Navigating the Chip Wars: Pakistan's Strategy in the Sino-US Battle for Semiconductor Dominance

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NAVIGATING THE CHIP WARS: PAKISTAN'S STRATEGY IN THE SINO-US BATTLE FOR SEMICONDUCTOR DOMINANCE

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ABSTRACT

The global semiconductor industry, a cornerstone of the current era with potential for economic growth, is dealing with disruptive supply chains due to geopolitical tensions, trade disputes, and increased demand etc. The technological competition between the US and China has further complicated the landscape, with each nation striving for dominance in semiconductor technology. This paper explores the intricate dynamics of the global semiconductor supply chain, highlighting the vulnerabilities. Considering the competition in access to semiconductors, the paper examines Pakistan's efforts to grow its semiconductor industry despite numerous limitations. The paper highlights potential avenues that Pakistan can explore to create a space for itself in the semiconductor marketplace. Furthermore, the paper underscores the important intersections of technology, economics, and geopolitics, presenting insights into the future of this vital industry.

Keywords: US-China Competition, Semiconductors, Supply Chain Disruptions, Geopolitical conflicts, Technological hegemony.

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1. INTRODUCTION

Global geopolitical tensions and market dynamics are causing significant disturbances to the semiconductor industry, which is fundamental to modern technological advancement and economic growth. Semiconductors, often referred to as "chips," are integral to a myriad of devices ranging from smartphones and computers to data center servers etc. These nano-sized silicon wafers, comprising up to 40 billion layers of material, are pivotal in powering contemporary technologies.[1] However, the industry is currently facing a multifaceted crisis characterised by supply shortages exacerbated by the international trade disputes, and escalating demand.

Amidst this crisis, a major factor influencing the semiconductor landscape is the technological rivalry between the US and China, which has profound implications for global supply chains and international trade. This rivalry underscores the strategic importance of semiconductors in driving advancements in computing, telecommunications, and defence. Both nations recognise the critical need to lead in semiconductor technology, with the US maintaining a competitive edge through stringent intellectual property laws and a culture of innovation, while China rapidly develops its semiconductor capabilities to reduce reliance on imported technology. This competitive dynamic has intensified issues surrounding technology transfer and

[1] Nayem Hossain, “Advances and Significances of Nanoparticles in Semiconductor Applications – A Review,” Results in Engineering, August 4, 2023, https://www.sciencedirect.com/science/article/pii/S2590123023004747.

intellectual property rights, prompting both countries to implement strategic measures to bolster their domestic semiconductor industries.[2]

Against the background of geopolitical rivalry and trade policies, the global semiconductor supply chain is clearly fraught with vulnerabilities. The focused nature of semiconductor production in certain states such as Taiwan, South Korea etc heightens the risk of supply chain disruptions because of conflicts and perceived security threats. In response, countries are making an investment in developing domestic semiconductor production skills to lessen dependence on foreign sources, although this calls for enormous capital investment and strategic planning.[3] Similarly, the ongoing trade war between China and the US has had a far-reaching impact on a global scale. This rivalry has been most obvious in the semiconductor industry. The two nations have found themselves in a tense geopolitical situation where any conflict or crisis by either side would affect all parties involved.[4]

The global semiconductor supply chain is crucial for various industries, including technology, automotive, and telecommunications. For Pakistan, this supply chain is particularly impactful due to several factors i.e. dependence on Imports which makes the country vulnerable to shortages and increased costs; Geopolitical tensions between major semiconductor producers like the US and China can lead to export restrictions and price hikes; trade policies can introduce barriers or sanctions that interrupt sourcing; economic implications include slowdowns due to affected

[2] Lawrence L. Harada, "Semiconductor Technology and U.S. National Security," April 21, 2010,https://doi.org/10.21236/ada526581

[3] Amitendu Palit, "The Geopolitical Imperative for Reorganising Global Supply Chains," orfonline.org, December 4, 2023, https://www.orfonline.org/research/the-geopolitical-imperative-for-reorganising-global-supply-chains.

[4] Manal Hamdani and Ismail Belfencha, "Strategic Implications of the US-China Semiconductor Rivalry," *Discover Global Society* 2, no. 1 (October 2, 2024), https://doi.org/10.1007/s44282-024-00081-5.

technology and electronics sectors; and technological lag could hinder Pakistan's ability to access cutting-edge technologies, affecting its global competitiveness and tech sector growth. This situation presents both challenges and opportunities for Pakistan, which aims to fill gaps in the market by enhancing its own semiconductor capabilities.

Developing a robust semiconductor industry requires substantial capital investment and strategic planning. The Pakistani government is working through the Special Investment Facilitation Council (SIFC) to create a favourable environment for foreign investors, particularly from China and the US, to set up design centres in the country.[5]

2. SINO-US TECHNOLOGICAL RIVALRY

The US-China competition for technological superiority has further disrupted the global supply chains and international trade. Their fierce rivalry and pursuit of technological superiority as well as economic security characterises this technological competition. The strategic importance of being at the forefront of semiconductor technology is acknowledged by both countries, as it plays a vital role in the production of emerging and niche technologies such as computing, warfare, and telecommunications.[6]

[5]Haadia Riaz, "Pakistan amidst US-China Chip Competition: Navigating Technological Opportunities," ISSRA - Insight, accessed July 30, 2024, https://ndu.edu.pk/issra/pub/insight/2024/PAKISTAN-AMIDST-US-CHINA-CHIP-COMPETITION/PAKISTAN-AMIDST-US-CHINA-CHIP-COMPETITION.html.

[6] Amar Diwakar, "'Chip Wars': US, China and the Battle for Semiconductor Supremacy," TRT World - Breaking News, Live Coverage, Opinions and Videos, March 16, 2021, https://www.trtworld.com/magazine/chip-wars-us-china-and-the-battle-for-semiconductor-supremacy-12760949.

The Chinese government is providing domestic companies with large subsidies to make them globally competitive, whereas the American government has implemented measures such as improving its intellectual property rights regime in recent years, by reviewing Patent Law, Trademark Law, and Copyright Law to increase penalties for infringement to safeguard its technological advantages.[7] In addition, China is a net importer, producing only 30 percent of its chips domestically.[8] However, Huawei has made headway in chip design with the Kirin chip that is reportedly, on par with rivals Samsung and Qualcomm.[9] Nevertheless, the production of high tech chips remains Beijing's biggest issue.

A significant addition to the subsidies intended to revive US manufacturing capacity, Washington's second prong of the US chip strategy was to use sanctions to cut off Beijing from essential supplies, thereby impeding China's domestic semiconductor and tech industries. Chinese manufacturers are attempting to strengthen their domestic electronics industry and indigenise chip production in response to the trade war over semiconductors. They are competing with Washington to gain the upper hand as it attempts to tighten sanctions.[10]

Support from the government has increased domestic chip production over time. As of 2021, China invested US$73 billion directly in domestic semiconductor companies to an additional US$50 billion through grants, equity investments, and

[7] Abu Hurrairah Abbasi, "US-China Semiconductor Rivalry and Its Economic Consequences," The Nation, March 7, 2024, https://www.nation.com.pk/07-Mar-2024/us-china-semiconductor-rivalry-and-its-economic-consequences.

[8] Brenda Goh, "China to Import $300 Billion of Chips for Third Straight Year - Industry Group | Reuters," Reuters, August 26, 2020, https://www.reuters.com/article/us-china-semiconductors-idUSKBN25M1CX/.

[9] Dieter Ernst, "China's Bold Strategy for Semiconductors Zero-Sum Game or Catalyst for Cooperation?" SSRN Electronic Journal, January 1, 2016, 10.2139/ssrn.2836331.

[10] Amar Diwakar, "'Chip Wars': US, China and the Battle for Semiconductor Supremacy."

low-interest loans.[11] Aside from the cutting-edge processing units that artificial intelligence and high-tech companies require, restrictions were also imposed on the tools that China would need to increase its own domestic semiconductor production.

China began receiving US-made semiconductors in October 2022, however, following this, a sharp decline in exports of these chips was observed. This was the result of America's extensive set of chip sanctions.[12] Similarly, the US semiconductor manufacturing equipment exports also experienced a decline of a similar magnitude; however, this was not as great as the US chip manufacturing equipment imports from China. Despite the export restriction by US, China is currently experiencing a record-breaking import of chip-making machinery from major hubs for chip manufacturing like Singapore, Japan, and the Netherlands. [13]

3. EFFORTS TOWARDS TECHNOLOGICAL SELF-SUFFICIENCY

3.1. China's strategic Maneuvers

In 2023, ASML, Advanced Semiconductor Materials Lithography (Dutch Co), a major semiconductor manufacturing company in Netherlands, saw a big increase in its sales to China, with the country accounting for 29% of its total sales, up from 14% in 2022. This shows that China has become an important market for ASML's high-tech machines used in making computer chips. However, ASML expects that sales to China will drop by 10-15% in 2024 due to US export restrictions. These rules affect ASML because it relies on some US-made parts for its machines. As a result,

[11] Thomasbeard, "China Boosts State-Led Chip Investment," Economist Intelligence Unit, March 13, 2024, https://www.eiu.com/n/china-boosts-state-led-chip-investment/.

[12] Joseph Politano, "The US-China Chip War Is Escalating," The US-China Chip War is Escalating. February 17, 2024, https://www.apricitas.io/p/the-us-china-chip-war-is-escalating.

[13] Prasanth Aby Thomas, "US Expands Curbs on China's AI Memory and Chip Tools, Raising Supply Chain Concerns," CIO, January 29, 2025, https://www.cio.com/article/3616135/us-expands-curbs-on-chinas-ai-memory-and-chip-tools-raising-supply-chain-concerns.html.

the total value of ASML's equipment exports from the Netherlands to China in 2024 could be lower than the $5.8 billion expected for 2023.[14]

Despite the aforementioned records, China's total chip production is reported to have increased by 40 percent in the first quarter of 2024. This further emphasises China's move to accelerate advanced semiconductor development processes, in the face of export limitations. Moreover, the capacity for producing chips is also growing rapidly. China's National Bureau of Statistics recently released data indicating that the country's chip production increased by 28.4 percent in March 2024 alone, reaching a record high of 36.2 billion units.[15]

The export of chip-making equipment from Japan to China has also increased significantly. These exports have nearly doubled and now exceed China's imports of semiconductors for the first time. Due to a surge in demand for Tokyo Electron's less expensive semiconductor equipment, China now accounts for 47% of the company's net sales, up from roughly 20% in 2022. Tokyo Electron is a well-known chip manufacturing equipment manufacturer in Japan.[16]

A considerable increase in imports is also coming from Singapore, where major production facilities are owned by US companies such as Applied Materials, Lam Research, and Ken levy and Bob Anderson (KLA). These companies accounted for 41 percent, 40 percent, and 45 percent of their total revenue in China last quarter,

[14] Joseph Politano, “The US-China Chip War Is Escalating.”

[15] “China’s Chip Production Surges by 40% in Q1,” Trend Force Insights, April 22, 2024, https://www.trendforce.com/news/2024/04/22/news-chinas-chip-production-surges-by-40-in-q1/.

[16] Will Hunt, Saif Khan, and Dahlia Peterson, “China’s Progress in Semiconductor Manufacturing Equipment,” March 1, 2021, https://doi.org/10.51593/20190018.

up from 23 percent, 24 percent, and 23 percent in the year 2022.[17] Additionally, China has increased its imports from a variety of other countries with smaller semiconductor machinery industries; Malaysia and non-Dutch EU members have been the main drivers of this increase.

3.2. US Strategic Plans

The US reached agreements with the Dutch and Japanese governments in 2023 to limit the export of vital semiconductor equipment to China.[18] The Dutch export restrictions went into force in September 2023, while the Japanese export controls started in late July 2023. Nevertheless, they allowed the export of material that had previously been approved to China, provided that deliveries took place before January 1, 2024.[19]

The US is setting new records for semiconductor and other electronic component production. In 2023 alone, production increased by 23 percent, while capacity increased by about 12 percent. The dollar value of shipments from US computer and electronics manufacturers has increased to its highest level since the Great Recession, but it is still far below the record highs set in the early 2000s. In the

[17] Lauly Li, "U.S. Chip Tool Makers Eye Southeast Asia as China Business Shrinks," Nikkei Asia, February 10, 2023, https://asia.nikkei.com/Economy/Trade-war/U.S.-chip-tool-makers-eye-Southeast-Asia-as-China-business-shrinks.

[18] Gregory C. Allen and Emily Benson, "Clues to the U.S.-Dutch-Japanese Semiconductor Export Controls Deal Are Hiding in Plain Sight," CSIS, 2023, https://www.csis.org/analysis/clues-us-dutch-japanese-semiconductor-export-controls-deal-are-hiding-plain-sight.

[19] Sujai Shivakumar, Charles Wessner, and Thomas Howell, "Balancing the Ledger: Export Controls on U.S. Chip Technology to China," CSIS, February 2024, https://www.csis.org/analysis/balancing-ledger-export-controls-us-chip-technology-china.

meantime, Chinese semiconductor production more than doubled between 2018 and 2021, and it has since grown steadily, reaching new all-time highs.[20]

There are also rumours that NVIDIA, a leader in GPU-accelerated computing, is making more chips especially for the Chinese market.[21] These chips are reportedly designed to avoid new export restrictions by the US. The Chinese government and military have already been able to obtain some of the highly-coveted NVIDIA A100 and H100 chips that American sanctions were intended to prevent them from purchasing. The US is still wrangling the trading companies that made those acquisitions possible and other potential ways to get around sanctions. [22]

In response, the US is successfully pressuring the Dutch government to further restrict ASML's exports to China, stepping up pressure to tighten export restrictions, and monitoring outbound investment in critical tech sectors. The emphasis on challenging these exports is so that the US can maintain an effective sanctions regime. However, such strategies are more complex than they appear. They require substantial financial investment, risk incentivising competitors to sever the economic ties intended for exploitation, and may ultimately prove to be ineffective and porous. Therefore, long-term success for the US is unattainable if they persist in their attempts to hinder China's semiconductor industry without simultaneously making progress at home.

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[20] "Semiconductor Industry News - May 2024 Update," Sourcengine, May 30, 2024, https://www.sourcengine.com/blog/semiconductor-industry-news.

[21] REUTERS, "Nvidia Developing New Flagship AI Chip for Chinese Market," *The Express Tribune*, July 22, 2024, https://tribune.com.pk/story/2481946/nvidia-developing-new-flagship-ai-chip-for-chinese-market.

[22] Charlotte Trueman, "Chinese Institutions Acquired Nvidia AI Chips despite US Export Ban - Report," All Content RSS, April 23, 2024, https://www.datacenterdynamics.com/en/news/chinese-institutions-acquired-nvidia-ai-chips-despite-us-export-ban-report/.

The ongoing battle over semiconductors serves as a reminder of the costly cycle of great power economic conflict that has come to dominate much of the formulation of economic policy. Disrupting or redirecting trade between the world's two largest economies carries a significant economic toll. Likewise, expanding redundant capacity to strengthen supply chains involves considerable costs. The US-China trade war has only gotten worse over time, as witnessed by the current level of trade restrictions and industrial policy spending. These expenses are currently being borne by both nations, and it is unclear which will be able to profit from victory. [23]

3.3. Prospects for India

The US, the Netherlands, and Japan have recently placed export restrictions on semiconductors in an effort to limit China's capacity to create cutting-edge chip manufacturing technologies, especially in the fields of semiconductor fabrication and high-performance computing. This strategic move creates potential benefits for countries like India, which can leverage the situation to enhance its own semiconductor industry and position in the global tech ecosystem.

The US and its allies limiting China's access to advanced semiconductor technology provide India with the opportunity to attract investments in its semiconductor manufacturing sector. The Indian government has already been promoting initiatives like the Production-Linked Incentive (PLI) scheme to encourage

[23] Cagan Koc and Jenny Leonard, “US Officials to Pressure Dutch Government on China Chip Curbs,” Bloomberg.com, April 2024, https://www.bloomberg.com/news/articles/2024-04-04/us-officials-to-pressure-dutch-government-on-china-chip-curbs.

local semiconductor production. This could lead to the establishment of a more robust domestic supply chain, reducing reliance on imports.[24]

Similarly, India and the US have established several agreements focused on enhancing cooperation in the semiconductor sector, aimed at building a resilient and innovative semiconductor supply chain. Such an agreement was signed between India and the US to establish a collaborative mechanism under the India-US Commercial Dialogue. This partnership focuses on semiconductor supply chain resiliency and aims to leverage the complementary strengths of both countries. It includes discussions on various aspects of the semiconductor value chain, encouraging research and development, as well as talent and skill development in the sector.[25]

In addition, Micron Technology (A, US group) announced plans to invest up to $825 million to build a semiconductor assembly and test facility in India, supported by the Indian government. This facility is part of a larger $2.75 billion project that aims to enhance India's semiconductor manufacturing capabilities.[26] Moreover, India-US Strategic Trade Dialogue (IUSSTD) facilitates co-production, co-development, and enhanced industrial cooperation in critical technologies, including semiconductors. It aims to grow connections across industry and academia in both

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[24] Konark Bhandari, The geopolitics of the semiconductor industry and India's place in IT - Carnegie Endowment for International peace, June 30, 2023, https://carnegieendowment.org/research/2023/06/the-geopolitics-of-the-semiconductor-industry-and-indias-place-in-it

[25] Pti, "India, US Ink MoU on Semiconductor Supply Chain, Innovation Partnership," The Economic Times, March 10, 2023, https://economictimes.indiatimes.com/tech/technology/india-us-ink-mou-on-semiconductor-supply-chain-innovation-partnership/articleshow/98537476.cms?from=mdr.

[26] Micron confirms up to $825 million investment in India Chip Facility | Reuters, June 22, 2023, https://www.reuters.com/technology/micron-confirms-up-825-mln-investment-india-chip-facility-2023-06-22/.

countries and establish a regular monitoring group to review progress in high-tech trade and technology partnerships.[27]

India can also forge strategic partnerships with countries like Japan, and the Netherlands, which are looking to diversify their semiconductor supply chains away from China. By aligning with these nations, India can gain access to advanced technologies and expertise, which can accelerate its own semiconductor capabilities.

As the global demand for semiconductors continues to rise, India could not only fulfill domestic needs but also export to other countries, thereby tapping into the growing global market. The restrictions on China may result in a shift of R&D activities to countries with more favorable tech environments, such as India. Indian firms could benefit from increased research collaborations and technology transfers from Western companies looking to mitigate their risks associated with China.

4. PAKISTAN'S POSITION AND POTENTIAL

Pakistan is actively working to develop its semiconductor industry, with a focus on exporting integrated circuit (IC) design services. The government aims to boost the skills of students and young professionals to generate foreign exchange and create job opportunities. The Pakistan National Semiconductor Plan outlines the country's strategy to enter the global semiconductor industry, which is projected to reach $1 trillion by 2030.[28]

[27] "India-U.S. Emerging Technologies Working Group - Carnegie India," Carnegie Endowment for International Peace, n.d., https://carnegieendowment.org/india/india-us-emerging-technologies-working-group.

[28] Aamir Saeed, "Pakistan Plans to Develop 'chip Design Cluster' to Enter Global Semiconductor Industry," Arab News PK, March 30, 2024, https://www.arabnews.pk/node/2485216/pakistan.

The Pakistan Semiconductor Summit, held on April 18, 2024 was organised by the Pakistan Semiconductor Association (PSA). This event aimed to support and advance the rapidly growing semiconductor market in Pakistan by bringing together international and local experts to discuss crucial topics such as semiconductor manufacturing, applications, emerging trends, data security, and workforce development. It was a significant event that aimed to support the rapidly growing semiconductor market in Pakistan. The summit brought together international and local experts to discuss the essentials of semiconductor technology, including manufacturing, applications, emerging trends, data security, and workforce development.[29]

SIFC is also playing a key role in pushing forward the plan to develop a multibillion-dollar chip design and semiconductor industry in Pakistan. The council is working to provide tax incentives and other facilitating programmers to foreign companies, especially Chinese and US investors, to encourage them to set up chip designing centers in Pakistan.[30] Chips are integral to a wide array of downstream equipment and devices, such as smartphones, cars and medical devices. The market for chip-incorporating equipment is estimated to be at least $4 trillion annually, yet Pakistan's share is less than $50 million.[31]

[29] "Pak Semi Summit - Pakistan Semiconductor Summit 2024," Global Semiconductor Startup Forum, April 18, 2024, https://paksemisummit.com/

[30] Mohsin Alam, "All in on Chips: The Express Tribune," International News, Latest News, Breaking News, April 14, 2024, https://tribune.com.pk/story/2462541/all-in-on-chips

[31] Aamir Saeed, "Pakistan plans to develop 'chip design cluster' to enter global semiconductor industry," Arab News PK, March 30, 2024, https://www.arabnews.pk/node/2485216/pakistan.

4.1. Challenges for Pakistan

The ongoing US-China chip war presents significant challenges for Pakistan, impacting its economic landscape and technological aspirations. The semiconductor industry. The US-China rivalry has led to increased tariffs and trade barriers that disturb the semiconductor supply chain. This instability affects countries like Pakistan that rely on imported semiconductors for critical infrastructure and industries, such as automotive and electronics. Any disruption can lead to production halts and financial losses, exacerbating economic instability in Pakistan.[32]

One of the primary hurdles for Pakistan is the lack of a skilled workforce in semiconductor technology. Although the country produces a significant number of engineering graduates, but they lack specialised training in semiconductor design and fabrication. The government is working to improve skilled educational programmes to address this gap, by building a competent workforce capable of meeting industry demands.

Similarly, access to advanced technological resources is another challenge. The US-China chip war has led to restrictions on technology transfers, which hinder Pakistan's ability to develop a competitive semiconductor industry. Without the necessary technology and infrastructure, it will be difficult for Pakistan to compete on a global scale.[33]

As countries like India and Vietnam ramp up their semiconductor capabilities, Pakistan faces stiff competition. These nations are also positioning themselves as

[32] Nabil Tahir, “All in on Chips: The Express Tribune,” International News, Latest News, Breaking News, April 14, 2024, https://tribune.com.pk/story/2462541/all-in-on-chips.

[33] Bates Gill and Konrad Lee, “Can Us High-Tech Restrictions on China Succeed?” The Diplomat, July 10, 2023, https://thediplomat.com/2023/07/can-us-high-tech-restrictions-on-china-succeed/.

attractive locations for semiconductor manufacturing, which could divert potential investments away from Pakistan unless it can offer compelling incentives and a conducive business environment.

4.2. Opportunities for Pakistan

Pakistan's youth bulge, which is tech-savvy, could probably be Pakistan's biggest asset. Despite the challenges, the chip war also opens avenues for Pakistan to position itself within the global semiconductor supply chain. With its low labour costs and a growing pool of engineering graduates, Pakistan could attract foreign investment in semiconductor design and manufacturing.

Pakistan boasts an abundance of human capital, graduating 25,000 engineers annually. Additional training can help them to contribute more effectively to the chip-designing process and fulfil China and America's pressing labour shortages. Pakistan may have the best chance to strengthen its position as a key player in the global semiconductor supply chain through the testing and packaging of semiconductors. Testing and packaging are more cost-effective, more in line with Pakistani market trends, and demand a different set of skills than manufacturing, which is available in Pakistan as the country already has businesses like Alta Nova which provides semiconductor testing services. The nation will need to work with well-known international testing and packaging companies in order to grow its testing and packaging operations, as well as encourage local businesses to make investments in the nation.[34]

[34] Muhammad Faizan Fakhar , "South Asia and the US-China Tech Competition," South Asia@LSE, April 21, 2023, https://blogs.lse.ac.uk/southasia/2023/04/17/south-asia-and-the-us-china-tech-competition/.

Pakistan has the potential to build a more resilient and diversified economy by decreasing its dependence on traditional sectors like agriculture and textiles, and instead, venturing into the semiconductor industry. This transition could enable the country to tap into a rapidly growing global market, fostering innovation and creating high-skilled job opportunities.

4.3. Leveraging Taiwanese Model

One example of such a country that has successfully transitioned to a semiconductor powerhouse is Taiwan. In the 1970s, Taiwan made a strategic decision to invest in the semiconductor industry, which has paid off tremendously. Today, Taiwan is home to the world's largest contract chipmaker, Taiwan Semiconductor Manufacturing Company (TSMC), accounts for over 60 percent of the global semiconductor foundry market.[35] Taiwan's success in the semiconductor industry can be attributed to several factors such as the Taiwanese government provided significant funding and incentives to attract foreign investment and develop local talent in the semiconductor industry. It has heavily invested in R&D, with the government and private sector collaborating to drive innovation in semiconductor technologies. It prioritised education in science, technology, engineering, and mathematics (STEM) fields, producing a highly skilled workforce to support the semiconductor industry. Taiwan has created a business-friendly environment with strong intellectual property rights protection and efficient

[35] Yu Chen, “A Short History of Semiconductor Technology in Taiwan during the 1970s and the 1980s,” Taiwan Insight, May 28, 2024, https://taiwaninsight.org/2024/05/10/a-short-history-of-semiconductor-technology-in-taiwan-during-the-1970s-and-the-1980s/

bureaucratic processes, making it attractive for semiconductor companies to invest and operate.[36]

By learning from Taiwan's example and implementing similar strategies, Pakistan can also become a successful player in the global semiconductor market. Through the introduction of automation and cutting-edge technology, investing in the semiconductor industry can enhance Pakistan's industrial sector's potential for modernisation. Other manufacturing industries in Pakistan may see an increase in overall quality standards due to the strict requirements of the semiconductor manufacturing industry. Pakistan's reliance on imported chips can be minimised by building up its domestic semiconductor industry, which will increase economic security and give it more negotiating power in international trade talks.[37]

5. RISKS AND BENEFITS FOR US AND CHINA

The ongoing semiconductor rivalry between the US and China presents both significant risks and opportunities for both nations. For the US, one of the primary risks lies in escalating trade wars and potential retaliatory actions from China. As the US imposes export controls on Chinese semiconductor companies, China may target other American industries, such as agriculture and automotive, disrupting broader economic stability and possibly reducing access to the Chinese market, a key revenue source for many US firms.[38]

[36] Michael Reilly, “How Taiwan Won the Semiconductor Race,” Engelsberg ideas, November 16, 2022, https://engelsbergideas.com/notebook/how-taiwan-won-the-semiconductor-race/

[37] Dr Farid A Malik, “Developing the Semiconductor Industry,” Recorder, April 17, 2024, https://www.brecorder.com/news/40299073.

[38] Michael Funke and Adrian Wende, “Modeling Semiconductor Export Restrictions and the US-China Trade Conflict,” SSRN Electronic Journal, January 1, 2022, https://doi.org/10.2139/ssrn.4307050.

Additionally, the US faces growing dependency on foreign supply chains for critical semiconductor production components, such as those from ASML and Tokyo Electron. This reliance becomes increasingly risky, particularly if other countries align with China, potentially hindering the US technological edge. The rising costs associated with ramping up domestic semiconductor production further complicate the situation, as the US may struggle with higher production costs due to a lack of skilled labor and underdeveloped infrastructure. Moreover, the global talent pool for semiconductor expertise is becoming more competitive, and the US risks losing valuable talent to emerging hubs like China, Taiwan, and India. The enforcement of sanctions also presents challenges, as loopholes and circumvention strategies could reduce their effectiveness, undermining the US efforts to maintain its competitive advantage.[39]

On the other hand, the US has several benefits that it can leverage. Its strong research and development ecosystem, with leading firms like Intel, NVIDIA, and AMD, ensures that it retains a global leadership position in semiconductor innovation. Through initiatives like the CHIPS Act, the US is boosting its domestic manufacturing capacity, which not only creates high-skill jobs but also reduces reliance on imports. By controlling key semiconductor exports, the US also gains strategic leverage, especially in sectors critical for national defence and emerging technologies like artificial intelligence. Furthermore, efforts to diversify its semiconductor supply chain, moving production away from Taiwan and China to other regions, enhance supply chain resilience and reduce geopolitical risks.[40]

[39] Will Hunt and Owen Daniels, “Sustaining and Growing the U.S. Semiconductor Advantage: A Primer,” June 1, 2022, https://doi.org/10.51593/20220006.

[40] Saif M. Khan, Alexander Mann, and Dahlia Peterson, “The Semiconductor Supply Chain: Assessing National Competitiveness,” January 1, 2021, https://doi.org/10.51593/20190016.

On the other hand, China has made significant strides in the manufacturing of semiconductor but the challenges remain in producing the most advanced chips, particularly those required for AI and high-performance computing. This gap affects critical sectors like autonomous vehicles and telecommunications. Similarly, China's over-reliance on government subsidies to drive its semiconductor growth also carries the risk of inefficiencies such as corruption or over capacity issues.[41]

Similarly, despite significant investments, China remains heavily dependent on foreign semiconductor technologies, leaving it vulnerable to export controls, especially from the US and its allies. Disruptions in the global semiconductor supply chain, whether from geopolitical instability or tightening sanctions, could severely hamper China's efforts to build an independent semiconductor industry.[42]

However, China is steadily moving toward technological self-sufficiency, reducing its dependence on external suppliers and positioning itself as a dominant force in the global semiconductor market. State-backed innovation and expansion have already led to significant growth in domestic semiconductor production, allowing China to capture a larger share of the global market. These efforts contribute not only to the diversification of China's economy but also support the development of key high-tech industries such as 5G, AI, and electric vehicles. Furthermore, by increasing imports from alternative sources like Japan, the Netherlands, and Singapore, China is mitigating risks associated with reliance on the West, ensuring a more resilient supply chain. As China's semiconductor capacity expands, it has the potential to become a key supplier in global markets, particularly

[41] Manoj Harjani, "The Institutional Challenge for China's Semiconductor Chip Industry," Asia Policy 19, no. 1 (January 1, 2024): 51–60, https://doi.org/10.1353/asp. 2024.a918868.

[42] Douglas B. Fuller, "China's Counter-Strategy to American Export Controls in Integrated Circuits," SSRN Electronic Journal, January 1, 2021, https://doi.org/10.2139/ssrn.3798291.

as countries seek to diversify away from US-based suppliers in the face of ongoing trade tensions.[43]

6. RECOMMENDATIONS

6.1. Role of the National Aerospace Science & Technology Park (NASTP)

NASTP should establish a dedicated semiconductor division to facilitate research and development (R&D), as well as chip testing. NASTP may enhance Pakistan's semiconductor capabilities by forming joint ventures and technology transfer partnerships with leading international technology companies. Moreover, NASTP should work closely with academic institutions to develop specialised training programs and offer scholarships to facilitate hands-on learning experiences that would build a highly skilled workforce in semiconductor design and manufacturing. NASTP can play a key role in creating an enabling environment for these initiatives, fostering an ecosystem where students gain practical experience and exposure to cutting-edge technologies.

6.2. Focus on Emerging Technologies

Pakistan's semiconductor strategy should prioritise the integration of emerging technologies such as artificial intelligence (AI) and quantum computing. Collaborating with global industry leaders and universities, particularly through

[43] Seamus Grimes and Debin Du, "China's emerging role in the global semiconductor value chain," Telecommunications Policy 46, no. 2 (April 18, 2020): 101959, https://doi.org/10.1016/j.telpol.2020.101959.

partnerships with China, can help Pakistan develop specialised chips and access high-value markets. In particular, Pakistan should focus on developing semiconductor technologies that support 5G, the Internet of Things (IoT), and other advanced applications to drive economic growth in telecommunications, healthcare, and defence sectors. Leveraging China's CIBOD (China International Big Data & Semiconductor Development) report can provide valuable insights and strategic direction for these efforts.

6.3. Strengthening Tech Connectivity

Pakistan should enhance its technological and logistical connections with key tech hubs such as Singapore, Taiwan and Malaysia etc. Strengthening these links will help integrate Pakistan into global semiconductor supply chains, enabling it to become a competitive player in the industry. NASTP can facilitate these collaborations by establishing partnerships and creating platforms for knowledge exchange, research collaboration, and joint ventures with tech hubs like Singapore, Taiwan and Malaysia to grow its semiconductor and tech sectors.

6.4. Comprehensive National Strategy

A comprehensive and cohesive national strategy is crucial to developing Pakistan's semiconductor industry. This strategy should align academia, industry, and government towards common objectives, focusing on policy incentives, infrastructure development, skills training, and international collaboration. NASTP, with its mandate to drive technological innovation, should act as the central hub for

coordinating these efforts, creating an enabling environment where all stakeholders can collaborate effectively to foster the growth of Pakistan’s semiconductor sector.

7. CONCLUSION

To sum up, a significant factor influencing the semiconductor landscape is the technological rivalry between the US and China. This competition revolves around the geopolitical significance of semiconductors and has disrupted global supply chains, impacting international trade. The Chinese government is providing large subsidies to domestic companies to make them globally competitive, while the American government has implemented measures to protect its technological advantages, such as improving intellectual property laws and increasing penalties for infringement. Washington's strategy includes sanctions to cut off Beijing from essential supplies, hindering China's domestic semiconductor and tech industries

China’s strategy to enhance its technological sovereignty and mitigate the impact of US sanctions involves a comprehensive approach to developing its own semiconductor capabilities. Through substantial government initiatives, financial investments, and strategic policies such as the “Made in China 2025” plan, China is significantly advancing its domestic semiconductor production. The country is heavily investing in research and development, building state-of-the-art fabrication facilities, and fostering a skilled workforce. Despite ongoing reliance on international suppliers for certain equipment and technology, particularly from countries like Singapore, Japan, and the Netherlands, China is steadily reducing its dependence on imports by focusing on indigenisation. This concerted effort is aimed at achieving long-term self-sufficiency in semiconductor manufacturing.

However, in this context, Pakistan is actively working to develop its semiconductor industry, and enhancing the skills of its workforce. The Pakistan National Semiconductor Plan aims to tap into the growing global semiconductor market, and the Pakistan Semiconductor Summit brought together experts to discuss the industry's future. Despite challenges such as a lack of skilled workforce and access to advanced technology, Pakistan has opportunities to position itself within the global semiconductor supply chain. By leveraging its low labour costs and geographic location, Pakistan can attract foreign investment and collaborate with international firms to establish a robust semiconductor industry. This transition could reduce Pakistan's reliance on traditional sectors and create high-skilled job opportunities, enhancing economic security.

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