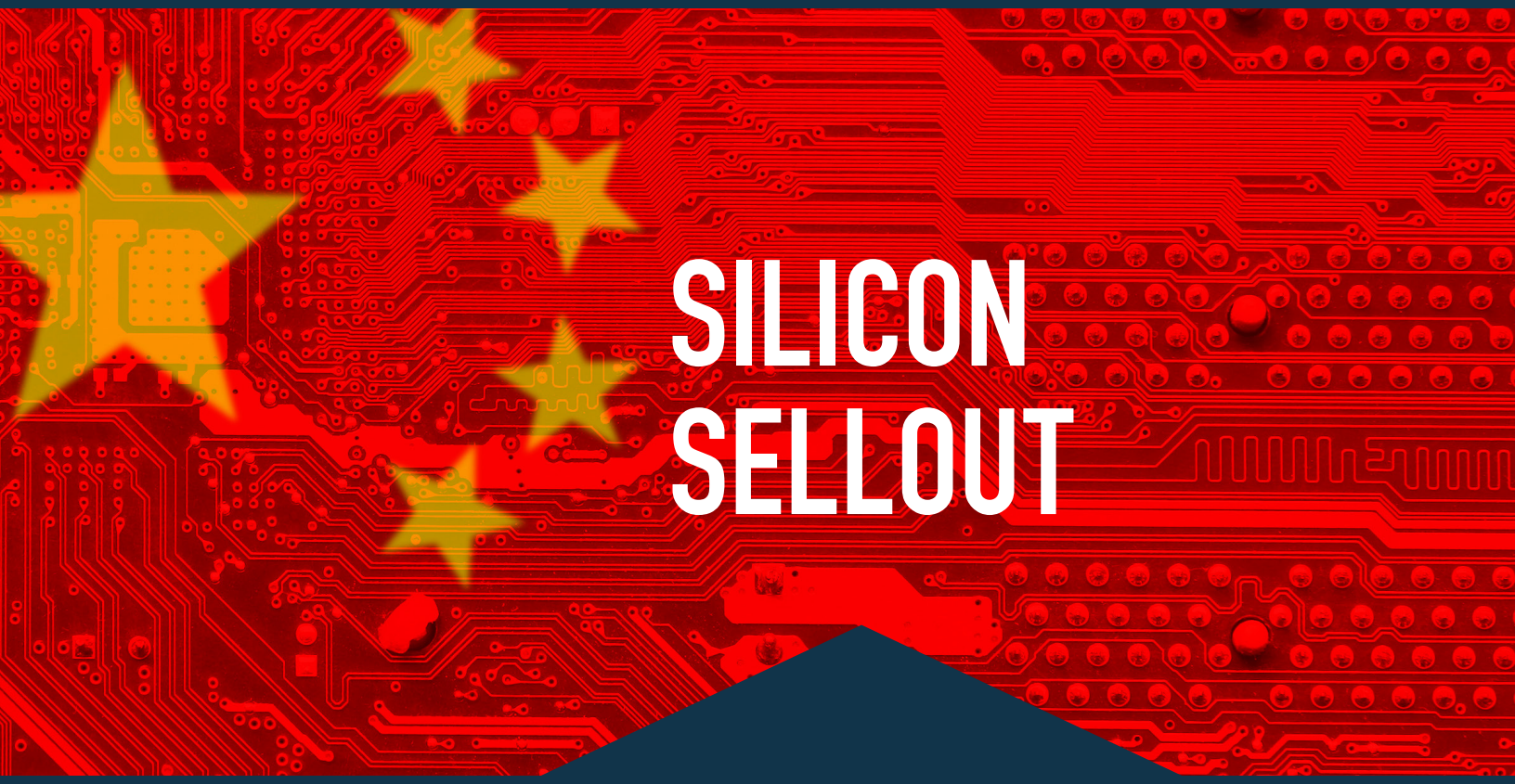


SILICON SELLOUT

HOW APPLE'S PARTNERSHIP WITH CHINESE MILITARY CHIP MAKER YMTC THREATENS AMERICAN NATIONAL SECURITY

ROSLYN LAYTON, PH.D.,
CO-FOUNDER, CHINA TECH THREAT

JEFF FERRY, CHIEF ECONOMIST,
COALITION FOR A PROSPEROUS AMERICA

JUNE 2022

China TECH THREAT

CPA COALITION for a PROSPEROUS AMERICA

TABLE OF CONTENTS

ROSLYN LAYTON, PhD co-founded China Tech Threat to improve U.S. policy to protect Americans from technological threats from the People's Republic of China (PRC). She is a Visiting Researcher at the Department of Electronic Systems at Aalborg University and Senior Vice President at Strand Consult. She is a Senior Contributor to Forbes. She holds a Ph.D. in business economics from Aalborg University, an M.B.A. from the Rotterdam School of Management, and a B.A. in international service from American University. She can be contacted at roslyn@chinatechthreat.com.

JEFF FERRY is Chief Economist at the Coalition for a Prosperous America (CPA). CPA is the only national, bipartisan organization representing exclusively a coalition of domestic manufacturers, labor unions, and family farm groups dedicated to rebuilding U.S. manufacturing and broadly restoring American prosperity. Ferry is an economist, author, and former technology executive. From 2005 to 2011, he served as a marketing executive at Infinera, a U.S. manufacturer of optical networking systems that designs and manufactures photonic integrated circuits in Sunnyvale, California. In 2019, the CPA economics team won the Mennis Award from the National Association for Business Economics for a paper, *Decoupling from China: an economic analysis of the impact on the U.S. economy of a permanent tariff on Chinese imports.* He can be contacted at jeff@prosperousamerica.org.

EXECUTIVE SUMMARY

Yangtze Memory Technologies Company (YMTC) is a Chinese semiconductor maker with known ties to the Chinese military. The Chinese government wants to disrupt the global memory chip market and win leadership for YMTC. As of May 2022, Apple reportedly will ship the iPhone 14 with YMTC memory chips. The deal could:

- Compromise iPhone users' security and privacy with untrusted Chinese technology
- Concentrate more chip production in China, increasing supply chain risk
- Force the exit of at least one memory chip supplier from the U.S. or another democratic country, thereby potentially reducing U.S. jobs
- Give legitimacy to state-subsidized military-linked YMTC as a chipmaker
- Bolster the Chinese government's quest to dominate global semiconductor production, reducing U.S. leadership and innovation

Ideally Apple will voluntarily end its partnership with YMTC. It can source its chips from existing suppliers like Micron, Kioxia, Samsung, SK Hynix, Western Digital, and Intel. Failing that, the report describes how US policymakers must restrict technology exports to and imports from YMTC.

INTRODUCTION

Yangtze Memory Technologies Company (YMTC) is a Chinese semiconductor maker with known ties to the Chinese military. In March, a Credit Suisse report revealed that Apple, the world's most valuable company, is qualifying YMTC memory chips for use in the iPhone 14, iPad, and potentially other products.[1] *Digitimes* reported that Apple cleared YMTC's validation process and that the phones would ship this May.[2]

Apple's engagement with YMTC, which has been called China's "national champion memory chip producer," raises concerns on several levels. First is its connection to Chinese military leaders. In December 2020, James Mulvenon, Director of Intelligence Integration at SOS International, released a report that identified YMTC's ties to the Chinese military. These ties include executives and board members leading efforts to modernize China's military.[3] Mr. Mulvenon also authored the similar seminal report on China's Semiconductor Manufacturing International Company's (SMIC) ties to the Chinese military. Subsequently the U.S. Commerce Department added SMIC to the Entity List.[4] The Apple deal also presents the possibility that malicious technology and practices from the Chinese military could be introduced to Apple end-users and others. A section in this paper details technological risks to users' security and privacy.

The Apple-YMTC partnership could provide material support to the Chinese military, which has used American-made semiconductor technology to advance its military capabilities.

The partnership with Apple provides YMTC with insight to world-class chip, computer and smartphone design and brings international credibility to YMTC, thereby furthering the Chinese government's ambitions to dominate the global semiconductor market. However, increasing chip production in China runs counter to the strategy proposed by the U.S. Departments of Homeland Security and Commerce to mitigate information and communications technology (ICT) production risk and strengthen supply chain resiliency.[5]

As demonstrated by semiconductor market economics and detailed in this report, the Apple-YMTC deal will likely hasten the exit of an existing memory chip maker from a democratic country. Finally, the Apple-YMTC partnership could provide material support to the Chinese military, which has used American-made semiconductor technology to advance its military capabilities. The partnership underscores failures in the United States to incentivize domestic chip production, which has become a focus of the Biden Administration.

WHY IS APPLE TURNING TO YMTC?

Apple's consideration of YMTC likely reflects its desire to drive down semiconductor costs by putting pressure on other manufacturers. Indeed talks began between the two companies in 2018.[6] Some analysts speculate that the Chinese government has pressured Apple to work with YMTC. Consistent with its goal to dominate the global chip market, the Chinese government could lean on the iPhone maker to use its preferred national champion chipmaker YMTC or even insist on it as a condition of retaining access to the Chinese market. For Apple, as for many U.S. companies, the opportunity to increase sales is an irresistible feature of the Chinese market. China has one billion consumers—and a government that conditions foreign companies' ability to sell on their willingness to play by its rulebook. Last year, Apple reported sales of $68 billion from China and revenues up 70 percent, making it Apple's fastest-growing market, notes *Light Reading* International Editor Iain Morris.[7]

The recent moves with YMTC and Apple suggests that subsidies could increase even further. Already YMTC has received some $24 billion in government investment funds structured to evade World Trade Organization rules against illegal state aid.[8] Such subsidies explain in part why China's share of global semiconductor manufacturing capacity, which was barely 1 percent in 2000, increased to 11 percent by 2010, 15 percent by 2020 and is forecast to increase to 24 percent by 2030, notes a recent industry report.[9]

However China has not gained chip market share because of superior, more innovative chips. Rather, it buys market share with low-priced, heavily subsidized chips, sold below cost. This drives down chip prices and reduces innovation. Such was the testimony of Stephen Ezell, Vice President of Global Innovation Policy for the Information Technology and Innovation Foundation (ITIF) to the United States Security and Economic Review Council.[10] He calculates that China's low-cost chip strategy has reduced the industry's overall chip patent intensity, costing U.S. firms some 5,000 patents, which would have otherwise been issued.

In any event, the consolidation of production within China is at odds with the post-pandemic recognition that supply chains must be diversified and redundant. While Apple recently issued warnings about slowed shipments from the Chinese factory closures because of Covid-19, the company appears to expand production in China and strengthen its ties to the government.[11] While Apple is diversifying some supply to India and Southeast Asia, it is also increasing the number of suppliers in China, which remains the core of its manufacturing capability. China's technology sector, carefully funded and orchestrated by the government, has better insight into Apple's manufacturing needs than any other country's technology sector, including the U.S.

Apple CEO Tim Cook's claims of American patriotism are meaningless rhetoric. Apple has created perhaps ten times as many jobs in China as it has in the U.S. Apple's strategy continues to be: (1) software development based in the U.S., (2) manufacturing based in China and (3) a global retail network to showcase the product. Manufacturing capabilities inevitably give rise to engineering and hardware design capabilities, creating momentum for the technology industry to migrate over time to China.

Apple's deal with YMTC will accelerate China's plans to become self-sufficient in semiconductors. It could put at least one major non-Chinese semiconductor producer out of business.

Apple's deal with YMTC will accelerate China's plans to become self-sufficient in semiconductors. It could put at least one major non-Chinese semiconductor producer out of business. It risks exposing yet more intellectual property to Chinese theft. It reduces American national and economic security and Americans' data privacy (and for Apple users globally) through increasing contact with the Chinese government's surveillance state. Policymakers should act while there is still a window to do so.

CHINA'S END GAME: CONTROLLING THE MEMORY CHIP MARKET

The Chinese government recognizes that the ability to produce advanced technologies is key to establishing China as the world's leading economic and political power. As a component of China's *Made in China 2025* plan, the National Integrated Circuit plan calls for China to meet 70 percent of its semiconductor needs through domestic production by 2025, and to reach parity with international leading-edge technology companies in all segments of the industry by 2030.[12] Today China manufactures an estimated 37 percent of the chips it consumes, still greater than the U.S. whose share of global production has fallen to 12 percent.[13] While some observe that China has fallen short of its professed goals, the fact remains that is has progressed significantly in chip production and threatens to unseat the U.S. and its competitors in different chip domains.

The following table illustrates some key points about the global market for semiconductors. While logic chips form the "brain" of an electronic device, memory chips are the "brawn" which store vast amounts of data and constitute an essential part of virtually every device. These two sectors comprise more than half of the total market for chips, with each accounting for some 28 percent of the market and more than $150 billion each in annual revenue. Six companies—Samsung Electronics, Kioxia, Western Digital, SK Hynix, Micron Technology, and Intel—dominate the memory chip market. Moreover the demand for memory chips, both DRAM and NAND segments (explained in the next section), is expected to double by 2030.[14]

Global Semiconductor Market By Function 2021			
Type	**Leading Companies**	**Sector Revenue (billions)**	**Percent of Global Chip Market**
Logic	Intel, TSMC, AMD	$154.8	27.8%
Memory	Samsung, Micron Technology, SK Hynix, Western Digital Kioxia, Intel etc.	$153.8	27.7%
Micro-controllers	Infineon, NXP Semiconductor, Texas Instruments	$80.2	14.4%
Analog	Texas Instruments, Analog Devices, Skyworks	$74.1	13.3%
Other	Broadcom, Qualcomm, Renesas	$92.8	16.7%
		$555.7	
Source: Based on World Semiconductor Trade Statistics, Boston Consulting Group and Coalition for a Prosperous America			

China's Advantages: Massive Government Subsidies and Rampant IP Theft

China has focused its semiconductor strategy, including subsidies of over $100 billion, on every sector of the chip market. It has achieved most success in relatively less complex chips like light emitting diodes (LEDs). Memory chips represent the first highly complex sector where it is breaking through to parity with leading-edge producers.

YMTC benefits from Chinese state subsidies. It also may have benefited from IP theft. That was a charge made by a Sanford Bernstein analyst Mark Newman in the *New York Times* in 2018 who said that YMTC memory chips had designs too similar to Samsung's to be a coincidence. [15]

Additionally, Fujian Jinhua, another Chinese chipmaker, entered into a joint venture with Taiwanese chipmaker UMC, which hired away Micron engineers and encouraged them to steal Micron trade secrets and pass them onto the Chinese company.[16] Fujian Jinhua was added to the Entity List in 2018.[17] Then in June 2020, a Taiwanese court found UMC and three engineers guilty of stealing the trade secrets.[18]

IP theft is a widespread, virtually routine, practice in China's technology industry.[19] This reduces costs for Chinese firms as compared to competitors. Hardware companies in the U.S., South Korea, and other non-China locations typically cross-license patents with each other in multimillion dollar deals. While this may add to the cost of chips, it compensates these companies for the R&D they have invested in developing their patented technologies, and it affords them the freedom to operate in the same markets as one another. Chinese companies routinely circumvent such deals by relying on the IP insulation that stems from their geographic location in China, a country whose court systems are notorious for shielding domestic companies against foreign companies' legitimate claims of IP infringement.

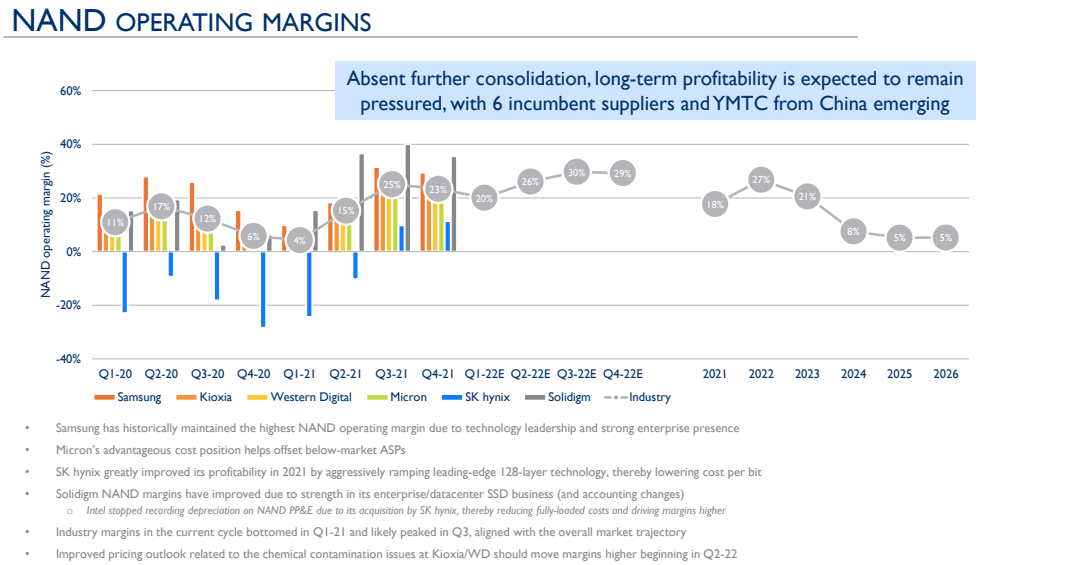
How Apple Benefits from an Unstable Chip Market

There are two kinds of memory chips, DRAM and NAND. DRAM memory chips are the faster of the two, but they lose their stored data when electricity is switched off, so they tend to be used in network or online storage devices that are always connected to a power supply. NAND or flash memory on the other hand, retains stored data even without power. That makes NAND essential for smartphones and many other devices. The Apple-YMTC partnership involves NAND memory.

Intense competition to manufacture memory chips has consolidated the sector. There were 25 memory chip companies in 1990, but only six major players remain today — Samsung Electronics, Toshiba, Western Digital, SK Hynix, Micron Technology, and Intel. YMTC presently accounts for only 3 percent of this market.

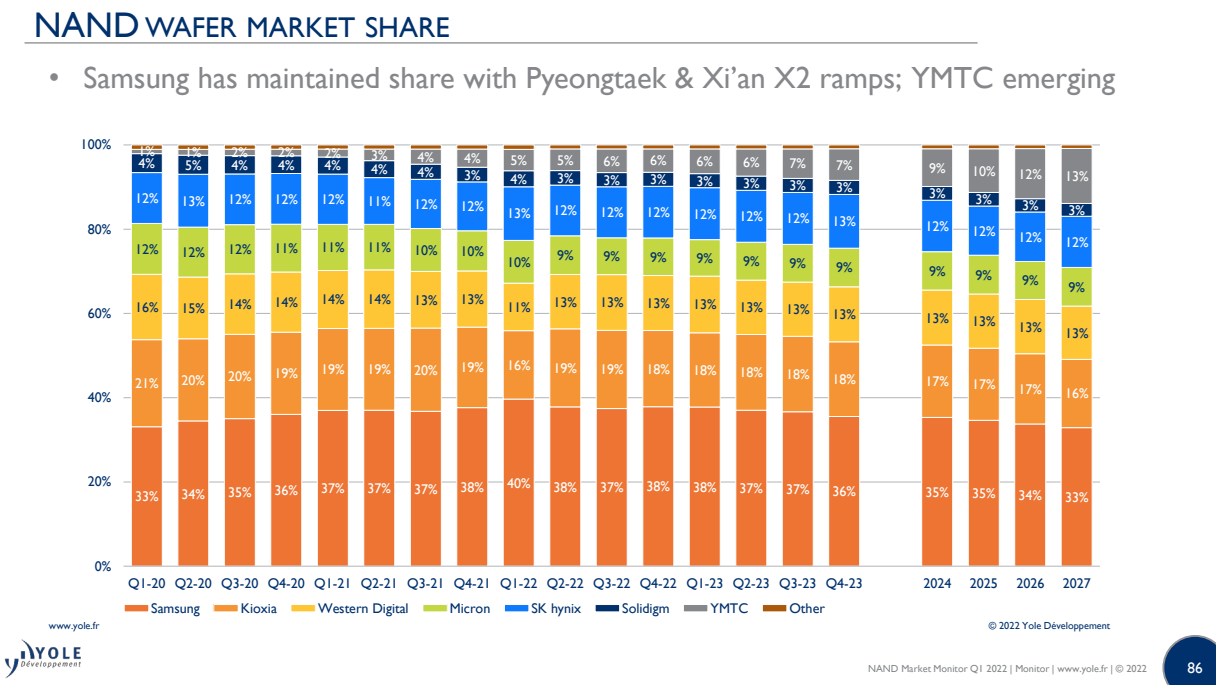
Three companies lead the DRAM memory business specifically: Samsung Electronics, SK Hynix, and Micron Technology. The only American company of these is the Idaho-based Micron, which makes both DRAM and NAND chips at its fabs in the U.S., China, Singapore, and elsewhere. The existence of only one American-based memory chip producer today is a result of competition and price volatility in the memory market which drove other U.S. players out of the industry. As private sector companies, U.S. chipmakers have tended to exit a sector during any extended period of low profits. Foreign chipmakers, including those in Korea and Japan, have traditionally been able to get support either from their governments or from profitable related divisions of the same parent company, to enable them to hold on through low-profit periods.

In the last few years, the NAND memory market has achieved a period of stability and reasonable profitability, as explained in Yole Development's NAND Market Overview report. The stability has been due to growing demand for memory as cloud computing has grown in popularity in the business sector, while smartphones and video applications have grown among consumers. The Covid pandemic accelerated both trends.



However, stable prices in NAND memory are not good news for Apple as it prefers declining prices on components to optimize its long-term cost reduction goals. The price stability likely prompted Apple to enter into talks with YMTC. YMTC is owned by a conglomerate of Chinese state entities: the National IC Industry Investment Fund, the state university-controlled investment fund Tsinghua Unigroup, and the Hubei Science and Technology Investment Group. YMTC has received most of its investment from Beijing's National IC Industry Investment Fund—a massive pool of state funding designed to evade World Trade Organization (WTO) restrictions on government subsidies. With billions of dollars of subsidies in hand, YMTC can underprice other NAND memory suppliers, provided it resolves its quality issues.

The chart below shows Yole's forecast of rapid gains in YMTC market share:



The memory capacity of YMTC chips is catching up to world-class chipmakers and is already competitive with Samsung at 128-layers (which refers to the level of sophistication and capability of the chip), though it suffers from yield issues.[20] These issues will likely be resolved in the near future, opening the door for YMTC to become a major player in the global NAND market. YMTC also has two more large-scale fabs in the works, doubling its facilities.

Apple choosing YMTC to supply NAND memory for the iPhone 14 would be the greatest victory for the Chinese semiconductor industry in its short,checkered history. It would lift YMTC into the upper echelon of chipmakers.

Apple choosing YMTC to supply NAND memory for the iPhone 14 would be the greatest victory for the Chinese semiconductor industry in its short,checkered history. It would lift YMTC into the upper echelon of chipmakers. Other users of memory chips, ranging from computer makers to auto producers to home appliance makers, would quickly line up to test YMTC memory devices.

TIME TO "THINK DIFFERENT": FIVE RISKS TO AMERICANS AND OTHERS FROM THE APPLE-YMTC DEAL

A deal with YMTC may be good for Apple's bottom line, but YMTC chips inside the world's devices presents profound risks to America and the world. Apple once prided itself on the ability to "Think Different." It needs to think different about YMTC.

Many U.S. policymakers and experts have cautioned that YMTC poses a clear and present danger to America's national security. In July of 2021, U.S. Senator Bill Hagerty and U.S. Representative Michael McCaul called on U.S. Commerce Secretary Gina Raimondo to add YMTC to the Entity List, citing "specific facts that link YMTC to the CCP military, the Party-state, and a national semiconductor plan designed to deplete the U.S. defense industrial base."[21] Likewise, after news of Apple's potential partnership with YMTC surfaced in March 2022, U.S. Senator Marco Rubio wrote in a letter to CEO Tim Cook, "In a more just world, the Biden Administration would have already added YMTC to its trade blacklists... America's premier tech companies should recognize the tremendous risks – both to American national security and to their own ledgers, should any presidential administration update its export control listings in the near future – incurred by doing business with YMTC for its memory chips or any other products."[22]

The Apple-YMTC deal presents risks to security, privacy, technology leadership, supply chain, and jobs. The following section demonstrates each risk.

Risk #1: National Security – The Battlefield Control Switch

Cyber intrusion via Chinese-made semiconductors is not theoretical. Supermicro is a U.S.- Taiwanese computer maker with worldwide manufacturing. During the 2010s, the Chinese military in concert with a Chinese government subcontractor, allegedly inserted a tiny chip into thousands of Supermicro motherboards with the capability to create stealth remote access. The attack was reported to have impacted almost 30 companies, including a major bank, Apple, and Amazon Web Services. Apple subsequently ripped and replaced 7,000 servers, and Amazon terminated a China-based supplier as a result. The case was corroborated by multiple U.S. intelligence and security officials.[23]

YMTC chips could be similarly, intentionally compromised with rogue features after normal memory products were approved and designed into the phone. These built-in and concealed vulnerabilities would not be detected during manufacturing. They could be exploited months or years later to disrupt performance or exfiltrate data from a system containing the compromised chip.

Such a scenario was detailed in P.W. Singer's novel *Ghost Fleet: A Novel of the Next World War*, which describes the grounding of U.S. fighter jets because of compromised chips made in China. The Pentagon's Trusted Integrated Circuit Strategy and Trusted Foundry Program was established to ensure clean chips for defense, but no such program exists for consumer devices. Chips for consumer products could also be hacked to produce devastating consequences or be leveraged to install a bot as part of a botnet attack on a larger system.

Electronics with embedded chips are enabled with a "kill switch," a feature to shut down the device upon the user's command. Such features, under Chinese military production, could be enabled or programmed to shut down remotely by an unauthorized Chinese government actor or another. Military hardware has been seemingly compromised by a kill switch in at least one known instance,[24] and in consumer devices. For example, a kill switch could shut off a phone used in a political demonstration or a critical device connected to a larger system, such as an electric grid.

Risk #2: Privacy – Apple Expands Chinese Government Surveillance

Apple has also touted its commitments to privacy. The company declares, "*Privacy* is a fundamental human right. At *Apple*, it's also one of our core values. Your devices are important to so many parts of your life."[25] Yet Apple's level of cooperation with the Chinese government – effectively helping the state surveil and censor 230 million Chinese users of Apple products – renders this statement hypocritical. Apple is no stranger to toeing the Chinese government's line on human rights abuse like censorship, surveillance or slave labor, as an exposé by the *New York Times* has detailed. In 2017, Apple, in conformity with China's Cybersecurity Law, launched a joint venture in China to build a data center that would enable the Chinese government's access to Apple customer data.[26]

YMTC chips equipped with spyware and installed on Apple devices could funnel collected data back to Beijing

Americans enjoy the protections of their civil liberties in a way that Chinese citizens do not. This prompted U.S. authorities, in part, to restrict Huawei. However, the same threats associated with Huawei exist with respect to YMTC. YMTC chips equipped with spyware and installed on Apple devices could funnel collected data back to Beijing increasingly difficult proposition for any company. A January 2022 letter from a technology industry trade groups told regulators that devices "...include hundreds of components – each with their own complex supply chains – sourced from around the world from trusted vendors and suppliers. Even network products that are assembled in the United States by U.S. companies rely on foreign inputs from their global partners."[27]

Risk #3: Lost U.S. Technology Leadership – The PRC's "National Champion" Model Unfairly Eliminates Competitors

Throughout the 1990s, many experts theorized that China would remain the low-end manufacturing "workshop" for products made with U.S. intellectual property. That view has given way to the realization that Chinese businesses and government had no intention of keeping their country just a workshop. China wants its entities to control the whole value chain: design, product development, manufacture, marketing, and distribution. China's strategy to steal and subsidize its way to success has worked in many domains. It could just be a matter of time before it reaches the tipping point in semiconductors.

China's strategy to steal and subsidize its way to success has worked in many domains. It could just be a matter of time before it reaches the tipping point in semiconductors.

This shift has already taken place across multiple industries. Today China manufactures a majority of the world's laptop and desktop computers. Some of them are designed and made by homegrown Chinese companies, like Lenovo, while some carry U.S. brand names, like HP. China also supplies a majority of the world's solar panels, flat panel displays, networking equipment and drones – and many of these products reflect indigenous effort in both product design and production.

Semiconductors could be more important than all these industries. Semiconductors are foundational and critical to all electronics, from simple household appliances to automobiles, to computers and to sophisticated defense electronics like missile systems or fighter jets. China's incursion threatens to disrupt and completely reshape the semiconductor industry as we know it today. China is driving a shift from an industry where chip leaders come from various countries in the free world to one in which the leadership of all segments in increasingly centralized in China.

A primary way the Chinese government has worked to turn China into the dominant technology producer is through an abundance of subsidies for state-backed or nominally independent "national champions." From 2011 to 2020, China invested as much as $100 billion,[28] and maybe more, to support the development of a home-grown industry and to end its dependence on semiconductor imports. The Biden White House supply chain report observes that YMTC itself has received an estimated $24 billion in subsidies.[29]

The Apple-YMTC deal will further strengthen China's position as the epicenter of global high-tech manufacturing and push it closer to leading in advanced research and development. The notion of China as an R&D leader can only be expected to grow stronger once Chinese semiconductor companies start producing chips comparable in quality to those produced by major western manufacturers. China's breakthrough in memory chips is also likely to pave the way for similar breakthroughs in logic chips and other semiconductor sectors.

China's playbook to steal and subsidize its way to tech industry domination is well-illustrated by Huawei, now the world's leading supplier of equipment for telecom networks. One of the byproducts of Huawei's subsidized growth was the failure of the two North American giants in the industry, Lucent and Nortel. Both were multi-billion-dollar companies in the 1990s but went into steep decline as Huawei leveraged subsidies to offer its products at lower prices in the early 2000s. A shrunken Lucent was sold to French telecom equipment maker Alcatel in 2006. Nortel went from being the largest company on the Canadian stock exchange in 1999 to bankruptcy in 2009.[30] By 2017, as the world's networks were upgrading to 5G wireless telecom, Huawei was the largest supplier of 5G equipment, even larger than the next two competitors, Nokia and Ericsson, combined.

Seeing the dangers of letting a Chinese company build the world's 5G networks, the Trump Administration embarked on a successful campaign to counter Huawei through export controls on American technologies destined for Huawei, as well as a diplomacy which convinced approximately sixty countries and numerous telecom operators to keep Huawei products out of their 5G networks.[31] However Huawei merely shifted its strategy to other products and services like smart phones and cloud computing, technologies which also present security and privacy risks.[32] Despite the handicaps placed on Huawei, no U.S. company has re-emerged as a major supplier of wireless networks. The American semiconductor industry should not be allowed to suffer the same fate.

Risk #4: Sluggish Economic Growth –More Supply Chain Shortages and Bottlenecks

An Apple-YMTC pact could exacerbate the risk of American consumers already experiencing shortages of goods. Today a global semiconductor shortage is damaging virtually every industry's capacity to produce goods and services. Automobile production is well below target levels, assembly line workers have been laid off, and the conversion to electric vehicles is behind schedule. Industry leaders have said they expect the shortages to last into 2023.

Global semiconductor supply chains are among the most complex in the world, with various constituent parts of many chips often crossing multiple borders in the production process. Many of these supply chains use parts made in China. China's "zero-COVID" goal has been enforced through rigorous lockdowns of millions of people, thus constricting the Chinese people's ability to move freely and work. China's severe and unpredictable COVID lockdowns, along with severe congestion in Chinese ports and a global shortage of freight ships, has led to shortages and snafus in western goods markets. The Chinese government made it clear during the 2020 COVID outbreak with protective equipment that at times of shortage, it would always prioritize its home market.

Apple is today experiencing the costs of crippled Chinese supply chains. It has warned of revenue shortfalls of as much as $8 billion.[33] Many Apple suppliers operate in China's lockdown-hit areas, and workers have revolted in some factories where they are forced to sleep on the premises and other injustices. Executives have warned that curbs are likely to have global impact, disrupting logistics and denting company's sales.[34] Apple's deepening engagement with Chinese business could make this situation worse. In 2021, China leapfrogged Taiwan to become Apple's largest source of suppliers, with 51 Chinese companies providing parts for the company's products.[35] In view of the lockdown situation in China, Apple concentrating operations further in China and sourcing YMTC chips does not seem smart or prudent.

While U.S. tariffs in 2019 cut U.S. imports from China, U.S. imports from China in the first quarter of 2022 reached their highest level ever, easily surpassing the 2018 level.[36] This was driven by the pandemic as people purchased electronics to work and learn from home. Most of the world's electronics are already produced in China with IP and inputs still distributed across countries. Further concentration of the crucial memory chip market to China only increases the likelihood of supply chain bottlenecks, not to mention increasing China's economic clout which can be leveraged for military advantage.

Risk #5: Jobs – YMTC'S Market Manipulation Jeopardizes U.S. Jobs

The Chinese government strategy puts YMTC in a strong position to tip the NAND market in its favor. Technology analyst firm Yole Development expects YMTC to have a 13 percent share of NAND wafer marke share by 2027.[37] Yole also forecasts that, partly due to aggressive pricing by YMTC, NAND prices could fall by half, from current levels of 11 cents per gigabyte today to 5 cents per gigabyte.

Such an aggressive role by a new, subsidized Chinese entrant would put huge pressure on the market. At least one player is likely to drop out. This could ultimately make the U.S. dependent on Chinese NAND chips, a catastrophic result from a national security point of view. If could also mean lost investment and jobs for the U.S. if it's an American company that is forced to exit.

The U.S. semiconductor business employs an estimated 250,000 people, including some 24,000 in the memory sector.[38] These jobs are at risk from a disruptive Chinese incursion into the market. But more than 24,000 well-paid U.S. research, design, engineering, and manufacturing jobs are at risk from the Apple-YMTC deal. A semiconductor fab is a complex facility that creates many indirect employment opportunities supporting local low-tech or mid-tech services around each fab.

When one sector of the industry disappears due to subsidized Chinese competition, a pillar of the U.S. industry is knocked out and the larger ecosystem weakened.

The local economy in Silicon Valley or Beaverton, Oregon or Boise, Idaho depends on high-paying, high-tech semiconductor-related jobs throughout those regions. In addition, semiconductor companies support research at universities because they need a pipeline of future employees in their highly specialized fields. In sum, the technology industry depends on a broad ecosystem of internet, software, hardware and system companies and the educational institutions that support them. When one sector of the industry disappears due to subsidized Chinese competition, a pillar of the U.S. industry is knocked out and the larger ecosystem weakened. The U.S. industry is already much weaker due to the loss of many sectors. The potential loss of memory semiconductors would mean the destruction of a major pillar of the U.S. industry.

EIGHT OPTIONS TO MITIGATE THE APPLE-YMTC TIE-UP

Ideally Apple will voluntarily end its partnership with YMTC. It can source memory chips from non-Chinese chipmakers like Micron, Kioxia, Samsung, SK Hynix, Western Digital, and Intel. However as Apple goes forward with a dangerous deal, U.S. policymakers should explore the following policy measures to mitigate the security risks of Apple's deal with YMTC and protect Apple users and others.

According to recent reporting by *The Information*, the U.S. Department of Commerce's Bureau of Industry and Security (BIS) is weighing restrictions on the sale of semiconductor manufacturing equipment (SME) to YMTC and other state-backed firms Hua Hong Semiconductor and ChangXin Memory Technologies (CXMT).[39] The rules, which reportedly will take months to develop, would build on a model developed for SMIC based on its ties to China's military-industrial complex. The strategy is designed to slow the company's ability to manufacture advanced or more complex chips while allowing the company to continue to manufacture less advanced chips. In practice, it is difficult to distinguish the types of equipment to be controlled. The policy will likely dent the sales of Applied Materials, Lam Research and KLA Corp., which collectively reported $14.5 billion in sales to China last year. U.S. companies producing in China would also be impacted because they could not import the needed machines. The policy would coordinate with other SME producing nations including Netherlands and Japan, where relationships have been strengthened through the recent efforts to restrict Russian entities following its invasion of Ukraine.

The policy could be integrated with the Creating Helpful Incentives to Produce Semiconductors (CHIPS Act) for America Act, offering some $52 billion in support to the industry. Some Congressional guardrails propose restrictions on U.S. firms selling to China, which also accept U.S. taxpayer dollars. However, semiconductor equipment manufacturers have succeeded in weakening such requirements by arguing that sales must be maintained with China to earn revenue for continued U.S. R&D. To many, this appears to be a self-serving, short-termist argument.

Notably, stakeholders differ on the rules' effectiveness, interpretation, and implementation. Some debate on the status of Chinese chipmaker SMIC and others has emerged between the U.S. Departments of Commerce, State, Energy and Defense, and on whether and how licenses and exemptions would be granted. Commerce tends to favor licenses and exemptions while national security-related agencies do not.[40] Indeed this predictable outcome prompts many to suggest that the export control function should be removed from Commerce.

Option #1 (Best Option): Restrict technology exports to and imports from YMTC

The best, most effective protection of national security restricts US technology exports to and imports from YMTC.

The best, most effective protection of national security restricts US technology exports to and imports from YMTC. This requires three steps: (1) adding YMTC to the Entity List; (2) creating a Foreign Direct Product Rule (FDPR) to prohibit the shipment of YMTC chips to Apple regardless of whether the resulting chips themselves are controlled; and (3) imposing import restrictions on Apple products using YMTC chips per Executive Order 13873 on Securing the Information and Communications Technology and Services Supply Chain.

The U.S. Commerce Department's Bureau of Industry and Security (BIS) Entity List regulates companies from doing business with entities engaged in activities sanctioned by the State Department and activities contrary to U.S. national security and/or foreign policy interests. It restricts the exports of controlled US technology (specialized hardware, software, and other products) to Entity List actors. Chips are typically made with semiconductor manufacturing equipment (SME) and integrated circuit design software. The FDPR would ensure the prohibition on YMTC chips being shipped to Apple and provide legal clarity. The import restriction would ensure the prohibition of imports of Apple products with YMTC chips to the US, a needed measure as parties could attempt to find workarounds to the other rules. Ideally there should be restrictions on all imports of Apple products made under partnership with firms affiliated with the Chinese military.

US House Foreign Affairs Committee Chairman Michael McCaul and Senate Foreign Relations Committee members Marco Rubio and Bill Hagerty have all called for BIS to add YMTC to the Entity List, given its deep ties to the Chinese military. The globalized world enables a relative free movement of goods and services, but this also allows the proliferation of weapons and dual-use items to be used for hostile purposes. Countries adopt export controls to manage the distribution of sensitive items to help ensure that people live in a secure environment.[41] As such, nations employ some amount of export control for safety, though no policy is perfect.

Option #2: Examine YMTC Violations of Foreign Direct Product Rule

Another means of protecting American national security from YMTC is to restrict it on the grounds that it violated the U.S. restrictions on Huawei in the Foreign Direct Product Rule (FDPR). In effect, the FDPR bans the transfers of any American technology to Huawei.

The Commerce Department, prompted by a report from the firm TechInsights, is already investigating whether YMTC violated U.S. export controls by providing chips for Huawei's 20e phone.[42] If found to be supplying Huawei, YMTC would be in violation of the rules. The Commerce Department should also investigate whether YMTC is providing technological components to Chinese surveillance gear maker Hikvision, which was also placed on the Entity List in 2019.[43] Hikvision's own advertising materials boast of the incorporation of YMTC storage components.[44] Indeed video cameras use large volumes of memory chips.

Subjecting YMTC to the FDPR alone will not be enough, because the U.S. government has little monitoring or enforcement capabilities to prevent Chinese companies from transferring necessary technologies to YMTC. The application of the FDPR to YMTC must happen in conjunction with YMTC being placed on the Entity List.

Option #3: Require Policy Assessment and Audit

Vital policy watchers like the U.S. China Security and Economic Review Commission could conduct an audit of BIS' activities and effectiveness. Potential negative findings could give Congress momentum to hold hearings on BIS if it were failing to fulfill essential objectives.

Investigative pressure on BIS from Congress would also have the effect of sending a warning signal to American companies that increased scrutiny of BIS could translate into increased scrutiny of their own adherence to the American export control regime.

BIS can also wield its own power of audit and investigation. Perhaps in conjunction with the Central Intelligence Agency, BIS could also conduct an audit of China-based semiconductor supply chains to determine the extent to which U.S. export controls are being violated. As new Director Alan Estevez has more national security experience than any prior BIS Director and does not need to defend the Agency's past performance, he is in an excellent position to lead a cross-agency collaboration.

Lastly, national security leaders must know which technologies are being sent to China. Congress could invite certain American business leaders to testify (or issue subpoenas) regarding their businesses' connections to China, and specifically activities related to sensitive technologies and semiconductors.

Option #4: Investigate Forced Labor Prohibitions

In 2021, President Biden signed into law the Uyghur Forced Labor Prevention Act (UFLPA), which prohibits the importation of products made with forced labor in the Xinjiang region of China. If YMTC can be proven to use forced labor in its supply chain, it would warrant a ban on the import of YMTC products into the U.S. Xinjiang produces between one third and one half of the world's polysilicon, the base material for silicon wafers.

Human rights advocacy organizations and U.S. government agencies can investigate whether YMTC chips are made from wafers produced with forced labor. At a minimum, given the extensiveness and opacity of supply chains associated with Chinese "national champion" companies, concerned entities responsible for enforcing provisions of the UFLPA like Customs and Border Protection, the State Department and the Forced Labor Enforcement Task Force established under the U.S.-Mexico-Canada Agreement Implementation Act should investigate how YMTC sources the polysilicon it needs to make its chips.

If China continues to block foreign officials from inspecting facilities in Xinjiang, the U.S. should presume that forced labor is indeed involved and enforce further action against YMTC.

Option #5: Invoke NDAA Section 1260

Section 1260H of the National Defense Authorization Act (NDAA) directs the Department of Defense to begin identifying, among other things, Military-Civil Fusion (MCF) contributors operating directly or indirectly in the United States. There may be potential to name YTMC as one such company.

YMTC has extensive ties to the Chinese military. As the Chinese government's leading contender to become a global powerhouse in semiconductor production, YMTC will likely gain access to advanced technological knowledge from suppliers and customers alike. It is probable that a military-linked entity like YMTC will be eager to find opportunities to transfer ostensibly civilian knowledge into military hands.

The Department of Defense consistent with 1260H should publicly identify YMTC as an MCF contributor. At a minimum, this designation would signal YMTC's ties to the Chinese military, potentially setting up the use of other authorities, such as a placement on the Entity List, to decouple it from American technologies.

Option #6: Employ the FCC Covered List

The Federal Communications Commission (FCC) has a unique, important authority granted by Congress to regulate commercial equipment which uses radio frequencies. Under the Secure and Trusted Networks Act of 2019, Congress has instructed the FCC to create a Covered List of equipment and services that meet certain criteria and determinations of national security risk, to update this list periodically, and to add and remove entities accordingly.

As China Tech Threat and Blue Paths Labs noted in a comment submission to the FCC in 2021, the FCC has made a good start to propose prohibiting equipment authorizations from entities on the Covered List, presently the five Chinese military aligned companies Huawei Technologies Company, ZTE Corporation, Hytera Communications Corporation, Hangzhou Hikvision Digital Technology Company and Dahua Technology Company. Given YMTC's well-established ties to the Chinese military, there is no reason to keep YMTC off the Covered List.[45] Doing so would likely prevent the sale of iPhones manufactured with YMTC chips inside the United States. Adding YMTC to the Covered List, however, likely wouldn't stop Apple from selling iPhones made with YMTC chips around the world.

Option #7: Use Existing Executive Orders – Securing the Information and Communications Technology and Services Supply Chain

Executive Order 13873 of May 15, 2019 gives the Secretary of Commerce authority to prohibit "any acquisition, importation, transfer, installation, dealing in, or use of any information and communications technology or service" which threatens the national security of the United States."[46] Under these authorities, the Secretary of Commerce could block the YMTC-Apple deal on national security grounds.

Option #8: Outbound Investment Screening: A New Tool on the Horizon?

U.S. companies receiving certain foreign direct investment are by law required to submit transactions to the Committee on Foreign Investment in the United States (CFIUS) for review. In recent months, members of the U.S. Senate, notably Bob Casey and John Cornyn, have urged the creation of a "reverse CFIUS" – a mechanism for screening American foreign direct investment destined for certain countries, including China, across several critical areas, including aerospace, electronic communications equipment, robotics, artificial intelligence and semiconductors.

Specifically, the U.S. Congress has in recent months debated a piece of legislation called the National Critical Capabilities Defense Act (NCCDA). According to a summary of the bill put out by Senators Casey and Cornyn, "Firms operating in critical industries would need to report outbound investments to certain foreign markets (such as China) and how that might compromise U.S. national security."[47] Should the U.S. stand up such an instrument, the U.S. government would be wise to evaluate whether American companies have made investments in YMTC or other companies feeding its supply chain.

CONCLUSION

This paper has described the Apple-YMTC partnership and the threats its poses to security, privacy, U.S. technological leadership, supply chain, and jobs. It has detailed how the deal would negatively impact the global flash memory market and likely put one western firm out of business, eliminating valuable high-paying jobs. The partnership also offers YMTC undeserved legitimacy as a chip supplier and bolsters China's quest to dominate global semiconductor production.

US technology exports to and imports from YMTC should be restricted.

The Chinese government wants more than mere displacement of U.S. economic and technology leadership. It wants its governance model to be the dominant force in the world and sees technology, particularly semiconductors, as key to economic and military power and preeminence.

Thanks to massive subsidies, YMTC is now in position to make competitive chips. American policymakers should follow the advice of various national security leaders and use its multiple legal authorities and investigative powers to stop the Apple-YMTC deal. US technology exports to and imports from YMTC should be restricted. BIS should act immediately to place YMTC on the Entity List.. Concurrently the U.S. can promote the proactive policy to improve the operating environment for domestic chip production thus improving security and opportunities for American workers.

ENDNOTES

1 Iain Morris, "Apple 14 iPhone may feature Chinese chips with military links," ***Light Reading,*** March 28, 2022, https://www.lightreading.com/semiconductorsnetwork-platforms/apple-iphone-14-may-feature-chinese-chips-with-military-links/d/d-id/776350

2 Siu Han and Willis Ke, "YMTC 128-layer NAND memory gains Apple validation," ***DigiTimes Asia,*** March 31, 2022, https://www.digitimes.com/news/a20220331PD200.html

3 Roslyn Layton, "China Aims to Dominate Flash Memory," ***Forbes,*** January 4, 2021, https://www.forbes.com/sites/roslynlayton/2021/01/04/china-aims-to-dominate-flash-memory/?sh=213d47882fd6

4 Dan Strumpf, "U.S. Weighs Export Controls on China's Top Chip Maker," The Wall Street Journal, September 6, 2020, https://www.wsj.com/articles/u-s-weighs-export-controls-on-chinas-top-chip-maker-11599324489

5 Department of Homeland Security, ***Assessment of the Critical Supply Chains Supporting the U.S. Information and Communications Technology Industry,*** February 25, 2022. https://www.dhs.gov/publication/assessment-critical-supply-chains-supporting-us-ict-industry

6 Cheng Ting-Fang, "Apple in talks for first order with a Chinese chipmaker," ***Nikkei Asia,*** February 14, 2018, https://asia.nikkei.com/Business/Electronics/Apple-in-talks-for-first-order-with-a-Chinese-chipmaker2

7 Morris, "Apple 14 iPhone may feature Chinese chips"

8 SOS International, "Blue Heron: Yangtze Memory Technologies Co. (YMTC)," SOS International, December 2020.

9 Antonio Varas et al., "Government Incentives and U.S. Competitiveness in Semiconductor Manufacturing," report by SIA and Boston Consulting Group, September 2020, https://www.semiconductors.org/wp-content/uploads/2020/09/Government-Incentives-and-US-Competitiveness-in-Semiconductor-Manufacturing-Sep-2020.pdf

10 Testimony of Stephen Ezell to USCC, "Challenging China's Trade Practices: Promoting Interests of U.S. Workers, Farmers, Producers, and Innovators. Panel II: Innovation, Technology, and Intellectual Property Concerns," April 22, 2022. https://www.uscc.gov/sites/default/files/2022-04/Stephen_Ezell_Testimony.pdf

11 Mark Gurman, "Apple's Overdependence on China Shows in $8 Billion Supply-Chain Snag," Bloomberg, May 1, 2022., https://www.bloomberg.com/news/newsletters/2022-05-01/will-apple-aapl-move-more-of-its-supply-chain-out-of-china-l2nchsuj

12 Justin Hodiak and Scott W. Harold, "Can China Become the World Leader in Semiconductors?," ***The Diplomat,*** September 25, 2020, https://thediplomat.com/2020/09/can-china-become-the-world-leader-in-semiconductors/

13 Jeff Ferry and Roslyn Layton, "Maintaining US Leadership in Semiconductors and Countering China's Threats," China Tech Threat and Coalition for a Prosperous America, March 2021 https://chinatechthreat.com/wp-content/uploads/2021/03/CTT-CPA-Semiconductor-White-Paper.pdf

14 Ray Tiernan. "Micron: The memory market will more than double by the end of the decade." The Technology Letter. May 13, 2022.https://www.thetechnologyletter.com/the-posts/micron-the-memory-market-will-more-than-double-by-the-end-of-the-decade

15 Paul Mozur. "Inside a Heist of American Chip Designs, as China Bids for Tech Power." New York Times. June 22, 2018. https://www.nytimes.com/2018/06/22/technology/china-micron-chips-theft.html

16 Ibid.

17 "Addition of Certain Entities to the Entity List," Notice published in the ***The Federal Register,*** October 30, 2018, https://www.federalregister.gov/documents/2018/10/30/2018-23693/addition-of-an-entity-to-the-entity-list

18 Deb Wu, "Engineers Found Guilty of Stealing Micron Secrets for China," Yahoo Finance, June 20, 2020, https://finance.yahoo.com/news/engineers-found-guilty-stealing-micron-142809629.html

19 Jeff Ferry. "Top Ten Cases of IP Theft." Coalition for a Prosperous America. May 1, 2018. https://prosperousamerica.org/top-ten-cases-of-chinese-ip-theft/

20 Dylan Patel, "The Impending Chinese NAND Apocalypse – YMTC 128 Layer NAND Is The First Semiconductor Where China Is Technologically Competitive," ***SemiAnalysis,*** September 28, 2021, https://semianalysis.substack.com/p/the-impending-chinese-nand-apocalypse-e01?s=r

21 U.S. House of Representatives Committee on Foreign Affairs, "McCaul, Hagerty Urge Raimondo to Include the CCP's YMTC on Commerce Department Entity List," press release issued July 12, 2021, https://gop-foreignaffairs.house.gov/press-release/mccaul-hagerty-urge-raimondo-to-include-the-Chinese governments-ymtc-on-commerce-department-entity-list/

22 Senator Marco Rubio, "Rubio to Apple: Deal With CCP Chip-Maker Would Threaten U.S. National Security, Strengthen China"

23 Jordan Robertson and Michael Riley, "The Big Hack: How China Used a Tiny Chip to Infiltrate U.S. Companies," ***Bloomberg Businessweek,*** 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

24 Sally Adee, "The Hunt for the Kill Switch," ***IEEE Spectrum,*** May 1, 2008, https://spectrum.ieee.org/the-hunt-for-the-kill-switch

25 Apple, Privacy webpage, accessed May 6, 2022, https://www.apple.com/privacy/#:~:text=Privacy%20is%20a%20fundamental%20human,should%20be%20up%20to%20you.

26 Jack Nicas, Raymond Zhong and Daisuke Wakabayashi, "Censorship, Surveillance, and Profits: A Hard Bargain for Apple in China" ***New York Times.*** June 20, 2021. https://www.nytimes.com/2021/05/17/technology/apple-china-censorship-data.html

27 Telecommunications industry letter to Sec. Raimondo, Sec. Buttigieg, and Secretary Vilsack, January 31, 2022, https://tiaonline.org/wp-content/uploads/2022/01/Industry-Letter-on-IIJA-and-Buy-American-v7.4-FINAL.pdf

28 Industry Association of America, "U.S. Needs Greater Semiconductor Manufacturing Incentives," infographic released July 2020, https://www.semiconductors.org/wp-content/uploads/2020/07/U.S.-Needs-Greater-Semiconductor-Manufacturing-Incentives-Infographic1.pdf

29 The White House, ***Building Resilient Supply Chains, Revitalizing American Manufacturing, And Fostering Broad-Based Growth,*** report issued June 2021, https://www.whitehouse.gov/wp-content/uploads/2021/06/100-day-supply-chain-review-report.pdf

30 Jeff Ferry. "Top Five Cases of Huawei Theft and IP Infringement." Coalition for a Prosperous America. December 13, 2018. https://prosperousamerica.org/top-five-cases-of-huawei-ip-theft-and-patent-infringement/

31 Roslyn Layton. "State Department's 5G Clean Network Club Gains Members Quickly." September 4, 2020. Forbes. https://www.forbes.com/sites/roslynlayton/2020/09/04/state-departments-5g-clean-network-club-gains-members-quickly/?sh=5fdba0907536

32 Silvia Elaluf Calderwood. "Huawei data centres and clouds already cover Latin America. Chinese tech influence is a gift to countries and politicians that don't respect human rights." Strand Consult Guest Blog. February 7, 2022. https://strandconsult.dk/blog/huawei-data-centres-and-clouds-already-cover-latin-america-chinese-tech-influence-is-a-gift-to-countries-and-politicians-that-dont-respect-human-rights/

33 Bloomberg News. "Apple Supplier Faces Worker Revolt in Locked Down China Factory". May 27, 2022. https://www.bloomberg.com/news/articles/2022-05-27/apple-supplier-faces-worker-revolt-in-locked-down-china-factory

34 Lauly Li, Cheng Ting-Fang and Shunsuke Tabeta, "Half of Apple Suppliers operating in China's lockdown-hit areas," ***Nikkei Asia,*** April 20, 2022, https://asia.nikkei.com/Spotlight/Supply-Chain/Half-of-Apple-suppliers-operating-in-China-s-lockdown-hit-areas

35 Cheng Ting-Fang and Lauly Li, "China ousts Taiwan as Apple's biggest source of suppliers," ***Nikkei Asia,*** June 2, 2021, https://asia.nikkei.com/Business/China-tech/China-ousts-Taiwan-as-Apple-s-biggest-source-of-suppliers

36 Kenneth Rapoza. "Monthly Trade Deficit Tops $100 Billion for First Time in History." Coalition for a Prosperous America. May 4, 2022. https://prosperousamerica.org/trade-deficit-us-march2022-supplychains/

37 Walt Coon. "NAND Market Monitor Q1 2022." Yole Development Report.

38 Antonio Varas et al. "Strengthening the Global Semiconductor Supply Chain a Global Era." Boston Consulting Group and Semiconductors Industry Association. April 2021. https://www.semiconductors.org/strengthening-the-global-semiconductor-supply-chain-in-an-uncertain-era/

39 Stephen Nellis. "US Weighs Broader Crackdown on Chinese Chipmakers. The Information. May 9, 2022. https://www.theinformation.com/articles/the-u-s-weighs-a-broader-crackdown-on-chinese-chipmakers?rc=byot9l

40 Jenny Leonard and Ian King, "Biden Team Mulls New Clampdown on China's Largest Chipmaker," ***Bloomberg,*** December 14, 2021, https://www.bloomberg.com/news/articles/2021-12-14/biden-team-considers-new-clampdown-on-china-s-biggest-chipmaker?sref=0qIeASWn.

41 Dai Tamada & Philippe Achilleas, ***Theory and Practice of Export Control: Balancing International Security and International Economic Relations.*** SpringerBriefs in Economics. 2017. https://www.amazon.com/Theory-Practice-Export-Control-SpringerBriefs/p/9811059594?asin=9811059594&revisionId=&format=4&depth=1

42 "US to probe claims that top Chinese chipmaker violated ban on Huawei," ***The Financial Times,*** April 27, 2021, https://www.ft.com/content/8078f71e-d115-43c1-8f68-e5b6ec6cfcda

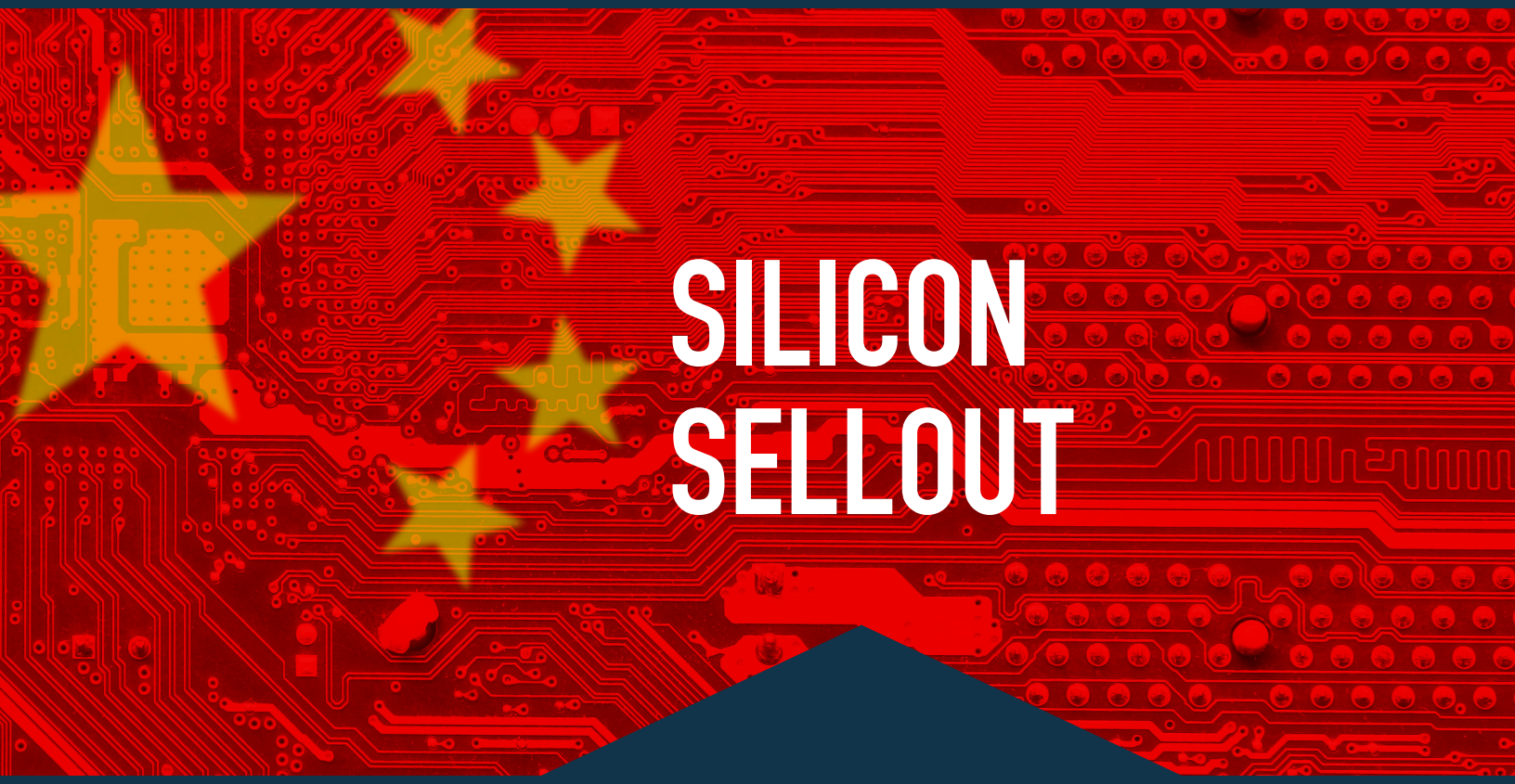
43 "Addition of Certain Entities to the Entity List," Notice published in the ***The Federal Register,*** October 9, 2019, https://www.federalregister.gov/documents/2019/10/09/2019-22210/addition-of-certain-entities-to-the-entity-list

44 "The 20th China Suzhou Electronic Information Expo in 2021," ***HikSemi,*** December 30, 2021, http://www.hikstorage.com/News/Detail?id=74ad0853-e21e-41a5-8f69-8abff483d1fb

45 Roslyn Layton and Peter Wood, "Comments of China Tech Threat and Blue Path Labs before the Federal Communications Commission," Comments submitted regarding ET Docket No. 21-232 and No. 21-233, September 20, 2021, https://chinatechthreat.com/wp-content/uploads/2021/09/ChinaTechThreat-BluePathLabs-FCC-Equipment-Authorization-21-232-and-21-233-FINAL.pdf

46 "Securing the Information and Communications Technology and Services Supply Chain," notice published in ***The Federal Register,*** May 15, 2019, https://www.federalregister.gov/documents/2019/05/17/2019-10538/securing-the-information-and-communications-technology-and-services-supply-chain

47 "National Critical Capabilities Defense Act," fact sheet released by Sen. Bob Casey and Sen. John Cornyn, publication date unknown, accessed May 7, 2022, https://www.casey.senate.gov/imo/media/doc/one_pager_nccda.pdf



SILICON SELLOUT

China TECH THREAT

CPA COALITION for a PROSPEROUS AMERICA

www.chinatechthreat.com

www.prosperousamerica.org