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# SEMICONDUCTORS AND THEIR EMERGING ROLE IN POWER PLAY: INDIA'S STRATEGIC QUEST FOR SUPREMACY AMIDST US-CHINA RIVALRY

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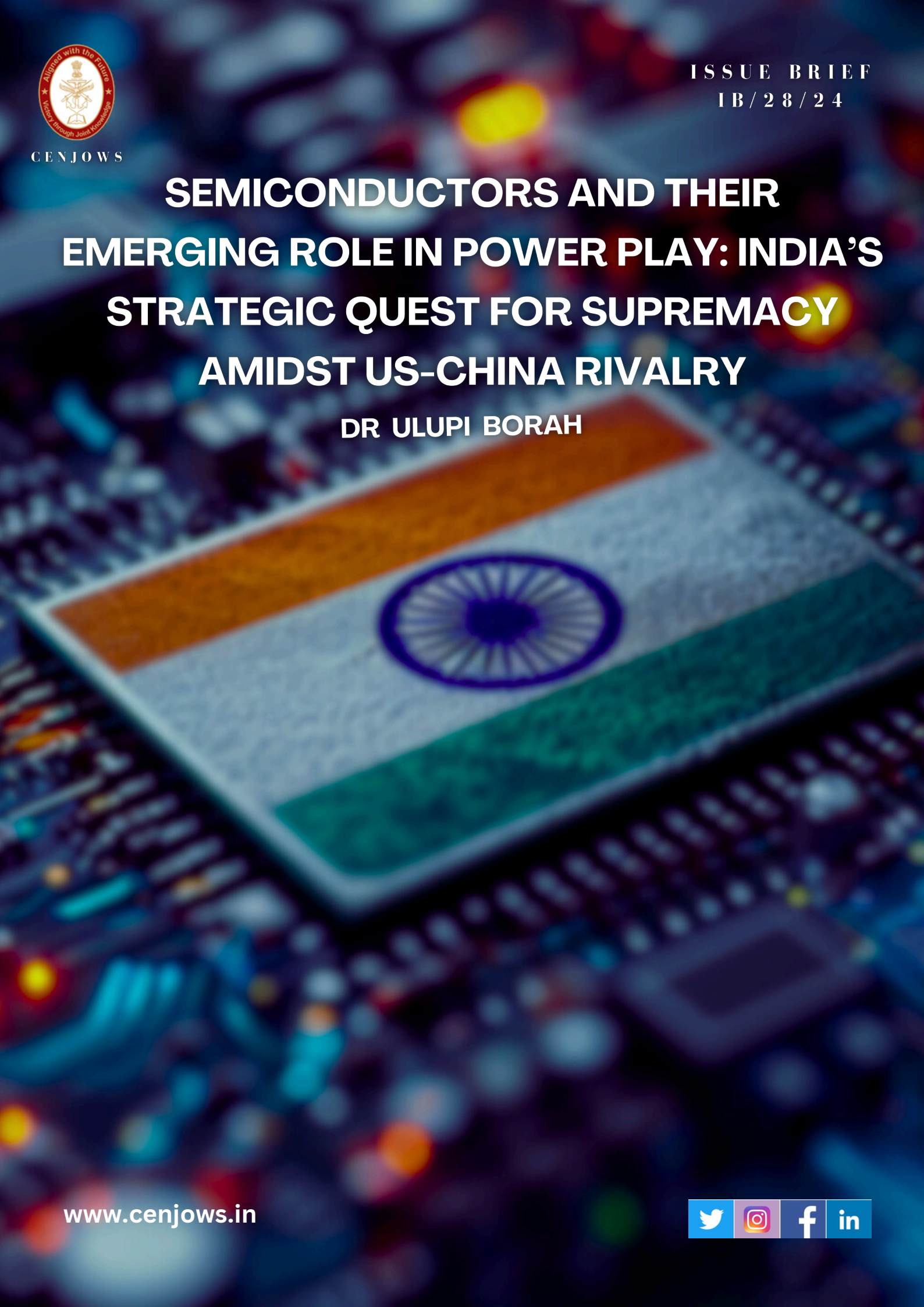

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# SEMICONDUCTORS AND THEIR EMERGING ROLE IN POWER PLAY: INDIA'S STRATEGIC QUEST FOR SUPREMACY AMIDST US-CHINA RIVALRY

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**Abstract**

*The nation with supremacy in the semiconductor industry will become the superpower in the 21st century. In terms of economic power and technological innovation, the role of semiconductors remains immense. It has permeated into every aspect of society and plays a pivotal role in shaping the future. While discussing about national security, international security and international affairs, chips remain salient and which enables it to shape international relations in the foreseeable future. Hence, semiconductors have emerged as a critical component in determining a nation's leverage and strategic strength on a global scale. The paper has made an effort to explore the significance of innovation and indigenisation in this advanced technology while understanding the chip war between the US and China. It also elaborates the factors that could provide an opportunity for India to step up and realise its aspirations of becoming a key player in the semiconductor industry.*

## Introduction

Although semiconductors are regarded as the backbone of advanced technologies, they had existed even during the Cold War period. It played a crucial role in shaping the power dynamics through advancements in communications and in the defence sector. There was a relentless pursuit for miniaturising the computer power and hence the competition to acquire supremacy in chip technology became salient. Chips are the necessary building blocks of any kind of technology, be it computer systems, microelectronics, advanced electronics or artificial intelligence (AI). They are used in the small drones to most powerful hypersonic missiles. Hence, it has been observed that the pivotal force is all about miniaturisation enabling not only advancement in technology but also has the ability to influence contemporary and future geopolitics.

This makes the semiconductor industry a highly strategic and lucrative opportunity for any nation that desires to have a greater voice on the global decision-making platform. However, this has also resulted in semiconductor trade being subject to extremely strict scrutiny and a high degree of control by powerful nations such as the US. Thus, it is not only economic imperatives that determine the global semiconductor manufacturing and supply chain, but more so by strategic and security considerations, many of which can be traced back to the Cold War era.[1]

Nonetheless, a Cold War 2.0 in this sector is seen between the US and China. The supply chain statecraft has become equally salient to international relations. It is not possible for one nation to produce everything by itself. Hence, being a part of that value addition becomes extremely relevant. As such, New Delhi too has developed the ambition of becoming a semiconductor hub. It aspires to set up a complete semiconductor ecosystem ranging from design to manufacturing. This will lead to self-sufficiency in meeting domestic chip demand for not only the civilian sector but also the defence and aeronautics sector. The paper examines how semiconductors have been essential since the Cold War and how the US has considerable influence over them. It discusses about China, which since the early 2000s has emerged as a major player in this industry. Chinese businesses have played a significant role in establishing Beijing as a global centre for the production of cutting-edge semiconductors, despite the restrictions imposed by the US. The article also discusses the areas and opportunities that could help India establish a leading position in this industry.

**Cold War 1.0: The US-Soviet Chip War**

Post-World War II, the US emerged as a dominant player in the semiconductor industry. It deployed a three-pronged strategy to further cement its position. It ensured that it maintained its commercial as well as technological lead over all other nations. It also denied its geopolitical rivals any access to its advanced technology. Chris Miller in his book, 'The Chip War' stated that the Soviet Union's failure to mass-produce semiconductors was a significant element in their defeat during the Cold War. Research and development were one of the areas where the US had invested heavily. Further, it integrated semiconductor R&D into its advanced systems which served the military purpose. On the contrary, the Soviet Union had hardly invested anything in the name of innovation. Their centrally planned system was never focused on adaptability and innovation. In addition, the Soviet Union lacked dynamic private sectors which could have enabled the utility of chips in the military systems and integrated it with the national economy.[2] The Soviet Union during that time was also known to have been involved in industrial espionage especially to acquire semiconductor technology. They were mostly into copying designs without fostering indigenous R&D. This eventually left the Soviet Union in a state of disadvantage in the race of semiconductor technology.

Meanwhile, the US made significant efforts to create a US led block of semiconductor supply chain with its allies and friendly nations. The first country to benefit from this measure was Japan, which received technical and financial aid from the US to develop its electronic industry. In the 1980s, Japan was the world leader in semiconductor manufacturing and was capable of becoming a rival to the US. Dynamic Random-Access Memory (DRAM) was one of many Japanese semiconductor products that American electronics businesses adopted. However, despite retaining a 50% stake, Japan now controls only 10% of the global semiconductor business.[3] The reduction was caused by Washington's ban on semiconductor exports, particularly CPUs with DRAM in order to limit Tokyo's dominance in this sector. The US wanted to protect its domestic semiconductor industry and feared that it was losing its dominance in this critical industry.

Apart from Japan, the US aid was also received by South Korea and Taiwan to become electronic giants, with South Korea specialising in memory chips and Taiwan specialising in logic chips. The two countries went on to become offshore sites from

which the US corporations could gain cheap labour. Then in the 1980s, the US aimed its sight at the even cheaper labour market of Southeast Asia. Thailand, Philippines, Malaysia, Indonesia and Singapore were roped into the task of assembly and testing. Thus, a new value chain arose with Southeast Asia being at the lower end, South Korea and Taiwan moving up to the middle with fabrication and the US at the top, leading in design and Semiconductor Manufacturing Equipment (SME) production.

**Cold War 2.0: The US-China Chip War**

With the end of the Cold War, the disintegration of USSR highlighted several mistakes it made. Among them, its lack of investment in technology and innovation remained the most critical one contributing to its defeat. China learned from Russia's mistakes in terms of critical technologies like semiconductors. Beijing made significant investments in this sector and since the early 2010s, it started developing 40nm chips. The country has concentrated on advanced node manufacturing, with companies such as Semiconductor Manufacturing International Corporation (SMIC) making significant strides in developing smaller, more efficient semiconductor components.[4] This greatly worried the Americans and encouraged them to impose sanctions on China. Nonetheless, in 2020, China achieved a milestone when SMIC announced its 7nm process node with Huawei.[5]

The CHIPS and Science Act was signed into a law by the US in August 2022.[6] It represented a significant expansion of industrial policy in the US. The legislation is stimulating a tremendous amount of investment activity in the semiconductor sector of the US. Meanwhile, the Act also commences export controls to hinder China's access to advanced technologies mostly those involving extreme ultraviolet (EUV) lithography. The chipmakers who receive funds are barred from extending their facilities in China and other "countries of concern" for a decade.[7] Despite sanctions, the SMIC's advancement demonstrated that the US blockade was insufficient, too late, and out of date.[8] SMIC is apparently establishing a dedicated team to develop 3 nm semiconductor node technology. This action is part of SMIC's strategy to gain independence from foreign corporations and minimise its dependency on US technology.[9]

Lieutenant General Raj Shukla, former Indian Army Commander, opined that the semiconductor industry is today becoming a pivotal factor in shaping Cold War 2.0. In this geopolitical contest, the race would be to gain dominance over 3nm chip technology. and the game is of 3nm. By 2024, China saw an increase of 40% (98.1 billion units) in its IC production.[10] It is expected by Beijing that the tech industry will achieve $13.9 billion worth of annual output by 2025.[11]

Although the West has a lead by ten years, it is a slender lead. The US is cognisant of the salience of critical technologies like EUV lithography and the Dutch company ASML holds its monopoly. If China gets a hold of those EUV lithography machines, then the US would be left far behind in this race despite its lead of ten years. The former President Joe Biden met the Dutch Prime Minister Mark Rutte several times and discussed on critical technologies. Since ASML has stakes in both China and the US, the US has made significant efforts to ensure that ASML is controlled by the US and that China does not have unrestricted access to it.

Furthermore, the Russia-Ukraine conflict and Russia's resurgence in terms of airpower and drones have become a concern for the West. This was possible for Moscow because of the Chinese chips. Russia faced global sanctions which prevented it from having access to advanced technologies. Despite that, Russia managed to have access to the essential components necessary to fight the war and it was made possible by China. This demonstrates Beijing's enhancing influence in enabling Moscow with advanced military capabilities. At the same time it also highlights the strategic role of semiconductors specially in terms of modern warfare.

## Understanding the other Current Semiconductor Economies

### Japan

In 1988, Japan held a share of 50.3% of the global semiconductor industry. However, post the 1990s, this continued falling till the country only held 10% by 2019.[12] Thereafter, in 2021, the country aimed to revive its semiconductor industry by identifying it as a national priority. A support strategy was developed by the Ministry of Economy, Trade, and Industry, which included initiatives such as the Post-5G Fund of JPY200 billion (approximately $1.3 billion) and Green Innovation Fund of JPY2 trillion

(approximately $13 billion).[13] Domestic chip sales have also been predicted to exceed JPY15 trillion (about $99.4 billion) by 2030.[14]

**Taiwan**

Some of the world's most advanced chips are manufactured by Taiwan Semiconductor Manufacturing Company Limited (TSMC). The company has also been approached to start operations in the US, Europe and Japan. In 2022, 63.8% of the global semiconductor production was done by Taiwan.[15] For integrated circuits (IC), Taiwan's packaging and testing output was at 58.6% and design production value at 20.1% of the world market.[16]

The country is home to more than 90% of the primary production sites, advanced processes, cutting-edge technology as well as forward-thinking research and development. New semiconductor production facilities are also being developed, apart from direct foreign investment, by major corporations like Entegris, LAM Research and ASML. Training centers have been established for modern process equipment by Tokyo Electron and Applied Material. Taiwan has also been chosen by leading IC and ICT businesses for IC packaging and testing, as well as contract wafer production.[17]

**South Korea**

The South Korean semiconductor industry is in an era of rapid expansion, which has been made possible due to government and private investments. In 2024, the South Korean government announced that a package worth 26 trillion won ($19 billion) would be invested in the semiconductor manufacturing industries. This would be a great boost to their R&D as well as infrastructure needs, especially for medium and small enterprises.[18]

Home to Samsung, SK Hynix and other such chip giants, South Korea declared its ambition to establish the world's biggest chip centre, requiring an investment of at the very least $456 billion. Professor Kim Dae-jong of Sejong University quoted that "South Korea is supplying 80 percent of the world's memory semiconductors and has said it is investing 300 trillion won ($220bn) in the Yongin cluster, but there has been a water supply issue with it." Regarding the government's funding plan, he said "On top of tackling such issues, today's announcement seems to be an effort to support

innovative small and medium-sized enterprises to further strengthen their competitiveness against [rivals] like Taiwan."[19]

However, with the country's chip sector being mostly based in South Korea and China, the over-dependence on specific locations is increased. Tackling this issue requires the country to diversify its manufacturing hubs by collaborating with friendly nations such as India. Overall, it is seen that in terms of production capabilities, Taipei leads making it a global leader in the semiconductor industry. Tokyo saw a decline after remaining one of the topmost leaders in the 80s. But today, it is reviving its industry with a lot of support and initiative by the Japanese government. Seoul has demonstrated its excellence in terms of memory chips. Comparatively, New Delhi is still at a nascent stage when it comes to manufacturing. However, with a strong political will, it is making significant efforts to build its footprints in this sector.

**India's Aspirations**

Amid a Cold War 2.0 between the US and China, it is crucial to understand if India had the potential to become a major global semiconductor hub. India already has a vision of Amrit Kaal through which the largest democracy of the globe emphasises on initiatives such as Atmanirbharta which means to be more self-reliant and be dependent on indigenously built products. At the same time, New Delhi wishes to play the role of Vishwa Bandhu, a global friend and rise to global prominence through its vision of Vikshit Bharat. In this backdrop, advanced technologies like the chips are central to meet these objectives.

Production of semiconductors in India began as far back as the 1960s, when germanium semiconductor ships were being manufactured by a few of the Indian electronics companies. Two public sector enterprises, namely Hindustan Aeronautics Ltd. (HAL) and Bharat Electronics Ltd. (BEL), which were under the Ministry of Defence, were prominent players in the domestic chip sector.[20] During 1983, under the then PM Indira Gandhi, a new electronics policy was launched. PM Rajiv Gandhi also sought to support the Indian semiconductor economy through various schemes and policy measures aimed towards promoting computer manufacturing and chip making.[21]

The Semiconductor Complex Limited (SCL) was also established in 1984 with an investment of $40 million.[22] This was made possible due to licensing agreements with other major players such as Rockwell, AMI and Hitachi. However, in 1989, a severe fire at the SCL complex in Chandigarh caused India to lose its manufacturing lead. Thereafter, in 2007, the Indian government announced its first policy on semiconductors. This policy, however, remained largely unsuccessful till 2015.[23]

In December 2021, under the “Program for Development of Semiconductors and Display Manufacturing Ecosystem” the "India Semiconductor Mission (ISM)" was initiated. The Mission would be the nodal agency tasked with ensuring smooth and efficient implementation of government initiatives aimed at establishing semiconductor and display fabs.[24] Furthermore, in 2021-2022, the “Modified Semiconductor Policy” was announced with a budget of $10 billion. The policy was aimed at promoting the semiconductor design ecosystem in the country which included the establishment of factories and ATMPS.[25] In 2023, Micron, a chip maker based in the US, announced the establishment of its ATMP worth $2.75 billion in Gujrat, India.[26]

Collaborations such as the greenfield initiative, wherein India’s Tata Electronics Private Limited and Taiwan’s PowerChip Semiconductor Manufacturing Corporation (PSMC) have agreed to collaborate[27], have already received cabinet approval. Outsourced Semiconductor Assembly and Test (OSAT) have also been set up by TATA in Morigaon, Assam under the aegis of the modified Semiconductor Assembly, Testing, Marking and Packaging (ATMP) scheme.[28] State governments such as Odisha and Tamil Nadu have also taken initiatives to promote their semiconductor production companies. With the US and China engaging in a technological war over semiconductors, a window of opportunity has opened up for India to fill up the vacuum created in the industry. It is estimated that the country would develop into the next global hub of semiconductors within a decade.[29]

In 2023, the size of India’s semiconductor economy was an estimated $34.3 billion.[30] This market is expected to grow at 20.1% CAGR, reaching $100.2 billion by 2032.[31] In comparison, the global semiconductor market of 2023 was at $664.54 billion, which was projected to expand at 12.5% CARG and grow to $1.9 trillion by 2032.[32] It is thus clear that India is aligned with the global projects data in this sector. Three factors

contribute to this trend- India's expanding market, backed by strong political will, and the country's technological capabilities.[33]

In 2024, Prime Minister Narendra Modi declared that "Our dream is that every device in the world will have an Indian-made chip".[34] And India has already stepped on the road of manufacturing chips, focusing on the production of 28nm nodes. As stated by the Vice President of the India Electronics and Semiconductor Association (IESA), Anurag Awasthi, "Of this, most applications will be in the aerospace and defence, automotive, industrial, wearables, consumer electronics, and handset segments. We have to cater to our own markets and focus on their growth with the prospective economies of scale and the corresponding job creation".[35]

**The Supply Chain Pillar of IPEF for India's Semiconductor Ecosystem and Self-Reliance**

In November 2023, India signed the Supply Chain Resilience Agreement (Pillar-II) with the Indo-Pacific Economic Framework for Prosperity (IPEF). The Agreement intends to enhance the supply chain, which is critical for national security and economic stability. The agreement entered into force on 24 February 2024 and established a Supply Chain Council (SCC) with the US as Chair and India as Vice-Chair.[36] It aimed to develop economic, commercial, and trade linkages between firms in the economies of the Parties while also improving supply chain resilience in crucial industries. Article 6.10 of the Agreement further encourages private sector participation in improving the resilience, efficiency, productivity, sustainability inclusivity, and other aspects of IPEF supply chains.[37]

The Department of Commerce of India has inked two Memorandums of Understanding (MoUs) with the US, one in the semiconductor industry and the other in the key minerals sector, both of which are significant steps towards safeguarding India's supply chain resilience in these sectors.[38] A huge percent of the components especially microcontrollers comes from China. Hence, indigenisation remains a major objective for India which aligns well with IPEF's supply chain pillar.

In most cases it has been observed that most semiconductor products go to China for assembly, manufacturing and processing. Later it is shipped to India and other

countries. However, the concern arises as to why it has to go to China and then return to India. Rather why not India becomes a direct destination and commence partnership at an international level so that it enables New Delhi to be integrated into the global semiconductor supply chain?

In this context, the supply chain pillar of the IPEF could provide New Delhi the forum to commence collaboration with the global semiconductor hubs like the US, Japan, Taiwan, South Korea etc. SCC could enable New Delhi in building fabs and assembly facilities by channelling investments. Most significantly, the Article 6.10 discusses the involvement of the private sector which is of great salience. This could enable New Delhi to strengthen its collaboration with the major global hubs of the semiconductor sector and involve capacity building, transfer of technology, manufacturing microcontrollers etc. IPEF also promotes sustainability and resilience which clearly aligns with the “Make in India” initiative of India. It promotes localising the semiconductor components in the global supply chain.

**Navigating the Roadblocks on India’s Path to Becoming a Global Hub**

To realise the Indian dream, the country has to first overcome certain challenges which include, but are not limited to:

- **Infrastructure:** The infrastructural requirement of a semiconductor industry is also very high. And while manufacturing electronics and chip design is not a problem for India, the country has faced challenges in setting up Semiconductor Wafer Fabrication (FAB) units. It is also crucial to ensure that the power supply to chip manufacturing units remains uninterrupted. This makes it difficult for India to rival its competitors such as China or Vietnam, which have been a preferred destination for chip manufacturers due to their low costs. India still lacks the infrastructural and financial capability to develop its domestic semiconductor sector.

- **Talented Labour Force:** Although India boasts a large and technically skilled workforce, there is a dearth of engineers who have the requisite knowledge in semiconductor device physics and its process technologies. This has resulted in the country being unable to advance in chip packaging or fabrication. And while

India aims to produce 28nm nodes domestically[39], China, in contrast, aims to produce 5nm chips.[40] Thus, compared to its peers, India can still be considered to be at the nascent stage of semiconductor manufacturing.

- **Lacks High Volume Fabs:** Currently Taiwan is leading in fabs which is considered to be the backbone of semiconductor manufacturing. In this context, New Delhi only has research fabs and low scale fabs, which are mostly used in academic purposes or in other experimentation related things. If seen from a commercial aspect, then New Delhi has zero high volume fabs. This has made New Delhi to be heavily reliant on imports from other countries. This has become a significant challenge, considering the emphasis on global supply chain resilience.

- **Deficit in IP and Manufacturing**: When it comes to designing products like CPU and wired or wireless communications, most of them have intellectual property getting generated in the US. Meanwhile, the packaging and manufacturing of these chips happen in Taiwan and China including other East Asian countries like South Korea and Japan. India's absence in this aspect demonstrates that despite being a technology hub, its role at a global level in the semiconductor supply chain is negligible. Chip fabrication facilities, chip design or packaging are few areas where New Delhi is far behind the global semiconductor hubs. This has to an extent raised concern about India's vulnerability especially considering the geopolitical tension between China and Taiwan.

- **Finance:** A huge amount of capital investment is required to set up a robust and all-rounded semiconductor ecosystem. It requires the development of infrastructure, training of a skilled workforce and continuous research and development. Setting up a semiconductor fabrication plant itself can cost from $15- $20 billion[41] which is more than the budget allocated in the country's "Modified Semiconductor Policy". In contrast, China's investment in its semiconductor industry has reached almost $100 billion since 2014[42], yet it is still far from reaching its goal of self-sufficiency.

- **Other Challenges:** There are several other challenges that must be faced if India aspires to set itself up as a semiconductor hub. One of them being environmental concerns over the usage of hazardous materials in the production process and the high demands of energy. Another is the issue of compliance with global and international regulations pertaining to the sector.[43]

**A Few Actionable Initiatives to Mitigate the Roadblock**

- **India's Policy of Neutrality:** Despite the challenges in the semiconductor supply chain resilience, India has a big opportunity as a politically neutral country. This will enable India to become one of the trusted partners in this supply chain at a global level which is not the case with most of the other global powers.

- **A Multifaceted Ecosystem**: To mitigate these challenges, it is crucial for New Delhi to emphasise on the creation of a semiconductor ecosystem. However, this ecosystem should be multifaceted in nature and not just focus on fabs. It should equally focus on the overall talent, infrastructure and supply chain. The Government of India is making significant efforts in this sector by initiating policies such as the semiconductor mission to address these needs. It not only emphasises on chip manufacturing but also commences packaging and supply chain expansion which remain critical in addressing these challenges.

- **Attract Global and Domestic Investment**: The ecosystem should be created in a manner that its major focus should be on policies which would attract global and domestic investment at the same time.

- **The Taiwan Model:** The Taiwan model of semiconductor is comprised of talent, technology and capital. But if we at the past, Taiwan had a very modest beginning. In the late 1990s, they did not emerge as a market leader. It was only towards the end of 2010 that Taipei achieved recognition in the global semiconductor market. It took them almost 20-30 years to reach this stage. Although India has talent, the country is still trailing behind since it is a highly capital-intensive industry. India could learn from Taipei but New Delhi cannot afford to take thirty years. At least within a time period of ten years India should

be able to become a global leader and achieve the vision of Vikshit Bharat by 2047.

- **A Symbiotic Relationship between the Defence and Semiconductor Sectors:** Role of defense is very critical as it has the capability to drive the technology roadmap. In fact, in the US, historically all semiconductor technology has originated from defense. They were mostly driven by the military need. Hence, it is said that defence and semiconductors share a symbiotic relationship. A significant level of advancement could be achieved by both the sectors if this symbiosis is fully harnessed. The defence sector could commence innovation and miniaturisation for its application in the semiconductor sector. This could later promote advancement in the commercial markets too. Conversely, the defence sector could also benefit from a resilient semiconductor ecosystem. India's defence sector could have possession of cutting-edge technologies for its advanced weapon system.

**Conclusion**

Semiconductors have emerged as the hidden behemoth of the digital age. These tiny chips hold immense power and their influence in geopolitics have been observed since the Cold War era to the ongoing conflict between the US and China. Nations are increasingly becoming aware of the effect that disruptions in semiconductor supply chains have on their economy and strategic power. As such, countries such as India are aiming to firstly create and support a domestic market of chips, with aspirations of becoming a global supplier. The semiconductor industry of India has become one of the country's primary focus areas. As such it has seen many policy initiatives and capital investment from the government as well as the private sector. Be it the Semiconductor Mission or Atmanirbhar Bharat Abhiyan, the Indian government has clearly shown its commitment to making the country a global semiconductor hub.

However, there are many challenges on the road to realising this goal. India must further develop its financial, infrastructural and technical capabilities, backed by a continued political will. The country needs to invest more effort into developing its chip manufacturing and designing capabilities and focus on supporting not only big enterprises but also medium and small scale indigenous manufacturers, to tap its full potential. Collaborations with other chip manufacturing nations, developing a talented

pool of engineers, attracting more foreign investment are some of the ways to go. India has already entered the race for becoming the next semiconductor hub, and in due course of time, the country is expected to achieve its desired outcome.

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