CHIP WARS: THE STRUGGLE FOR SEMICONDUCTORS SUPREMACY

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INTRODUCTION

The Global Financial Crisis (GFC) between 2007 and 2009 led to a sharp decline in economic activity, plummeting output, and increasing unemployment. The crisis did not spare the world's only superpower, the USA, which was reeling under an economic setback brought about by the GFC and worsened by its burgeoning defence expenditure due to the operations in Iraq and Afghanistan. China, which had benefited from globalisation and had impressive economic growth, pumped billions of dollars into its domestic economy to prevent the fallout of the GFC. Sensing the preoccupation of the USA and Europe in the multiple crises, China slowly but surely started becoming more aggressive, giving wings to its expansionist dreams. Using a potent mix of inducement, cooperation and coercion, China's footprints in global affairs were on the upswing. Its uncontested actions in militarising the South China Sea (SCS) emboldened it to simultaneously augment its non-kinetic war against the West by using stolen technology and huge capital to strike at its technological underbelly. Chinese telecom companies such as Huawei and ZTE expanded their global reach and secured access

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to critical telecom networks. In doing so, they installed backdoors that enabled it to spy and gather data. However, it took some time for the USA to initiate action. In 2012, a US House of Representatives committee launched an investigation that concluded that Huawei had broken American laws and was either unable or unwilling to explain its ties to the Chinese government. The report recommended not using Huawei systems in any government or contractor network.[1] At this stage, the world at large was dithering and, in many cases, even opposed to acting against Chinese telecom companies. This inaction enabled China to embark upon its mission to be the world's technology leader, thereby paving the path towards global supremacy.

THE IMPORTANCE OF SEMICONDUCTORS

The manufacture of semiconductors, commonly known as microchips or chips, involves single-atom elements like germanium or silicon and compounds like gallium arsenide. The addition of slight quantities of contaminated substances to the single-atom elements through a procedure known as doping significantly alters the material's conductivity.[2] One semiconductor chip has many transistors. The first commercially sold chips for commercial applications had only four transistors in the mid-1960s. In the last five decades, semiconductor technology advancements have improved electronic gadgets' miniaturisation, processing speeds, and reliability.[3] Today, a smartphone chip has 15 billion transistors. This gives an idea of the mammoth increase in computing power over the decades.

1. Steve Blanks, "The Chip Wars of the 21st Century", June 11, 2020, available at https://warontherocks.com/2020/06/the-chip-wars-of-the-21st-century/. Accessed on November 9, 2023.
2. https://www.semiconductors.org/semiconductors-101/what-is-a-semiconductor. Accessed on November 11, 2023.
3. https://www.nod-pcba.com/news/163-en.html. Accessed on November 14, 2023.

Chips have also become more powerful since the initial days of the chip industry in 1965. As a crucial constituent in electronic equipment, semiconductors have allowed improvements across various civil and military fields. These include Information and Communication Technology (ICT), quantum computing, medicare, vehicles, sustainable energy, weaponry, Internet of Things (IoT), Artificial Intelligence (AI) and even Chat GPT [it is reported that Open AI's Chat GPT, underwent training amongst the top 10,000 sophisticated Central Processing Units (CPUs) now existing].[4] An inalienable part of our activities and modern economy, chips are central to technologies that have taken centre-stage in various human endeavours.[5] It is a truism that the 'intelligence' of electronic gadgets lies in chips. For example, chips numbering in thousands constitute the brains of modern automobiles, handling their various operating aspects.[6] The semiconductor materials market size was estimated at $ 70.30 billion in 2023 and is expected to reach $ 88.66 billion by the next five years.[7]

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Many of these technologies have strategic value due to their applications in newer forms of warfare. It would interest the reader that although the erstwhile USSR had developed many cutting-edge military technologies during the Cold War, one reason why it was so far behind the USA at the end of the Cold War was that the USA had invested in computing technology (principally semiconductors). Historically, there has also been a direct

4. Alex W. Palmer, "An Act of War: Inside America's Silicon Blockade Against China", *New York Times*, July 12, 2023. Updated August 11, 2023.
5. "The Basics of Microchips", ASML, available at https://www.asml.com/en/technology/all-about-microchips/microchip-basics. Accessed on November 12, 2023.
6. "An Act of War: Inside America's Silicon Blockade Against China", Dalian Treadmill Inc.. https://www.oupailang.com/news/an-act-of-war-inside-americas-silicon-blockade-against-china.html. Accessed on November 14, 2023.
7. https://www.mordorintelligence.com/industry-reports/semiconductor-materials-market. Accessed on November 11, 2023.

relationship between intelligence gathering and the capability of computing power.[8]

MANUFACTURING AND SUPPLY CHAIN OF CHIPS: A COMPLEX ECOSYSTEM

An insight into the complexities involved in manufacturing chips and the inter-connected supply chain is essential to comprehend the geopolitics behind the ongoing technological war. After World War II, the United States took a vanguard position in semiconductor research, development, design, and manufacture. Even today, it leads the world in chip research, development and design. The raw materials required in semiconductors include silicon, germanium, phosphorus, boron, indium phosphide and gallium. In 2022, the Chinese produced roughly 60 per cent of global germanium and 80 per cent of gallium.[9] As raw materials, the electronics-semiconductor ecosystem requires certain Rare Earth Elements (REEs) such as lanthanum, cerium, neodymium, samarium, europium, terbium, and dysprosium. China accounts for 60 per cent of the world's REEs extraction and 87 per cent of their production.[10]

Semiconductor chips are incredibly complex. A mistake in a produced chip can't be 'patched' and could have disastrous consequences.[11] The whole chip requires redesigning and refabrication. This method is typically overly time-consuming and costly, causing the venture to fail. The intricacy of chip design and development is so considerable that the requirement to accomplish it perfectly becomes an uncompromising necessity. The manufacturing of chips requires extremely high-end sophisticated software. Such software is

8. https://www.youtube.com/user/NDUniv (Excerpts from a talk by Chris Miller, author of "Chip Wars", delivered at the National Defence University).
9. https://www.reuters.com/markets/commodities/where-are-strategic-materials-germanium-gallium-produced-2023-07-04/. Accessed on November 11, 2023.
10. International Energy Agency 2022, quoted in R. Chadha, G. Sivamani, and K. Bansal. "Assessing the Criticality of Minerals for India: 2023", CSEP Working Paper 49. (New Delhi: Centre for Social and Economic Progress, 2023).
11. "What is Electronic Design Automation (EDA)? – How it Works", available at https://www.synopsys.com/glossary/what-is-electronic-design-automation.html. Accessed on November 14, 2023.

available only in the USA. Once the required software is available, the chips need to be 'designed.' The design of chips for various applications is diverse and different. Most of the sophisticated chip design companies are based in the USA. Once the design for the chips is acquired, the next step is to acquire the lithography machine and tools required to manufacture the chip. Chris Miller defines lithography as "the process of using light to create patterns on silicon wafers."[12] Chip-making tools could easily rank as the most complex tools humans have ever made. The most advanced chip-making tools are made in the USA, Japan, and the Netherlands. ASML, a Dutch company, exclusively has the ability to produce state-of-the-art photolithography scanning equipment utilised in etching microscopic circuits onto silicon wafers.[13] This extreme ultraviolet (EUV) lithography machine made by ASML has the capacity to create very low-sized chips, up to 10 nanometres (nm). Comparatively, red blood cells in humans are about 7,000 nm.[14] The EUV machine employs a laser that generates plasma whose temperature is 40 times more than the sun's surface. The EUV light produced from this process remains unseen to human eyes and is then imitated over a silicon chip through a succession of mirrors. The source of this laser, which has 4,57,329 parts, resides in a German company, and a whole EUV encompasses in excess of one lakh apparatuses of comparable intricacy.[15]

Despite manufacturing the world's most sophisticated lithography machine, ASML hardly produces chips. The world leader in chip production is Taiwan. Its manufacturing share is in excess of 60 per cent of the globe, and in the highly sophisticated ones, it is more than 90 per cent.[16] The race to produce smaller chips is becoming more intense, with a Taiwanese company,

12. Chris Miller, in a podcast with Nilay Patel, available at https://www.theverge.com/23578430/chip-war-chris-miller-asml-intel-apple-samsung-us-china-decoder. Accessed on April 3, 2024.
13. https://www.theguardian.com/world/2023/jul/05/chip-wars-how-semiconductors-became-a-flashpoint-in-the-us-china-relationship. Accessed on November 5, 2023.
14. Alex W Palmer, "An Act of War: Inside America's Silicon Blockade Against China", June 13, 2023, available at https://www.oupailang.com/news/an-act-of-war-inside-americas-silicon-blockade-against-china.html. Accessed on November 14, 2023.
15. Ibid.
16. https://www.economist.com/special-report/2023/03/06/taiwans-dominance-of-the-chip-industry-makes-it-more-important. Accessed on November 14, 2023.

Taiwan Semiconductor Manufacturing Company (TSMC), which is capable of producing 5nm chips and aiming to produce 3nm ones. Meanwhile, Samsung has already produced a 3nm chip, while IBM has developed a 2nm chip in lab conditions. Taiwan's pole position in chip production and China's stated goal of reunifying it (even forcefully, if need be) have complicated the geopolitical conundrum around semiconductors. Chinese access to Taiwanese manufacturing of chips (through occupation/reunification) becomes a great risk to the US and its allies. South Korea accounts for 8 per cent of global chip production.[17] Together, Taiwan and South Korea have the lion's share in global chip production. Japan is the source of virtually every speciality chemical required for the manufacture of semiconductors, while companies in Japan and South Korea hold sway in the production of wafers.[18] Notably, all these countries have a frayed relationship with Beijing.

CHINESE PLANS

Chinese foreign policy underwent a significant change when Xi Jinping became the president. China's aggressiveness became pronounced, and it made no bones about its aim to replace the USA as the world's *numero uno* power. China identified that in the information age, the path to becoming a superpower was to possess, regulate, and control high-end and cutting-edge technology. It put in place an elaborate plan to reduce the technological, military and power gap between itself and the USA. Semiconductors held the key in this quest. However, China was heavily dependent upon the import of high-end chips and was spending almost an equal amount on importing chips as it was on importing oil. As of June 2023, China and the USA were in a 'neck-and-neck' competition for the speediest supercomputers globally, with China claiming 134th positions, as compared to 150th that the U.S. secured. However, such is the technological lead and prowess of the USA

17. Congressional Research Service, ''Frequently Asked Questions: CHIPS Act of 2022 Provisions and Implementation", April 25, 2023, available at https://crsreports.congress.gov/product/pdf/R/R47523. Accessed on November 5, 2023.
18. https://www.mckinsey.com/industries/industrials-and-electronics/our-insights/semiconductor-design-and-manufacturing-achieving-leading-edge-capabilities. Accessed on April 3, 2024.

that China is inextricably dependent on the entire range of 'high-end' chips essential for its highly advanced projects and its industry.[19] Chris Miller, author of "Chip War: The Fight for the World's Most Critical Technology", says about China, "The entire industry can only function with US inputs. In every facility that's remotely close to the cutting edge, there are US tools, US design software and US intellectual property throughout the process." In spite of struggling to achieve 'indigenous innovation' and spending 'double-digit billion dollars', China's predicament continued to be severe. Thus, chips were China's crucial vulnerability. To technologically outsmart the USA, China had to leapfrog its capability in this field. Chinese ambitions, therefore, were to control the entire supply chains of raw materials used in modern electronics and chips. Coinciding with Xi Jinping's ascendance to power, in 2014, China launched a National Integrated Circuit Industry Fund (commonly referred to as China's "Big Fund") with funding of $ 21 billion. This was a focussed plan to ensure the growth of the chip industry in China. In 2015, China released a 'Made in China 2025 Plan' (MIC 2025) to rapidly develop 10 high-tech industries. Prominent ones included Electric Vehicles (EVs), next-generation Information Technology (IT), advanced robotics, Artificial Intelligence (AI), aerospace engineering, and biomedicine. All these technologies require semiconductors. China's leading chipmaker and a key supplier to Huawei, the Semiconductor Manufacturing International Company (SMIC), had already bought and installed production equipment for 14nm and 7nm chips in 2018 and 2019.[20] The "Big Fund" was allocated an additional $ 35 billion in 2019. Apart from the "Big Fund", provincial administrations in China raised funds for semiconductor manufacturing valued at $ 25 billion.[21] Citing various reports from outside China, including those of the Organisation for Economic

19. https://www.oupailang.com/news/an-act-of-war-inside-americas-silicon-blockade-against-china.html. Accessed on November 14, 2023.
20. https://asia.nikkei.com/. Accessed on October 14, 2023 (Cheng Ting-Fang, Nikkei Newsletter, October 12, 2023).
21. Gregory C Allen, "China's New Strategy for Waging the Microchip Tech War", CSIS Report, May 3, 2023, available at https://www.csis.org/analysis/chinas-new-strategy-waging-microchip-tech-war. Accessed on November 9, 2023.

Technologies such as facial recognition software, 3-D printing, virtual reality systems, AI, and autonomous vehicles have both civil and military applications.

Cooperation and Development (OECD) and a think-tank associated with the U.S. Congress, specialists have opined that gross Chinese investments to strengthen its semiconductor industry amounted to approximately $ 150 billion in the years between 2014 and 2020.[22]

China's elaborate plan encompassed forcing foreign companies in China to share Intellectual Property Rights (IPRs), investing in US firms engaged in hi-tech manufacturing, recruiting foreign scientists, and stealing data as well as intellectual property. Aware of the crucial importance of Dutch technology to the development of its semiconductor industry, the Chinese also targeted key Dutch tech companies. These efforts included increasing its acquisitions of Dutch technology companies (such as Nexperia and innovative start-ups like Nowi) and intensifying its intelligence activity at universities. Since 2015, ASML has reported several data leaks and espionage incidents. For example, Yu Zongqiang, a Chinese-born engineer and former ASML employee, stole the source key of Optical Proximity Correction (OPC) software that the company had been working on for a decade.[23] In 2019, the China National Intellectual Property Administration granted a patent to another business owned by Yu, the Beijing-based Dongfang Jingyuan Electron Ltd company, for software he had stolen from ASML.[24] Technologies such as facial recognition software, 3-D printing, virtual reality systems, AI, and autonomous vehicles have both civil and military applications. Without explicitly naming the USA, the Chinese Defence White Paper of 2015 had enough hints to discern who it thought to be its main geopolitical rival. The White Paper of 2019 was more direct

22. Alicia García-Herrero and Pauline Weil, "Lessons for Europe from China's Quest for Semiconductor Self-Reliance", Policy Brief, Bruegel, November 18, 2022, available at https://www.bruegel.org/policy-brief/lessons-europe-chinas-quest-semiconductorself-reliance. Accessed on October 25, 2023.
23. Paulina Uznańska, Centre for Eastern Studies, Commentary, September 4, 2023, available at https://www.osw.waw.pl/en/publikacje/osw-commentary/2023-09-04/european-front-war-over-microchips-netherlands-joins-anti. Accessed on November 14, 2023.
24. Ibid.

in conveying the need to win informatised and intelligentised wars in the face of the so-called 'threat' China imagined from the USA. An American think-tank confirmed America's worst fears in June 2022 when it discovered that the People's Liberation Army (PLA) had unlawfully used American chip designs in AI.[25]

The civil-military synthesis in China obliterated any division amongst the non-military and military players involved in dealing with such sophisticated, crucial technologies. As a result, the Chinese military could indirectly gain access to the unsurpassed technology possessed by the USA as well as its allied countries.

GRADED RETRIBUTION: THE EMPIRE STRIKES BACK

Evidence of Chinese malfeasance kept increasing. It left no doubt in military and strategic circles that China had no qualms about weaponising an item with wide-ranging civil and military uses for its own geopolitical powerplay. Equally, it left no doubt in the USA that China was on a devious path to using US technology against it by deceit and violation of rules. No wonder, the USA viewed China's effort to become the global leader in hi-tech as a national security risk. The Obama Administration took baby steps by restricting the accessibility of sophisticated chips to China's military but did not deny US technology to commercial entities in China.[26] The US company 'Intel' was barred from the sale of its superior Xeon chips to universities and centres in China that were engaged in military research.[27] Yet, "it was completely ineffective at stopping indirect sales to the shell companies that helped the Chinese military evade export controls."[28] Additionally, the civil-military synthesis in China obliterated

25. Ryan Fedasiuk, Karson Elmgren, and Ellen Lu, "Silicon Twist Managing the Chinese Military's Access to AI Chips," Centre for Security and Emerging Technology, June 2022, available at https://cset.georgetown.edu/publication/silicon-twist/. Accessed on November 14, 2023.
26. https://www.orfonline.org/wp-content/uploads/2023/04/ORF_OccasionalPaper_397_US-China-Chips.pdf. Accessed on September 9, 2023.
27. Ibid.
28. Gregory C. Allen, "Choking off China's Access to the Future of AI," Centre for Security and International Studies, October 11, 2022, available at https://www.csis.org/analysis/choking-chinas-access-future-ai/. Accessed on October 25, 2023.

any division amongst the non-military and military players involved in dealing with such sophisticated, crucial technologies. As a result, the Chinese military could indirectly gain access to the unsurpassed technology possessed by the USA as well as its allied countries.[29] Taking cognisance of fears over the Chinese company Huawei's indulgence in acts inimical to US national security, the US government included it in the 'Entity List' in May 2019. This action aimed to prevent (with some exceptions) Huawei from receiving US technology.[30] Intensifying its earlier actions, in May 2020, the US government subjected Huawei to export controls through the 'Foreign Direct Product Rule' (FDPR).[31] This rule subjected goods produced abroad by means of US technology or software to control by the US government. Huawei was badly affected since it was denied access to semiconductors. Its slide in the smartphone segment from being the topmost seller in 2020, when it accounted for 18 per cent of global sales, to just 2 per cent in 2022 was prodigious.[32] Dipping proceeds and an attempt to survive had also forced Huawei to sell a smartphone brand owned by it.

But the real punch came in August 2022 when the USA passed the Chips and Science Act (Chips Act for short). The Act intended to strengthen the American pole position in semiconductor technology with measures to domestically bolster research, development, as well as production capacity.[33]

29. Matt Sheehan, "Biden's Unprecedented Semiconductor Bet", Carnegie Endowment for International Peace, October 27, 2022, available at https://carnegieendowment.org/2022/10/27/biden-s-unprecedented-semiconductor-bet-pub-88270. Accessed on 25 October 2023.
30. https://www.federalregister.gov/documents/2019/05/21/2019-10616/addition-of-entities-to-the-entity-list. Accessed on November 6, 2023.
31. https://www.oupailang.com/news/an-act-of-war-inside-americas-silicon-blockade-against-china.html. Accessed on November 14, 2023 in Alex W Palmer, "An Act of War': Inside America's Silicon Blockade Against China". Also available at https://www.federalregister.gov/documents/2020/05/19/2020-10856/export-administration-regulations-amendments-to-general-prohibition-three-foreign-produced-direct.
32. https://www.oupailang.com/news/an-act-of-war-inside-americas-silicon-blockade-against-china.html. Accessed on November 14, 2023.
33. The White House, "FACT SHEET: CHIPS and Science Act Will Lower Costs, Create Jobs, Strengthen Supply Chains, and Counter China", August 9, 2022 available at https://www.whitehouse.gov/briefing-room/statements-releases/2022/08/09/fact-sheet-chips-and-science-act-will-lower-costs-create-jobs-strengthen-supply-chains-and-counter-china/. Accessed on October 26, 2023.

According to the White House Fact Sheet, the Act will "strengthen American manufacturing, supply chains, and national security, and invest in research and development, science and technology, and the workforce of the future to keep the United States the leader in the industries of tomorrow, including nanotechnology, clean energy, quantum computing, and artificial intelligence." The focus of the Chips and Science Act is on domestically producing chips that the USA needs. The Act led to significant investment in US semiconductor manufacturing, with the current investment at $52.7 billion.[34] Although unwritten, the Act sought to eradicate China's entire ecosystem of theft and clandestine acquisition of advanced technology. In October 2022, the USA enforced new export controls on China that aimed at making it tougher for it to acquire critical technologies. These measures were to be implemented by a series of actions, such as imposing a ban on transferring or selling chips produced using US technology sans a licence to export, curbing the export of chip manufacturing tools as well as technology, and limiting the engagement of US subjects and organisations with semiconductor manufacturers in China by making prior approval mandatory.[35] In the same year, the US government prohibited Chinese companies from importing AI-based chips designed in the USA and manufactured in Taiwan. This was based on credible intelligence reports that, although these chips were ostensibly being imported for civilian uses, they had instead been diverted for military applications (by China). Later, the USA extended the export licence requirements to Graphic Processing Units (GPUs) made by Nvidia and AMD to prevent Chinese entities from accessing these sophisticated chips.[36]

However, given the complex ecosystem that prevails in chips, the success of the US measures depended on its partners, especially the Netherlands, Taiwan, and Japan. In January 2023, the Dutch and Japanese announced their intention to restrict the export of certain chips to China. The Japanese measures came into

34. Chris Miller, Talk at National Defence University, available at https://www.youtube.com/watch?v=JrOiI2b-mA4.
35. https://carnegieendowment.org/2022/10/27/biden-s-unprecedented-semiconductor-bet-pub-88270 (Matt Sheehan, 'Biden's Unprecedented Semiconductor Bet').
36. Cheng Ting-Fang, *Nikkei Newsletter*, October 12, 2023.

effect on July 23, 2023, while the Dutch measures came into effect on September 1, 2023. The Japanese restrictions were more stringent than the US ones. While the US limited the export of tools for making chips of 14nm and below, Japan extended its restrictions to even older, less advanced chip generations (up to 45nm).[37] The Netherlands limited the exports of deep ultraviolet (DUV) as well as EUV lithography machines used to pattern chips to China. These steps caused worry in the semiconductor sector in China about their harmful effects on the manufacture of common items such as automobiles.[38] The USA and even the European Union (EU) have instituted measures to control the export of sensitive technology to China. The European Commission is assessing whether to ban exports of semiconductors, AI, quantum computing and biotechnology to China.[39] In addition, the European Chips Act that came into force on September 21, 2023, aims to bolster Europe's competitiveness and resilience in semiconductor technologies and applications. Through the Act, the EU intends to invest $46.98 billion. Interestingly, learning from their sour experience during the China-induced supply chain disruptions during COVID, through the EU Chips Act, the member states and their international partners have established procedures for predicting, preparing, and promptly responding to likely interruptions in supply chains, besides aiming to build semiconductor partnerships with like-minded countries.[40]

Wary of the Chinese, in December 2023, Taiwan issued a policy listing 22 technologies on its first list of core protected sectors, which included Integrated Circuits (IC) below 14nm, security of chips, cyber defence, protection of post-quantum cryptography, in addition to wafer-level sophisticated chip packaging.[41] The policy defines "national core technologies" and covers

37. https://www.technologyreview.com/2023/07/12/1076156/us-china-tech-war-escalating/. Accessed on November 18, 2023 (Zeyi Yang, "The US-China Chip War is Still Escalating", *MIT Technology Review*, July 12, 2023).
38. Ibid.
39. Andy Bounds, "EU to Assess Export Controls on Sensitive Technology to China", *Financial Times*, October 3, 2023.
40. European Chips Act, available at https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/europe-fit-digital-age/european-chips-act_en. Accessed on November 20, 2023.
41. Thompson Chau, "Taiwan Outlines Five Critical Tech Fields Under its Protection", *Nikkei Asia*, December 6, 2023, available at https://asia.nikkei.com/Business/Technology/Taiwan-

businesses that encompass agriculture, aerospace, semiconductors, and ICT, apart from enforcing investments, manpower, operations, and technology transfer in these areas.[42] Elevating 'critical technology in the supply chain' and 'semiconductors' as national security imperatives, the policy aims to prevent Chinese efforts to acquire crucial technology. Through an amendment to its National Security Act in 2022, Taiwan added "economic espionage" as a crime to discourage the illegal handover of core technology.[43]

RESHORING MANUFACTURING

A public policy research institute of the US Congress had brought out in a policy brief that the worldwide share of the US in the manufacture of semiconductors was 40 per cent in 1990, which, over three decades, reduced to 10 per cent by 2020.[44] Lower costs of manufacturing, cheaper labour and better incentives in East Asia had led to US companies preferring Taiwan and South Korea for manufacturing chips. The rising geopolitical tensions and China's growing aggressiveness to coerce Taiwan meant that Taiwan's share of manufacturing semiconductors could become a strategic vulnerability. Mitigating this vulnerability implied not only restricting China's access to high technology but also diversification of high-end chip manufacturing. After decades of outsourcing and offshoring chip manufacturing, the USA seriously intended to enhance its share of domestic semiconductor manufacturing. Encouraged by this move, TSMC announced in 2020 that it would build a chip manufacturing plant in Arizona. The tool installation ceremony was held in December 2022. However, progress has not been smooth due to the lengthy review process in the USA and lack of skilled

outlines-five-critical-tech-fields-under-its-protection. Accessed on January 6, 2024.

42. Thompson Chau, and Cheng Ting-Fang, "Taiwan to Tighten Tech Safeguards against China this Year", *Nikkei Asia*, October 5, 2023, available at https://asia.nikkei.com/Politics/International-relations/Taiwan-tensions/Taiwan-to-tighten-tech-safeguards-against-China-this-year. Accessed on October 16, 2023.
43. https://www.theindependent.co.zw/index.php/international/article/200017840/taiwan-to-tighten-tech-safeguards-against-china-this-year. Accessed on April 4, 2024.
44. https://crsreports.congress.gov/product/pdf/R/R47523. Accessed on November 5, 2023. (Congressional Research Service, "Frequently Asked Questions: CHIPS Act of 2022 Provisions and Implementation").

In June 2023, Japan revamped its chip strategy. By placing chips at the heart of its economic security policy, Japan aims to achieve $108 billion worth of sales of domestically produced semiconductors by 2030.

workers.[45] Consequently, the scheduled start of mass production has been delayed to 2025.

Japan enacted an Economic Security Promotion Act in May 2022. The causal factor for this was the geopolitical fight initiated by China. The Act entails safeguarding supply networks from interruption by adopting indigenisation, depending upon a cohort of reliable friends, and excluding China. Aimed at minimising Japan's vulnerability to economic coercion from other countries (read China), the Japanese government hopes to enhance its strategic autonomy while simultaneously making itself indispensable due to the global dependence on high-quality Japanese technology.[46] In June 2023, Japan revamped its chip strategy. By placing chips at the heart of its economic security policy, Japan aims to achieve $108 billion worth of sales of domestically produced semiconductors by 2030.[47] Towards this, Japan has proceeded in 'mission mode' by making policy changes. It began by initiating steps to ease the shortage of land for chipmakers by relaxing rules on building in farmlands and forests.[48] TSMC, in partnership with Sony, is building a $ 8 billion semiconductor manufacturing plant at Kumamoto in Japan, the construction of which commenced in 2022, with large-scale manufacturing planned from this year. Japan has earmarked $3.5 billion worth of subsidies for the TSMC project and streamlined regulations, enabling smoother and faster execution.[49] On its part, TSMC has trained more than 300 Japanese technical personnel in Taiwan. It also sent several hundred experienced 'seed' employees, in addition to hiring

45. Cissy Zhou, "TSMC Pant in Phoenix, Arizona", *Nikkei Asia*, October 5, 2023.
46 Kazuto Suzuki, "How Will the Economic Security Law Change Japan's Sci-Tech Policy?", May 9, 2023, available at https://www.tokyofoundation.org/research/detail.php?id=943. Accessed on November 20, 2023.
47. Yoshiaki Nohara, "Japan Renews Chip Plan and Confirms Sales Goal of ¥15 Trillion", *The Japan Times*, June 6, 2023.
48. https://asia.nikkei.com/Business/Tech/Semiconductors/TSMC-s-8bn-Japan-chip-project-steams-ahead-as-U.S.-site-hits-snags/. Accessed on October 3, 2023 (Cheng Ting-Fang & Ryohtawh Satoh, "TSMCs $ 8 Billion Japan Chip Project Steams Ahead as US Site Hits Snags", *Nikkei Asia*, October 3, 2023).
49. Ibid.

local Japanese people in preparation for the establishment of the plant. In October 2023, TSMC augmented the strength of engineers by hundreds with the aim of hastening operationalisation.[50] Japan has also allocated a $1.2 billion subsidy for Micron's Hiroshima chip plant. To cater to the growing market and maintain its lead, TSMC is investing $ 2.87 billion to build a plant in western Taiwan that handles advanced packaging of high-performance semiconductors necessary for generative artificial intelligence.

The mastery of complex technology and producing semiconductors cost-effectively are mammoth challenges that China is finding difficult to overcome. It is facing a severe shortage of 28nm chips. To make matters worse, China's economic woes have adversely affected funding for the Big Fund.

IMPACT ON CHINA

The action by 'China-affected countries' began hurting China slowly but surely. In 2022, Chinese imports of semiconductor-producing apparatus declined by 15 per cent ($ 34.7 billion) for the first time since 2019, and the descending path also continued in the early months of 2023.[51] The export control measures have exacerbated the challenges and costs associated with China's acquisition of chips. From 2023, a major part of this endeavour was enacted by Taiwan and TSMC, whose actions, along with those of South Korea, Malaysia, Japan, and Vietnam, resulted in Chinese chip imports declining by 40 per cent.[52] There is evidence that despite China's possible anticipation of restrictions and its own efforts to mitigate the effects, the restrictions have critically impacted China's ability to establish an indigenous base in these high-tech areas.[53] The mastery of complex

50. Ibid.
51. Aishwarya Sanjukta Roy Proma, "The US-China Rivalry: Emergence of the Chip War in the Semiconductor Industry", August 2, 2023, available at https://moderndiplomacy.eu/2023/08/02/the-us-china-rivalry-emergence-of-the-chip-war-in-the-semiconductor-industry/. Accessed on September 9, 2023.
52. Ibid.
53. Will Knight, "US Chip Sanctions 'Kneecap' China's Tech Industry," *Wired*, October 12, 2022, available at https://www.wired.com/story/us-chip-sanctions-kneecap-chinastech-industry/. Accessed on November 10, 2023.

technology and producing semiconductors cost-effectively are mammoth challenges that China is finding difficult to overcome. It is facing a severe shortage of 28nm chips. To make matters worse, China's economic woes have adversely affected funding for the Big Fund. The exit of industrial entities entails a reputational and financial loss to China as an advantageous place. A Japanese company, Kyocera, which is among the global leaders in chip components, has exited from China and is instead concentrating its efforts and capital on establishing manufacturing in its home country.[54] A large amount of investment from Taiwan that used to go to China has been curtailed and is now going to countries like Vietnam.

CHINESE REACTION

The Chinese Ministry of Foreign Affairs spokesperson Zhao Lijian officially denounced the Chips Act by saying, "The so-called Chips and Science Act is purportedly aimed at bolstering the competitive edge of the US' sci-tech and chip industries. However, certain provisions in the Act restrain normal sci-tech cooperation between China and the US. China is firmly against it".[55] Reacting to the Chips Act, China activated the World Trade Organisation (WTO) dispute settlement mechanism in late 2022 by formally protesting against the US moves, characterising the US measures as "discriminatory and disguised trade restrictions".[56] According to the *Financial Times*, China is using creative techniques such as renting chips or buying them via intermediaries and in the black market to get around the export controls.[57] Retaliatory measures by Beijing included banning chips made by Micron from being used in critical

54. Eri Sugiura, 'China No Longer Viable as World's Factory, says Kyocera,' Financial Times, February 21, 2023.
55. Ministry of Foreign Affairs of the People's Republic of China Regular Press Conference on July 28, 2022, quoted by Rajan Sai Sukrut in ICWA Issue Brief titled, 'US-China Chip War', July 14, 2023 available at https://www.icwa.in/show_content.php?lang=1&level=3&ls_id=9740&lid=6225.
56. https://www.wto.org/english/tratop_e/dispu_e/dispu_e.htm (World Trade Organisation, "United States - Measures on Certain Semiconductor and Other Products, and Related Services and Technologies: Request for Consultations by China").
57. Amy Hawkins, "Chip Wars: How Semiconductors Became a Flashpoint in the US-China Relationship," *The Guardian*, July 5, 2023, available at https://www.theguardian.com/world/2023/jul/05/chip-wars-how-semiconductors-became-a-flashpoint-in-the-us-china-relationship. Accessed on November 10, 2023.

infrastructure projects. In early 2023, China placed Raytheon and Lockheed Martin on a list of unreliable entities. In early July, on the eve of US Trade Secretary Janet Yellen's visit to Beijing, the Chinese escalated by introducing strict conditions for exporting gallium, germanium, optical fibres, and solar cells; measures that were clearly targeted at the US.[58]

By trying to choke the supply of these two minerals, China unambiguously indicated its willingness to up the ante. It has also taken certain institutional and policy measures to overcome its predicament. The government has decided to subsidise leading domestic companies to produce and deploy localised chip-making tools without any funding cap.[59] A report in October by the Centre for Strategic and International Studies noted that SMIC's technical capabilities have progressed, and raised the possibility that the company may be able to mass-produce advanced semiconductors with equipment previously used on production lines for older chips.[60] In 2023, a Chinese company claimed to have developed a lithography machine capable of building a 28nm chip.[61] Tsinghua University, Nanjing University, and Chinese Academy of Sciences have filed patents for EUV technology, although the patents were explicitly meant to create a source for EUV light as against the machine itself. To obviate the need for high-end chip-making apparatus (which is denied), the Chinese have invested in evolving a shorter method termed 'advanced packaging', that seeks to produce an increasingly powerful device.[62] If successful, China may be able to produce powerful chips domestically without requiring EUV machines.

Another development that has been observed lately is that the Chinese have embarked upon a buying spree of chip-making equipment, as a likely

58. https://www.technologyreview.com/2023/07/12/1076156/us-china-tech-war-escalating/. Accessed on November 18, 2023.
59. https://www.thediplomat.com/ (Eve Register, "Can China Leapfrog ASML in Its Quest for Semiconductor Self-Reliance?", *The Diplomat Magazine*, November 2023, Issue 108).
60. Gregory C Allen, CSIS Report, October 6, 2023, available at https://www.csis.org/analysis/chip-race-china-gives-huawei-steering-wheel-huaweis-new-smartphone-and-future. Accessed on November 22, 2023
61. https://www.bloomberg.com/news/articles/2023-12-20/chinese-chip-gear-leader-achieves-key-breakthrough-backer-says?srnd=technology-vp. Accessed on April 4, 2024.
62. n.59.

safeguard against export controls by the USA and others. Resultantly, Chinese imports of chip-making equipment rose by 93 percent (to $ 8.7 billion) in the July-September 2023 quarter.[63] Import of lithography equipment increased more than six times. Although these were in the 'mid-critical' and 'mature' production processes rather than advanced ones, the possibility of them being used to produce high-end semiconductors remains. Exploiting loopholes in the US-led export controls remains high on the Chinese agenda. An investigation by a team of journalists from Nikkei Asia revealed how cutting-edge machines made by Japanese and German manufacturers reached the China Academy of Engineering Physics (CAEP), China's main research institute for nuclear weapons.[64] At a time when the Middle East is becoming a flashpoint for US-China tensions, Chinese universities (Shenzen Research Institute of Big Data, and Chinese University of Hong Kong, Shenzen) are collaborating with a U.S. ally, Saudi Arabia (King Abdullah University of Science & Technology) on developing AI.[65] The risk in such collaborations is that the Chinese may be able to access semiconductors through Saudi Arabia.

THE INDIA STORY

The importance of semiconductors has not been lost on India. Semiconductor manufacturing in India started when Texas Instruments (TI) set up an Research and Development (R&D) centre in Bengaluru in 1985. India had promulgated a semiconductor policy in 2007 and again in 2013. However, translating policy into action remained a weak area. In March 2022, the government announced an 'India Semiconductor Mission' (ISM) envisioned to develop India into a universal electronics manufacturing and design

63. Ryosuke Eguchi, *Nikkei Asia*, November 14, 2023, available at https://asia.nikkei.com/Business/Tech/Semiconductors/China-s-chipmaking-equipment-imports-surge-93-despite-curbs/. Accessed on November 15, 2023.
64. Nikkei Asia Investigation Report, November 7, 2023, available at https://asia.nikkei.com/static/vdata/infographics/china-nuclear-supply-chain. Accessed on November 20, 2023.
65. https://asia.nikkei.com/. Accessed on October 14, 2023 (Cheng Ting-Fang, Nikkei Newsletter, October 12, 2023).

pivot.[66] The programme, with an outlay of approximately $ 9.14 billion (Rs 76,000 crore), intends providing funding to businesses actively involved in the semiconductors', display manufacturing and design ecosystem.[67] A year ago, in March, India inked a Memorandum of Understanding (MoU) with the US to forge a close relationship in the semiconductor supply chain and spur novelty in the field.[68] Encouragingly, Micron has announced the setting up of a chip manufacturing plant in Gujarat, with production slated to begin in 2024. Taiwan's Foxconn has announced a partnership with a US company, Applied Materials, to manufacture chip-making tools in Karnataka.[69] India is deepening its partnership with Japan, and the two governments signed an MoU in July 2023 on promoting semiconductor supply chain cooperation.

By 2026, India is expected to have a $80 billion market for semiconductors.[70] However, this will still constitute less than 10 per cent of the global market. Unlike its prowess in software, India's capacity and capability in hardware have been quite low. Hence, creating and developing manufacturing capability in India is an uphill task. Only offering subsidies to establish manufacturing will not suffice. Since semiconductor manufacturing and chip design operations typically work best in clusters, in an ecosystem where raw materials, components, and machinery are readily available within a relatively small area, India needs to create such clusters that encourage collaboration and promote synergies among companies. According to a report by McKinsey, participants in a cluster are able to attain better output, improve efficiency, and garner enhanced global discernibility compared to

66. https://pib.gov.in/PressReleasePage.aspx?PRID=1808676. Accessed on October 4, 2023 ("India Semiconductor Mission", Press Information Bureau, Ministry of Electronics & IT, Government of India, March 23, 2022).
67. https://pib.gov.in/PressReleasePage.aspx?PRID=1808676.
68. https://www.pib.gov.in/PressReleasePage.aspx?PRID=1905522.
69. https://www.ndtv.com/india-news/foxconn-to-invest-600-million-in-2-manufacturing-projects-in-karnataka-4262512. Accessed on October 10, 2023.
70. Konark Bhandari, "Is India Ready for Semiconductor Manufacturing?" available at https://carnegieindia.org/2023/05/23/is-india-ready-for-semiconductor-manufacturing-pub-89814. Accessed on November 22, 2023.

As private consumers and public transport shift towards EVs, the demand for chips will only rise. This is because, compared to automobiles with internal combustion engines, EVs rely more on software, which requires more chips. Hence, while a traditional car requires around 1,000 chips, an EV needs almost double the numbers.

a solitary unit functioning independently.[71] The success of India's semiconductor mission will also depend upon multiple factors, namely business climate, domestic market, export potential, infrastructure, and talent. India plans to train 85,000 engineers to address the human capital aspect as part of its Chips to Startup (C2S) scheme.

Recent developments portend well for the nation. A joint venture between the Tatas and PowerChip Semiconductor Manufacturing Corporation (PSMC) of Taiwan has been accorded approval to set up a greenfield project. This factory will produce 28nm chips at a planned rate of 50,000 wafers, per month, starting in 2026.[72] State governments in Odisha and Tamil Nadu have instituted policies to incubate fabless chip-making, and subsidise R&D. Considerable work is underway at educational institutions such as the Indian Institute of Technology (IIT) Madras to develop homegrown chips.

India has embraced Electric Vehicles (EVs) in a big way. As private consumers and public transport shift towards EVs, the demand for chips will only rise. This is because, compared to automobiles with internal combustion engines, EVs rely more on software, which requires more chips. Hence, while a traditional car requires around 1,000 chips, an EV needs almost double the numbers.[73] The consulting firm McKinsey has projected an increase in global revenue for

71. For more advantages of clusters, see https://www.mckinsey.com/industries/industrials-and-electronics/our-insights/semiconductor-design-and-manufacturing-achieving-leading-edge-capabilities. Accessed on November 22, 2023.
72. https://thediplomat.com/2024/03/the-dawn-of-indias-semiconductor-era/. Accessed on April 5, 2024.
73. Chin Hsueh, "How Taiwan-ASEAN Semiconductor Cooperation Can Bolster Taipei's National Security", *The Diplomat*, December 23, 2023, available at https://thediplomat.com/2023/12/how-taiwan-asean-semiconductor-cooperation-can-bolster-taipeis-national-security/. Accessed on February 19, 2024.

automobile chips, reaching $147 billion by 2030.[74] According to estimates by S&P Global Mobility, automobiles individually are likely to comprise chips worth $ 1,400 by 2028, indicating a rising trend in their use and applications.[75] These developments present a good opportunity for India to capitalise on the market potential and establish chip manufacturing for automobiles in India by entering into 'win-win' partnerships with Taiwanese chip manufacturers.

Semiconductor technology has come a long way from a predominantly techno-commercial piece to one with huge geopolitical ramifications. Today, this 'meta-critical' technology is at the heart of the technology and geopolitical contest and has influenced foreign policy.

CONCLUSION

To achieve the Chinese ambition of overturning the current world order and replacing it with its own version, the Chinese government adopted a 'whole of governmemnt' approach that included deceit, theft, coercion, threats, and inducements. It correctly identified technology as the core domain in which it had to beat the USA. For too long, the USA was hesitant to act against China despite overwhelming evidence of harmful Chinese activities that threatened the USA itself. Fortunately, the tide has turned due to bipartisan support in the USA to act against Chinese malfeasance and the realisation in Europe that it cannot be business as usual with an assertive China. Semiconductor technology has come a long way from a predominantly techno-commercial piece to one with huge geopolitical ramifications. Today, this 'meta-critical' technology is at the heart of the technology and geopolitical contest and has influenced foreign policy. It is not, therefore,

74. Ondrej Burkacky, Johannes Deichmann, Michael Guggenheimer, and Philipp Pfingstag, "Will the Supply–Demand Mismatch Persist for Automotive Semiconductors?", October 14, 2022, available at https://www.mckinsey.com/industries/industrials-and-electronics/our-insights/will-the-supply-demand-mismatch-persist-for-automotive-semiconductors. Accessed on February 19, 2024.
75. Jeremie Bouchaud, "With Mobile Phone Semiconductor Demand Cooling, Automotive Chips are Red-Hot", June 19, 2023, available at https://www.spglobal.com/mobility/en/research-analysis/with-mobile-phone-semiconductor-demand-cooling-automotive-chip.html. Accessed on February 19, 2024.

unsurprising that all major economies have elevated semiconductors from an ordinary electronics component to a national security priority.

Although the gap between the US and Chinese capabilities in chip manufacturing has narrowed, China is still far from reaching the technological level that countries such as the US, Taiwan, South Korea, or Japan possess. The large size of the Chinese market makes decoupling difficult. Cleverly, therefore, the US has put in place a strategy for selective 'de-risking' in the hi-tech sector. US National Security Advisor Jake Sullivan has termed the US export controls on China as part of a "small yard high fence" strategy. It seeks to hinder China's economic dynamism and military muscle alike. The Chips Act has already made a difference. This augurs well for India as it opens windows of opportunity to partner with leading countries such as the US, Japan, South Korea, and Taiwan and leapfrog our tech capability. India should send its engineers to Taiwan and learn from the tremendous shop-floor knowledge that the TSMC has. Despite being its primary threat and strategic adversary, for too long, India has been 'ultra-sensitive' to Chinese concerns, including over Taiwan. This constrained India strategically while the Chinese power kept growing. China's military modernisation rides high on technology that requires high-end chips. This technology would give the People's Liberation Army (PLA) a significant military advantage over India. There is another aspect of the chip wars that India must be aware of, and guard against. The Western sanctions on Russia have resulted in a critical shortage of chips for their weapon systems. There are indications that China is clandestinely supplying chips to Russia. Indian dependence on Russia, therefore, becomes a strategic vulnerability. There is no guarantee or assurance that contracted/future Russian weapons bought by India will not have Chinese chips. Clearly, China's rise will be at the cost of India's rise. Therefore, the ongoing chip war is a strategic opportunity for it to reverse this. Amongst other steps, bolstering strong partnerships within the Quadrilateral Security Dialogue (QUAD) and creating robust semiconductor partnerships with South Korea, Taiwan, Singapore, and the EU is called for. In the chip war, India's interests lie in ensuring that the Chinese 'chips are down.' It is time for action stations.