consortium. An additional $2 billion are to go to the Department of Defense for university-based prototyping and lab-to-fab transition semiconductor technologies.[2]

To better understand the effectiveness of the CHIPS Act, it is important to first understand the comparative advantages of major industrial stakeholders and how the CHIPS Act policy measures up. This paper looks at the European Union (EU), East Asian industrial giants minus China (Japan, Taiwan, and South Korea), and China. [3]

The State of the Global Semiconductor Industry

The EU

The EU is developing its own version of the CHIPS Act to increase its share of global chip output to 20 percent by 2030. Similar to the United States, the EU aims to increase manufacturing capabilities as well as skills and research development. Since the initial announcements last year compounding an EU Chips Act, the bloc has garnered over €100 billion of public and private investments. The EU Chips Act is built on three pillars: (1) supporting wider technology innovation capacity, (2) decreasing supply chain dependence on Asia through increased investments in production and manufacturing capacities, and (3) establishing a network between member-states to manage supply chain vulnerabilities.
The EU hosts a member country whose industrial capabilities are intrinsic to the supply chain.[4]
The Netherlands is the home of the world's only manufacturer of the most advanced critical machinery for chipmaking, ASML. In particular, the company has monopolized the manufacturing of extreme ultraviolet (EUV) lithography used in etching the smaller and finer details on the most advanced semiconductor chips.[5] While Japanese companies Nikon and Canon are competitors in the manufacturing of photolithography machines, ASML is the sole producer of EUV lithography. [6]
The EU accounted for only 9 percent of the global semiconductor sales in 2021 but held 21 percent of the market share in semiconductor manufacturing equipment (SME). The European dominance in SME makes the world's leading chipmakers- Intel (U.S), Samsung (South Korea), and TSMC (Taiwan)- dependent on ASML.

East Asia (Japan, Taiwan, South Korea)

Equally powerful and relevant to the global semiconductor supply chain are Japan, Taiwan, and South Korea. The three countries together have amassed manufacturing, innovation, memory, and chip equipment capabilities.

Japan: SME

Japan has managed to remain a significant industrial actor by specializing in the equipment manufacturing process of the supply chain. As of 2021, Japan holds 27% of the global share of SME. Companies like Nikon, Canon, and Tokyo Electron produce key parts: lithography and EUV photoresists. As the biggest SME producer in the region, it has significant trade relations with China. In 2021, Prime Minister Fumio Kishida's administration approved a $6.8 billion domestic chip investment.[7] The investment is part of an attempt to bring manufacturing, once a strength of Japan's, back to Tokyo in a grand strategy aimed at "economic security".[8] In a related sector, Japan has increased its defense expenditure by 26 percent and is on a trajectory to spend up to 2 percent of its Gross Domestic Product (GDP) on defense by 2027. The government "plans to increase self-resilience by encouraging the Japanese arms industry to expand its domestic manufacturing and maintenance capacity" at the heart of advanced semiconductor chip technology.[9]

South Korea: Memory Giant

South Korea has made a name for itself in the global semiconductor economy with the dominance of companies like Samsung and SK Hynix in memory chip manufacturing. In 2020, the sale of NAND and DRAM memory chips comprised 25 percent of the global revenue of the semiconductor industry. South Korea controls 50 percent and 70 percent of the global market share of NAND and DRAM flash memory chips respectively. Accordingly, Seoul's dominance in the production capacity of chips less than 10 nanometers is second only to Taiwan.

Korea's industry, however, is significantly dependent on China.[10] Sixty percent of all chip exports from Korea are to China as some are manufactured locally in fabrication plants owned by Samsung or SK Hynix. In a strategic attempt to preserve its domestic industry and reduce dependency on China, South Korea introduced the K-CHIPS Act. The Act includes various tax breaks and incentives for firm R&D.

Additionally, the Korean government is communicating with the United States over concerns about Chinese export restrictions affecting some of its major fabrication plants. Through the K-CHIPS Act initiative, South Korea seeks to strengthen onshore manufacturing and expand its dominance in memory chips.[11]

Taiwan: Advanced Chips Manufacturing

Taiwan may be a small island nation, yet it is a major force in the global semiconductor economy. In fact, it is impossible to talk about chip manufacturing without mentioning the relevance of Taiwan's industrial capacity.

The leading company in the country, Taiwan Semiconductor Manufacturing Company (TSMC), has amassed talent and skills in the most advanced chip manufacturing. TSMC is second to none when it comes to pioneering breakthrough processes to manufacture the most intricate of advanced chip designs.[12]The company produces 60 percent of the world's semiconductors and over 90 percent of the most advanced chips alone.

These unrivaled attributes have earned the company the nickname, "Taiwan's silicon shield," partly due to Taiwan's dominance in the industry but mostly to elicit a reason for the world to come to the island's defense in the case of a Chinese invasion.[13]Additionally, TSMC has made huge investments in America in an effort to "help build more secure and resilient supply chains" to set up fabrication plants in Arizona. [14]The company is already planning to open a second fab by 2026 to start offshore production of the 3-nanometer chips – the most advanced semiconductors.

Earlier this year, Taiwan passed its CHIPS Act, which offers chipmakers tax credits as part of efforts to maintain leadership in cutting-edge chip production. The tax credit allows chip firms a 25 percent

deduction from their R&D expenses. Government agencies and TSMC executives have all echoed the sentiment of having the latest technologies remain at home in Taiwan. [15]

China: Strength and Ambition

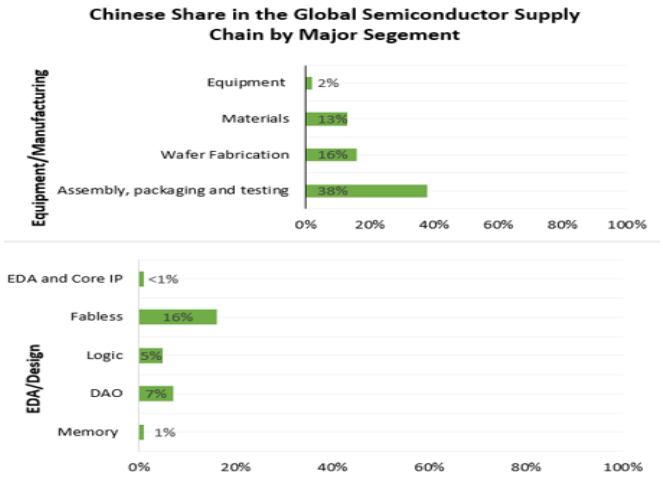
The strength and ambition of China's supply chain resilience lie in the fact that the country accounts for more than 30 percent of the semiconductor market. China's strength in the global semiconductor industry centers on its large domestic market, its government support, and its diversified supply chain. This gives China a strong incentive to develop its own semiconductor capabilities and reduce its reliance on foreign imports.

China also has a supportive policy environment for the semiconductor industry, with various plans and initiatives to foster innovation, investment, and talent development.[16] The country sees this effort as a way to generate revenue, expand other industries, and advance its military. As a result, China has also invested in emerging technologies such as AI and quantum computing, which could give it an edge in the future.[17]

Specifically, the "Made in China 2025" plan developed by the Chinese Communist Party (CCP) is an ambitious goal to increase semiconductor self-sufficiency. The CCP has declared an urgency in obtaining a stable and resilient chip industry invulnerable to foreign control.[18] One vehicle for achieving this goal is the National Integrated Circuits Industry Development Fund, or Big Fund. As a result, China is the leading country in industrial investments with a combined national and local Big Fund of $73 billion.

Moreover, China has a diversified supply chain that covers various segments of the semiconductor value chain, from design and fabrication to packaging and testing. These significant market shares are in critical sectors of the semiconductor supply chain, making China a valuable industrial global actor.[19]

Figure 1



Source: Ravi, Sarah. "Taking Stock of China's Semiconductor Industry." Semiconductor Industry Association, July 13, 2021. Pg. 3 https://www.semiconductors.org/taking-stock-of-chinas-semiconductor-industry/.

The CHIPS Act So Far

The American CHIPS Act is purported to achieve two main goals: (1) support the growth of a vibrant U.S. semiconductor industry and (2) make the U.S. home to at least two large-scale clusters of cutting-edge logic chip fabs. The CHIPS Act aspires to support large-scale investments in leading-edge manufacturing, semiconductor materials, equipment facilities, and R&D facilities. Over the next decade, the policy is intended to tackle the problem of semiconductor supply chain disruptions caused by the pandemic, climate events, geopolitical tensions, and global competition. Between 2022 and 2026, the CHIPS Act is expected to preserve or create over 500,000 jobs in both related and unrelated fields. [20]

The CHIPS Act also led to the creation of the NSTC – a public-private consortium. The institution will bring together industry, academia, government, and key stakeholders to serve as the principal body for discussing semiconductor-related issues. [21]Currently, government and private entities are working together to achieve this goal.

As mentioned previously, TSMC has elected to build an additional fab in Arizona by 2026 to begin the production of 3-nanometer chips. This

new fabrication will be second to the previously constructed plant that is scheduled to produce N4 process technology in 2024. [22]By investing in domestic semiconductor production and R&D, the United States will be able to reduce its dependence on foreign sources and ensure its technological competitiveness and leadership in the 21st century.

International Security Concerns

The semiconductor industry faces numerous geopolitical security concerns that threaten its global supply chain and market stability. This vital sector powers innovation and growth across many industries and is continuously at risk due to the integrated nature of the global supply chain. The COVID-19 pandemic, the conflict in Ukraine, earthquakes, and a potential Chinese invasion of Taiwan are four major sources of uncertainty and risk for the industry. These challenges are briefly examined for their implications for the semiconductor industry.

Potential Chinese Invasion of Taiwan

The potential Chinese invasion of Taiwan poses a severe threat to the semiconductor industry. Taiwan is home to some of the world's leading chipmakers, including TSMC and United Microelectronic Corporation (UMC). These companies account for more than half of the global foundry market share and produce some of the most advanced chips. A military conflict in Taiwan could disrupt or destroy their production facilities, jeopardize their intellectual property and trade secrets, and subsequently trigger a global chip crisis. This hypothetical would be an unimaginable nightmare for the world as it could cripple many industries and economies.

Instability in Europe: Russia-Ukraine War

The ongoing conflict in Ukraine has the potential to exacerbate the semiconductor supply chain issues and the chip shortage that has impacted the industry for the past two years. The most immediate risk is the supply of specific raw materials used in semiconductor manufacturing such as neon (Ne) and palladium (Pd).[23] Russia is a major producer and exporter of these materials, and any disruptions or sanctions could affect their availability and price. About 35 percent of all Pd comes from Russia and 70 percent of all Ne comes from Ukraine.[24] The war could also have indirect effects on the semiconductor industry through inflation, currency fluctuations, trade barriers, and geopolitical tensions.

COVID-19 Supply Chain Disruption

The COVID-19 pandemic has disrupted the semiconductor industry in multiple ways. It has caused demand shocks, production delays, transportation deadlocks, and labor shortages. This has resulted in a severe chip shortage that has affected many sectors such as automotives, consumer electronics, medical devices, and cloud computing. At the height of the pandemic, experts estimated that the global chips market would decline by about 5-15 percent. The pandemic has exposed the vulnerabilities of the semiconductor industry to global health crises, demonstrating the need for more resilient and diversified supply chains.[25]

Earthquakes: Japan and Taiwan

Japan and Taiwan are both island nations that sit in an active seismic zone geographically. This predisposes them to frequent and sometimes unpredictable earthquakes, posing a sizable risk to chip production and presenting a threat to the global supply chain.

Earthquakes near these areas can damage the equipment and wafers in the fabrication facilities, leading to delays, losses, and quality issues. A 2022 earthquake in Japan was expected to reduce the number of cars and trucks produced. Renesas Electronics – a supplier of one-third of global chips for the automobile industry- has three fabs that were close to the epicenter of northeast Japan. An earthquake that hit near Hsinchu Park in Taiwan's Silicon Valley resulted in power outages which shut down the chip manufacturing process in plants.[26] This has led the domestic industries in both countries to work on risk mitigation by diversifying their production locations, prioritizing resilience, and improving their recovery plans.[27]

Recommendations

These geopolitical security concerns highlight

the importance and fragility of the semiconductor industry in a world driven by globalization. They also call for more aggressive actions from governments, businesses, and other stakeholders to protect and support this strategic sector that is essential for innovation, competitiveness, and prosperity. In this case, while the U.S. CHIPS Act is a starting point, it is not enough to achieve supply chain resilience. Therefore, the U.S. government and major onshore industrial actors should consider the following:

Address the Industrial Talent Shortage

The CHIPS Act may not be enough to foster long-term innovation and competitiveness in the advanced computing and AI technology base, which requires sustained funding, talent development, and collaboration across academia, industry, and government. This is because a big part of achieving supply chain resilience lies in the technical knowledge used to produce and manufacture chips.[28]

While many physical semiconductor fabrication plants are set to be built in the United States, the technological knowledge on how to best produce and manufacture chips is still safeguarded by other leading countries. The $40 billion TSMC plant that was built in Arizona sent over 300 workers to Taiwan to be trained in this extremely intricate process. Additionally, TSMC is set to bring in workers from Taiwan to help kickstart the Arizona plant. However, concerns raised by some Taiwanese have suggested the uneasiness of workers about moving to the United States and also disclosing valuable industry knowledge to a competitor.[29]

The success of the U.S CHIPS Act will require a more proactive attempt to secure valuable talent by investing in American students pursuing careers in electrical and mechanical engineering. [30]

Remove Unnecessary Barriers and Conditions on CHIPS Act Incentives

The CHIPS Act of 2022 relies on incentives and subsidies to attract private sector investment in semiconductor innovation and production. But it does not address the structural challenges that hinder the competitiveness of the U.S chip industry, such as incentive barriers and trade restrictions.[31] As part of the qualifications, all companies seeking CHIPS Act grants over $150 million are mandated to provide an affordable childcare plan for workers. [32]This childcare policy is an attempt to reduce the industrial talent shortage and make it more flexible for parents to work at fabrication plants. Some necessary investors and important allies like South Korea, regard this requirement as “unusual conditions”.[33]

Moreover, in October 2022, the Biden Administration rolled out new export restrictions on China, barring the sales of SME to Chinese companies. Non-tariff measures (NTMs) such as sanctions, licensing requirements, restricted entity lists, and export controls also impact U.S companies and those of allied nations.[34] NTMs require a more comprehensive and coordinated strategy that involves collaboration among federal agencies, state governments, industry associations, and academic institutions.[35] Given these barriers, the CHIPS Act may face implementation challenges, such as coordinating across multiple federal agencies, ensuring compliance with environmental and labor standards, and allocating funds efficiently and transparently.

Introduce Parallel Policies in Demand-Market Sectors like AI and Consumer Electronics

The CHIPS Act focuses mainly on boosting the onshore chip manufacturing capacity but it does not address the demand side of the market, which is driven by consumer electronics, cloud computing, 5G, and artificial intelligence. These sectors are dominated by Chinese companies such as Huawei, Alibaba, and Tencent, which have access to cheaper and more advanced chips from China and other countries.[36] The CHIPS Act excludes domestic companies like Apple, AT&T, and Amazon Web Services.

Increase the Investment Budget for the CHIPS Act to Gain Industrial Capacity

The CHIPS Act provides $52 billion in funding for semiconductor research, development, and manufacturing. But this amount may not be sufficient to close the gap with China, which has invested more than $100 billion in its domestic chip industry and

plans to spend another $150 billion by 2025.[37]

The chip-making industry requires continuous investments in all aspects of the production process. Most important is research and development, which is allocated $11 billion of the entire fund. While this is a significant investment, it is nowhere near that of China or other major actors in the global industry. Increasing the entire budget would ensure that vital areas in the domestic industry are prioritized to give the United States a global edge.

Pursue Ally-Shoring With Industrial Giants

The CHIPS Act does not guarantee that the United States will have access to the most advanced chip technologies, which are currently dominated by Taiwan and South Korea. America is bound to face competition from China's own efforts to develop its semiconductor industry. The legislation does not address the underlying causes of the global semiconductor shortage, such as trade tensions, supply chain disruptions, and surging demand from various sectors. The law relies on voluntary incentives and matching grants from private sector investment, which may not be sufficient to overcome the high costs and risks of building and operating domestic chip factories.

Washington initiated the quadrilateral group known as the Chip 4 Alliance. The Alliance is concentrated in Asia, with membership from industry powerhouses Japan, South Korea, and Taiwan.[38] However, America does not include the Netherlands and Europe in this alliance. The Chip 4 Alliance is a good start, but it needs to include the Netherlands to achieve an efficient and complete ally-shoring strategy.

Possible Alternatives to Suggested Recommendations

Replicate the Global Supply Chain Through a Complete Resilience Approach

As an alternative to the above recommendation, one can argue for a complete resilience approach. This will mean the U.S will replicate the global chip supply chain at home. However, this is nearly impossible.

The global supply chain is not only integrated into the current economic climate but also requires a long time to function at this level. Even if the United States is able to achieve replication, it would take a really long time before the system will function efficiently.

Gradual Decoupling from China's Economy

Another possible solution is for U.S. policymakers to pursue gradual decoupling from China. The notion stems from the idea that Washington will not need to fight China on every front if there is no economic, political, or social link.

This proposition, which has been criticized by both Secretary of the Treasury Janet Yellen and Secretary of State Antony Blinken, indiscriminately cuts off economic ties between two economic superpowers, in turn decreasing both the cost of war and the benefits of the status quo. The U.S economy and the Chinese economy are like yin and yang. While both countries operate under different political and economic ideologies, they are very economically intertwined, and this interdependence has made both countries prosperous. Therefore, any proactive attempt at decoupling could do more harm than good to the U.S. economy while making military conflict more likely.

Conclusion

The CHIPS Act of 2022 is a significant step forward for the U.S. semiconductor industry, but it may not be enough to ensure its long-term competitiveness against China. While the CHIPS Act provides significant funding and incentives for domestic research and production of semiconductors, it does not address the underlying challenges of competition in this critical technology. These challenges include a talent shortage, unusual incentive barriers, insufficient funding, and demand in the consumer market.

To overcome these challenges, the U.S. needs a comprehensive and long-term strategy that leverages its strengths in innovation, entrepreneurship, and alliances. A coherent strategy that addresses both

supply-side and demand-side issues, as well as geopolitical and security implications, is necessary. The U.S. government will also need to work with its allies and partners to create a more resilient and diverse global chip supply chain that fosters a robust and diverse ecosystem of semiconductor suppliers, customers, and users.

Endnotes

1 "Biden-Harris Administration Launches First Chips for America Funding Opportunity." U.S. Department of Commerce, February 28, 2023. https://www.commerce.gov/news/press-releases/2023/02/biden-harris-administration-launches-first-chips-america-funding.

2 Vishnu, Vishnu, and Vishnu Feldgoise. "After the Chips Act: The Limits of Reshoring and next Steps for U.S ..." Carnegie Endowment for International Peace . Accessed May 12, 2023. https://carnegieendowment.org/2022/11/22/after-chips-act-limits-of-reshoring-and-next-steps-for-u.s.-semiconductor-policy-pub-88439.

3 MARK, JEREMY, and DEXTER TIFF ROBERTS. "United States–China Semiconductor Standoff: A Supply Chain under Stress." Atlantic Council, March 23, 2023. https://www.atlanticcouncil.org/in-depth-research-reports/issue-brief/united-states-china-semiconductor-standoff-a-supply-chain-under-stress/.

4 "The European Chips Act." Cyber Risk GmbH. Accessed May 12, 2023. https://www.european-chips-act.com/.

5 Cyber Risk GmbH, pg.11-13

6 "How ASML Became Chipmaking's Biggest Monopoly." The Economist. Accessed May 12, 2023. https://www.economist.com/business/2020/02/29/how-asml-became-chipmakings-biggest-monopoly.

7 Furukawa, Yuki, and Takashi Mochizuki. "Japan Approves $6.8 Billion Boost for Domestic Chip Industry." Bloomberg.com. Accessed May 12, 2023. https://www.bloomberg.com/news/articles/2021-11-26/japan-approves-6-8-billion-boost-for-domestic-chip-industry#xj4y7vzkg.

8 Sposato, William. "Japan Bets Big on Bringing Semiconductor Manufacturing Home." Foreign Policy, January 9, 2023. https://foreignpolicy.com/2023/01/09/japan-semiconductor-chip-manufacturing-china/.

9 Liang, Xiao, and Nan Tian . "The Proposed Hike in Japan's Military Expenditure." SIPRI. Accessed May 12, 2023. https://www.sipri.org/commentary/topical-backgrounder/2023/proposed-hike-japans-military-expenditure.

10 Stice, Craig. Semiconductor Industry Association | SIA | voice of the semiconductor ... Accessed May 13, 2023. Pg. 8 https://www.semiconductors.org/wp-content/uploads/2021/09/2021-SIA-State-of-the-Industry-Report.pdf.

11 Stangarone, Troy. "The Role of South Korea in the U.S. Semiconductor Supply Chain Strategy." The National Bureau of Asian Research (NBR), April 13, 2023. https://www.nbr.org/publication/the-role-of-south-korea-in-the-u-s-semiconductor-supply-chain-strategy/.

12 Cyber Risk GmbH, pg.8-10

13 "Taiwan's Dominance of the Chip Industry Makes It More Important." The Economist. Accessed May 12, 2023. https://www.economist.com/special-report/2023/03/06/taiwans-dominance-of-the-chip-industry-makes-it-more-important.

14 Cyber Risk GmbH, pg.9

15 Wu, Debby. Bloomberg.com. Accessed May 12, 2023. https://www.bloomberg.com/news/articles/2023-01-09/taiwan-passes-its-chips-act-offers-tax-credits-to-chipmakers#xj4y7vzkg.

16 Ravi, Sarah. "Taking Stock of China's Semiconductor Industry." Semiconductor Industry Association, July 13, 2021. https://www.semiconductors.org/taking-stock-of-chinas-semiconductor-industry/.

17 Lee, John, and Jan-Peter Kleinhans. "Mapping China's Place in the Global Semiconductor Industry." – The Diplomat, September 11, 2021. https://thediplomat.com/2021/09/mapping-chinas-place-in-the-global-semiconductor-industry/.

18 McBride, James, and Andrew Chatzky. "Is 'made in China 2025' a Threat to Global Trade?" Council on Foreign Relations. Accessed May 12, 2023. https://www.cfr.org/backgrounder/made-china-2025-threat-global-trade.

19 Ravi, Sarah. "Taking Stock of China's Semiconductor Industry." Semiconductor Industry Association, July 13, 2021. Pg. 3 https://www.semiconductors.org/taking-stock-of-chinas-semiconductor-industry/.

20 Mazewski, Matt, and Christian Flores. "Eco-

nomic Impacts of the US Innovation and Competition Act." https://www.dataforprogress.org/. Accessed May 13, 2023. https://www.filesforprogress.org/memos/Economic-Impacts-of-USICA-One-Pager.pdf.

21 "The National Semiconductor Technology Center Update to the Community." CHIPS.GOV, November 16, 2022. https://www.nist.gov/chips/national-semiconductor-technology-center-update-community.

22 "TSMC Announces Updates for TSMC Arizona - Pr.Tsmc.Com." TSMC. Accessed May 13, 2023. https://pr.tsmc.com/english/news/2977.

23 Ghai, Palak. "Why Only Few Companies Produce Semiconductor Chips?" StartupTalky, July 4, 2022. https://startuptalky.com/why-few-companies-produce-semiconductor/.

24 "Ukraine-Russia Sector Considerations: Semiconductor Industry." KPMG, August 17, 2022. https://kpmg.com/xx/en/home/insights/2022/08/semiconductor-considerations.

25 Bauer, Harald, Ondrej Burkacky, Abhijit Mahindroo, Mark Patel, and Peter Kenevan. "Coronavirus: Implications for the Semiconductor Industry." McKinsey & Company. Accessed May 13, 2023. https://www.mckinsey.com/~/media/mckinsey/industries/financial%20services/our%20insights/accelerating%20winds%20of%20change%20in%20global%20payments/2020-mckinsey-global-payments-report-vf.pdf.

26 Wayland, Michael. "Toyota, Major Chip Supplier Suspend Production Due to Earthquake in Japan." CNBC, March 18, 2022. https://www.cnbc.com/2022/03/18/toyota-major-chip-supplier-to-cut-production-due-to-japan-earthquake.html.

27 Robinson, Sara. "Taiwan's Chip Plants Left Idle by Earthquake." The New York Times, September 22, 1999. https://www.nytimes.com/1999/09/22/business/taiwan-s-chip-plants-left-idle-by-earthquake.html.

28 Yue, Jack. "Op-Ed: The United States Semiconductor Talent Shortage." Fung Institute for Engineering Leadership, January 20, 2023. https://funginstitute.berkeley.edu/news/op-ed-the-united-states-semiconductor-talent-shortage/.

29 Liu, John, and Paul Mozur. "Inside Taiwanese Chip Giant, a U.S. Expansion Stokes Tensions." The New York Times, February 22, 2023. https://www.nytimes.com/2023/02/22/technology/tsmc-arizona-factory-tensions.html.

30 Yue, Jack. "Op-Ed: The United States Semiconductor Talent Shortage." Fung Institute for Engineering Leadership, January 20, 2023. https://funginstitute.berkeley.edu/news/op-ed-the-united-states-semiconductor-talent-shortage/.

31 Capri, Alex. "Semiconductors at the heart of the US-China tech war." Hinrich Foundation (2020): 22.

32 Shepardson, David. "U.S. Commerce to Ask Companies Seeking Chips Funding to Provide Childcare for Employees." Reuters, February 28, 2023. https://www.reuters.com/world/us/us-commerce-ask-companies-seeking-chips-funding-provide-childcare-employees-2023-02-28/.

33 Sohn, Jiyoung. "South Korea Says US Chips Act Subsidies Have Too Many Requirements." Fox Business, March 7, 2023. https://www.foxbusiness.com/markets/south-korea-us-chips-act-subsidies-requirements.

34 Capri, Alex. "Semiconductors at the heart of the US-China tech war." Hinrich Foundation (2020): 22.

35 Shivakumar, Sujai, Charles Wessner, and Thomas Howell. "A Seismic Shift: The New U.S. Semiconductor Export Controls and the Implications for U.S. Firms, Allies, and the Innovation Ecosystem." CSIS. Accessed May 12, 2023. https://www.csis.org/analysis/seismic-shift-new-us-semiconductor-export-controls-and-implications-us-firms-allies-and.

36 Melnik, Jeffrey. "China's 'National Champions': Alibaba, Tencent, and Huawei." Association for Asian Studies, April 29, 2020. https://www.asian-studies.org/publications/eaa/archives/chinas-national-champions-alibaba-tencent-and-huawei/.

37 Thomas, Christopher. "A New World under Construction: China and Semiconductors." McKinsey & Company, November 1, 2015. https://www.mckinsey.com/featured-insights/asia-pacific/a-new-world-

under-construction-china-and-semiconductors.

38 He-rim, Jo. “Preliminary ‘chip 4’ Meeting Expected next Week as China Monitors.” The Korea Herald, September 22, 2022. https://www.koreaherald.com/view.php?ud=20220922000642.