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THE SEMICONDUCTOR PROBLEM OF INDIA

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Abstract

This paper aims to address the research gap regarding India's progress in the semiconductor industry, which has been extensively researched for other countries such as China and the United States. Specifically, it investigates the path that India should take in terms of investing in the complete supply chain or being part of the supply chain. Additionally, it examines the measures taken by the Government of India for establishing semiconductor fabs in the country and the challenges faced by the Quad initiative, which India is part of. The paper uses a qualitative research methodology for the challenges of the Quad initiative and a mixed-methods research methodology for the measures taken by the Indian government. The findings reveal several challenges for India in setting up a semiconductor supply chain, such as trust issues, red tape, lack of incentives, and environmental challenges. The paper concludes that the Indian government needs to provide tax benefits, incentives, and initiatives for foreign companies to participate in the Quad's supply chain and invest in human capital to strengthen the country's position in the semiconductor industry.

1. Introduction

The semiconductor industry plays a crucial role in the modern world, providing the building blocks for various electronic devices. India, as a rapidly developing country, has been increasingly dependent on semiconductor imports to fuel its growth. However, the recent global semiconductor shortage has highlighted the need for India to strengthen its domestic semiconductor industry.

India imports more than 80% of its semiconductor requirements, primarily from East Asian countries like Taiwan, South Korea, and China. This dependence on imports not only exposes India to supply chain disruptions but also makes it vulnerable to geopolitical risks.
China's dominance in making semiconductors is linked to a variety of factors, including its large and growing market for electronics, the availability of low-cost labor, and significant investments by the Chinese government in the research, development, and manufacturing of semiconductors.

However, China's dominance in this area has also raised concerns in other countries, particularly with respect to the global supply chain for semiconductors. Many countries, including the United

States and its allies, worry that China's control of semiconductor manufacturing could give it an unfair advantage in areas such as military technology and critical infrastructure.

The China-Taiwan conflict is also a significant factor in this issue, as Taiwan is a major producer of semiconductors and a critical link in the global semiconductor supply chain. China considers Taiwan to be a part of its territory and has not ruled out the use of force to bring it under its control. This has raised concerns that any disruption to the semiconductor supply chain resulting from a conflict between China and Taiwan could have significant global consequences.

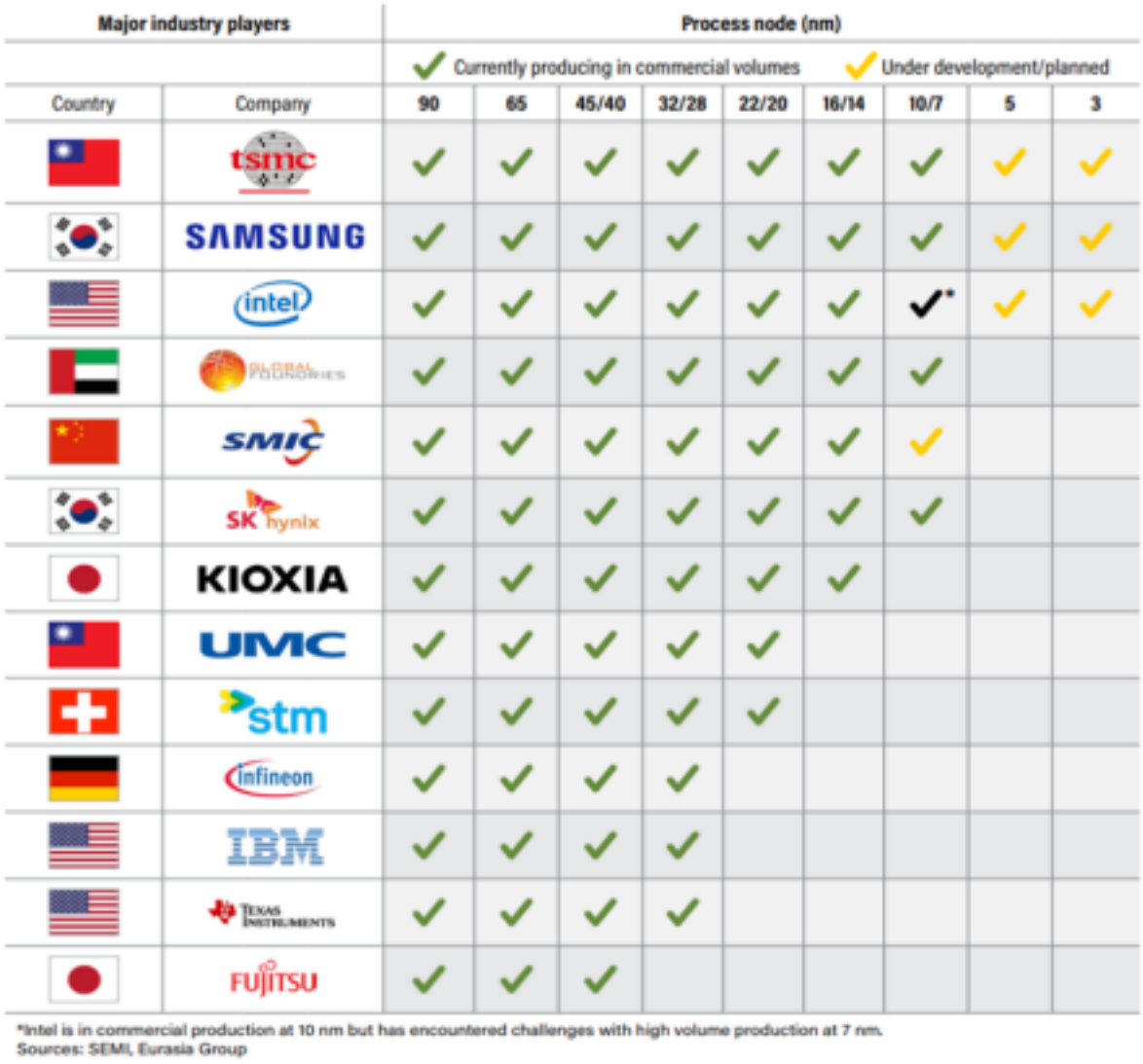
The QUAD initiative and other alternative measures are seen as important steps to address these concerns and ensure the continued availability of semiconductors in the global market. The QUAD countries are working together to develop alternative supply chains and technologies to reduce their dependence on China and ensure the security and resilience of their semiconductor supply chains.

The Indian government has also recognized the importance of developing its domestic semiconductor industry and has launched several initiatives to promote local manufacturing. But in spite of these initiatives, India's domestic semiconductor industry has yet to take off. There are several reasons for this. Firstly, the lack of a robust supply chain and infrastructure makes it difficult for semiconductor companies to set up manufacturing facilities in India. Secondly, the high cost of electricity and lack of skilled labor makes it less attractive for companies to invest in the country. Finally, the lack of a supportive ecosystem and a market for semiconductors has hindered the growth of the industry. Thus this forms the background of the research on how to handle this issue of semiconductors and what areas to focus on to resolve India's "China Problem" in the field of semiconductors as well as the potential of emerging as a global technological powerhouse.

2. Literature Review

a)The Geopolitics of Semiconductor prepared by Eurasia group September 2020

This highlights how its semiconductor is at the heart of the conflict between China and the USA, as well as the importance of Taiwan in this issue. As China continues to advance its semiconductor industry, high-end chips remain a hurdle for them to cross as they rely on Taiwan for such chips. As shown in the image below, while China is more than capable of making chips with process node[1] 16/14 nm when it comes to advanced chips of size 10 nm, 7 nm, or 5nm it has to rely heavily on Taiwan.



Major industry players		Process node (nm)								
		✓ Currently producing in commercial volumes						✓ Under development/planned		
Country	Company	90	65	45/40	32/28	22/20	16/14	10/7	5	3
	tsmc	✓	✓	✓	✓	✓	✓	✓	✓	✓
	SAMSUNG	✓	✓	✓	✓	✓	✓	✓	✓	✓
	intel	✓	✓	✓	✓	✓	✓	✓*	✓	✓
	GLOBALFOUNDRIES	✓	✓	✓	✓	✓	✓	✓		
	SMIC	✓	✓	✓	✓	✓	✓	✓		
	SK hynix	✓	✓	✓	✓	✓	✓	✓		
	KIOXIA	✓	✓	✓	✓	✓	✓			
	UMC	✓	✓	✓	✓	✓				
	stm	✓	✓	✓	✓	✓				
	Infineon	✓	✓	✓	✓					
	IBM	✓	✓	✓	✓					
	Texas Instruments	✓	✓	✓	✓					
	FUJITSU	✓	✓	✓						

*Intel is in commercial production at 10 nm but has encountered challenges with high volume production at 7 nm.
Sources: SEMI, Eurasia Group

[1] Process node is an industry term for feature size which means half the distance between source and drain on a MOS transistor, equivalently it shows how small a chip can be, smaller chips mean more can be used for higher computation power.

Figure 1 Shows major semiconductor companies along with their capabilities in process nodes and country

This paper also explains that despite massive investment by CCP, the chances of China becoming a significant player before 2030 is highly unlikely, but the US not exporting chips to China could throw the entire supply chain in trouble as a large amount of revenue is lost, considering China is the biggest consumer of semiconductor. Moreover, tensions rise between Taiwan and China as Taiwan's TSMC[2]is pressured by the US to not supply high-end chips to China.

b)Siliconpolitik: The Case for a Quad Semiconductor Partnership by Pranay Kotasthane

Pranay Kotasthane (2021) in this paper explains how COVID-19 exposed the bottlenecks that are already present in the current semiconductor supply chain. This model of globalization for semiconductor manufacture and design, while cost-effective can also act as a handicap, as manufacturing is largely concentrated in east Asia, and any political crisis in the region or delay by one component can put a stop to all the participants down the supply chain. Moreover, this divided importance between different players of conflicting interests can also lead to halts if one of them decides to use this for geopolitical purposes.

While this globalized market has its faults, the paper also explains why for countries like USA, Japan, and India, the idea of an indigenous semiconductor market is unlikely to achieve the goal of "self-sufficiency" because of significant upfront cost in the construction of fabs, high labor demand as well as patents on the information tech. While the USA has the design, the cost of manufacturing semiconductors within states is extremely high, which is why most industries have emerged out of East Asia. Similarly, While Japan has a high supply of etching gas[3], as well as other necessary chemicals and manufacturing materials, the cost of production and lack of design has seen Japan account for only one percent of global revenue from semiconductors. India while having a large supply of skilled laborers, does not have the design and the capital to go with it. This is where Quad, Australia providing raw materials, Japan providing secondary materials, the US providing design, and India supplying skilled labor can come into play.

c)Supply chain Regulation in the service of geopolitics-Dieter Ernst

This paper is focused on the executive order of president Joe Biden, under which, to protect the US technological leadership in semiconductor design, the US has restricted the export of high-end semiconductor technology to both the Chinese military as well as Chinese companies.

[2] TSMC stands for Taiwanese Semiconductor Manufacturing Company, which is the largest semiconductor and chip manufacturing company in the world.
[3] Etching gas makes it possible to precisely remove unwanted material from the chip. Japan makes 70% of the global etching gas supply.

This is to target the weakness in China's indigenous semiconductor market plans, as it doesn't possess the leading edge semiconductor manufacturing equipment (SME) or electronic design automation (EDA), both of which are required for high-end processing. This paper views the US policy as a protectionist view, which will harm both the US as well as China economically and will force other suppliers to choose between US and China Supply chains as their markets.

d) Technology, power, and uncontrolled great power strategic competition between China and the United States - Xiangning Zu

In the article "Technology, power, and uncontrolled great power strategic competition between

China and the United States," Xiangning Zu discusses the impact of technology and power dynamics on the strategic competition between China and the United States.

The author argues that the competition between the two countries is driven by their quest for technological dominance, which is seen as essential to achieving global power status. The author suggests that the US and China are engaged in a "race to the bottom" in terms of technological innovation, as they seek to outdo each other in areas such as artificial intelligence, 5G networks, and quantum computing.

The article also highlights the risks associated with this competition, including the potential for conflict and the risk of an arms race. The author argues that the current trajectory of US-China relations is unsustainable and that a new approach is needed to address the underlying power dynamics that are driving the competition.

The author suggests that one potential solution is to focus on shared goals and cooperation in areas such as climate change and public health, which could provide a basis for building trust and reducing tensions between the two countries. The author also argues that the international community has a role to play in shaping the US-China relationship and that international organizations such as the World Trade Organization and the United Nations could provide a framework for addressing some of the underlying issues.

Overall, the article provides a comprehensive analysis of the technological and power dynamics driving the strategic competition between the US and China. The author highlights the risks associated with this competition and suggests that a new approach focused on shared goals and cooperation may be necessary to reduce tensions and promote stability.

e) How the United States marched the semiconductor industry into its trade war with China - Chad P Brown

The article "How the United States marched the semiconductor industry into its trade war with China" by Chad P. Brown discusses the role of the semiconductor industry in the ongoing trade war between the United States and China.
The author argues that the US government's decision to target the Chinese tech giant Huawei with sanctions has had a significant impact on the semiconductor industry, as many US companies rely on sales to Huawei for a significant portion of their revenue. The author suggests that the US government's actions have effectively forced the semiconductor industry to take sides in the trade war.

The article provides a historical perspective on the relationship between the US and Chinese semiconductor industries, noting that China has long sought to develop its own domestic semiconductor industry to reduce its reliance on US technology. The author suggests that the US government's actions have fueled these efforts by creating a sense of urgency and national pride

among Chinese policymakers and investors.

The article also highlights the potential risks associated with the US-China trade war for the semiconductor industry, including the possibility of supply chain disruptions, reduced innovation, and increased costs. The author argues that the semiconductor industry is particularly vulnerable to these risks, given its global nature and its reliance on a complex network of suppliers and customers.

In conclusion, the article suggests that the US government's decision to target Huawei has had a significant impact on the semiconductor industry and has forced companies to take sides in the trade war. The author argues that the semiconductor industry is particularly vulnerable to the risks associated with the trade war and that policymakers should take steps to mitigate these risks and promote a more stable and predictable trading environment.

f) The Global Semiconductor Chip Shortage: Causes, Implications, and Potential Remedies - W. Mohammad, A. Elomri, L. Kerbache

W. Mohammad, A. Elomri, and L. Kerbache's research paper titled "The Global Semiconductor Chip Shortage: Causes, Implications, and Potential Remedies" provides a comprehensive review of the causes, implications, and potential remedies of the current global semiconductor chip shortage. The paper offers an in-depth analysis of the factors contributing to the shortage and the impact of the shortage on various industries.

The authors highlight the growing demand for semiconductor chips in various industries, including automotive, consumer electronics, and telecommunications, and the supply chain disruptions that have led to the shortage. The paper discusses the factors contributing to the shortage, including the COVID-19 pandemic, geopolitical tensions, and natural disasters. The authors present a clear and concise explanation of the complex interactions between these factors and how they have impacted the semiconductor supply chain.

The authors also provide a thorough analysis of the impact of the semiconductor chip shortage on various industries, including increased prices, supply chain disruptions, and delays in new product launches. They present data and examples to support their arguments and provide insights into the short- and long-term implications of the shortage on these industries.

The paper concludes with several potential remedies for addressing the semiconductor chip shortage, including increasing investment in semiconductor manufacturing capacity, improving supply chain resilience, and promoting international cooperation. The authors provide a detailed explanation of these potential remedies and their potential benefits, as well as potential challenges and limitations.

g) Understanding systemic disruption from the Covid-19-induced semiconductor shortage

for the auto industry - Vinay Ramani, Debabrata Ghosh, ManMohan S. Sodhi

V. Ramani, D. Ghosh, and M. Sodhi's research paper titled "Understanding systemic disruption from the Covid-19-induced semiconductor shortage for the auto industry" provides a comprehensive review of the impact of the semiconductor chip shortage caused by the COVID-19 pandemic on the automotive industry. The paper offers a detailed analysis of the underlying causes of the shortage and the resulting impact on the industry's supply chain.

The authors emphasize the critical role played by semiconductor chips in modern-day vehicles, powering everything from electronic control units to advanced driver assistance systems (ADAS) and infotainment systems. They explain the factors that contributed to the shortage, including the pandemic-related shutdowns of semiconductor plants and the resulting disruption to supply chains, geopolitical tensions, and natural disasters.

The paper presents a comprehensive analysis of the impact of the semiconductor shortage on the automotive industry, including production shutdowns, reduced vehicle production, and higher prices for consumers. The authors provide data and examples to support their arguments and provide insights into the short- and long-term implications of the shortage in the industry.

The authors conclude with several recommendations for addressing the semiconductor shortage and mitigating its impact on the automotive industry. These recommendations include increasing investment in semiconductor manufacturing capacity, diversifying supply chains, and improving supply chain visibility. They provide a detailed explanation of these recommendations and their potential benefits, as well as potential challenges and limitations.

3. Research Gap

Even though comprehensive research is present on the geopolitical conflict and situation of Taiwan and China, as well as the US-China conflict regarding semiconductors, there exists a deficit in the research on India’s progress in the field of semiconductors.

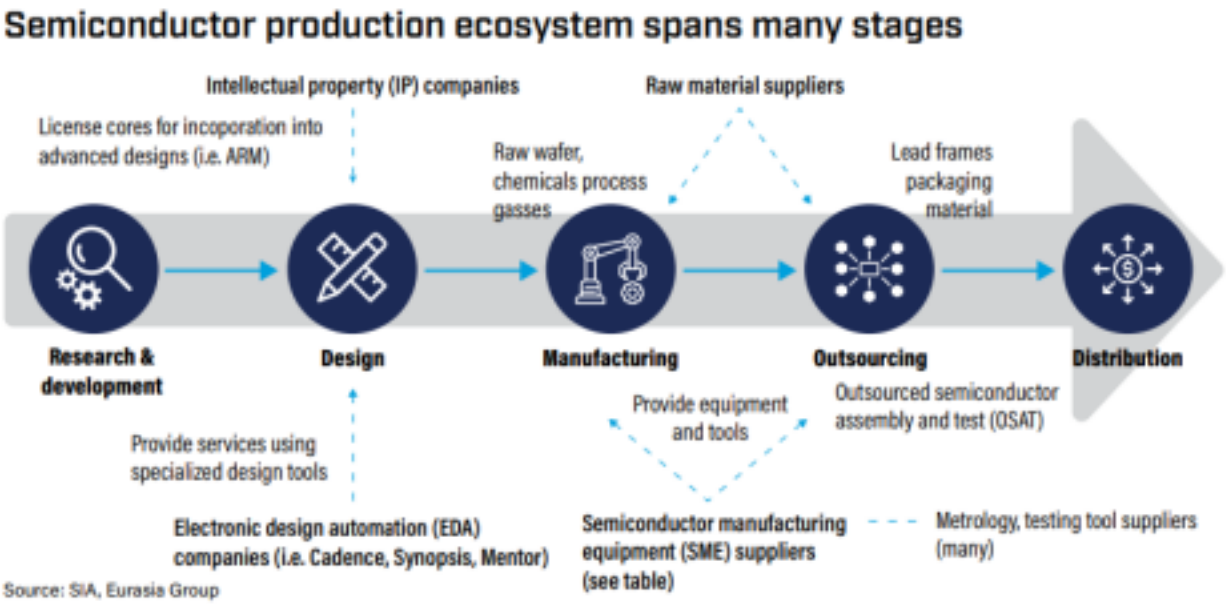


Fig2 Stages involved in the semiconductor industry

Semiconductor manufacturing consists of lots of stages as shown above in Fig.2, so research is needed into which path would be better for India. Can it invest in the complete supply chain with all levels to achieve "self-sufficiency" or should it be a part of the supply chain?

Need of the Study: It's important to understand the path for the semiconductor supply chain in India, as it will decide where the government should invest its time and resources.

Any collaboration with other countries (like QUAD) would require companies of both countries to find favorable business conditions and certain benefits and perks. So to enhance participation in Quad's supply chain, Does the Government of India provide the government initiative, tax benefits, and perks for such companies or not?

Need of the study: Since all the Quad countries follow free trade and a capitalistic form of economy, it is important to look at the profits for companies and government initiatives to ease the business as it demarcates the strength of India as well tells the feasibility of the partnership.

4. Research Objectives

a. What are the major challenges for the Quad initiative?

b. What are the measures taken by the Government of India for establishing semiconductor FABS in India?

5. Research Methodology

For the research question "What are the major challenges for the Quad initiative?", a qualitative research methodology would be appropriate. This could involve reviewing interviews with experts in the field, and analyzing government and policy documents. This will mostly be primary/raw data. We will also examine media reports to identify and analyze the major challenges facing the Quad initiative. A qualitative approach would allow for a deeper understanding of the complex issues and dynamics at play in the Quad initiative, and provide insights into how the partnership could be strengthened to achieve its objectives. This would involve the collection and analysis of secondary data.

For the research question "What are the measures taken by the Government of India for establishing semiconductor FABS in India?", a mixed-methods research methodology would be appropriate. This would involve collecting both quantitative and qualitative data through surveys, interviews, and analysis of government and industry reports to identify and analyze the measures taken by the Indian government to establish semiconductor FABS in India. This would largely be primary data and is an extension of the first question. Secondary data for this would involve case studies of companies that have started setting up parts of production in India.

6. Discussion

a. Challenges to be faced by the Quad Initiative

As mentioned above, in different stages of manufacturing, QUAD has four countries that are planning to specialize in specific aspects of the semiconductor supply chain. This involves the USA taking charge of the research and development of semiconductor designs, Japan being responsible for materials manufacturing, which involves silicon wafers and the etching process, Australia responsible for Raw materials, and India being responsible for human capital. This was discussed in the QUAD meeting in September 2021. Of this, Japan and USA already have expertise in their respective domains since they were part of the supply chain from the very beginning of semiconductors. But for new players like India and Australia, a lot of challenges emerge in different formats. Since the semiconductor supply chain involves different stages and each stage is heavily reliant on the other, even minute mistakes can cause losses worth millions of dollars. This is why any problem faced by a single country in this aspired supply chain can put the entire chain in danger.

Here are some of the major challenges that are faced by QUAD and largely India in setting up a Semiconductor supply chain:-

1. Trust Issues

In the past, the US has been extremely reluctant to share any piece of patented information with any country, However, the AUKUS defense alliance has shown that the

US is now shifting to a global manufacturing stage, But still, when it comes to manufacturing of chips in India, it is largely presumed that India will be with tail-end design chips in this supply chain Until US agrees to share the technology for higher-end chips, for which it has been extremely reluctant in the past.

Suggestive Actions: India needs to capitalize on the present tensions between USA and China, as the need for a robust semiconductor supply chain is more immediate, specially after covid exposed its bottlenecks, the US needs an alternative to chinese assembly setup as much as India, and now can be good time to start sharing technology as India and US relations tend to be better than ever before.

2. Red Tape / Lack of Facilities

This is India's third attempt in past two decades to attract foreign companies or countries to set up factories in India for semiconductor manufacturing. However, Due to tedious and very slow-paced bureaucracy, many companies in the past have been reluctant to set up factories in India. This was also the reason why India failed to attract investors in 2007, 2013, and 2018. The FABS also requires a very clean environment, with temperature control and electricity control. In the past, many companies have faced electricity supply errors leading to companies having to establish their supply lines, adding to the already expensive initial cost of a semiconductor Supply chain.

Suggestive Actions : Covered in the second research objective in more depth. **3. Lack Of Incentives**

Moreover, the number of incentives that the Indian government is almost nothing in a semiconductor supply chain compared to its competitors (see fig3). Below is a graph showing the amount of money invested by different countries to attract foreign companies. However, unlike its competitors in South Korea, Vietnam, or other East Asian countries, India has an untapped potential in terms of human capital.

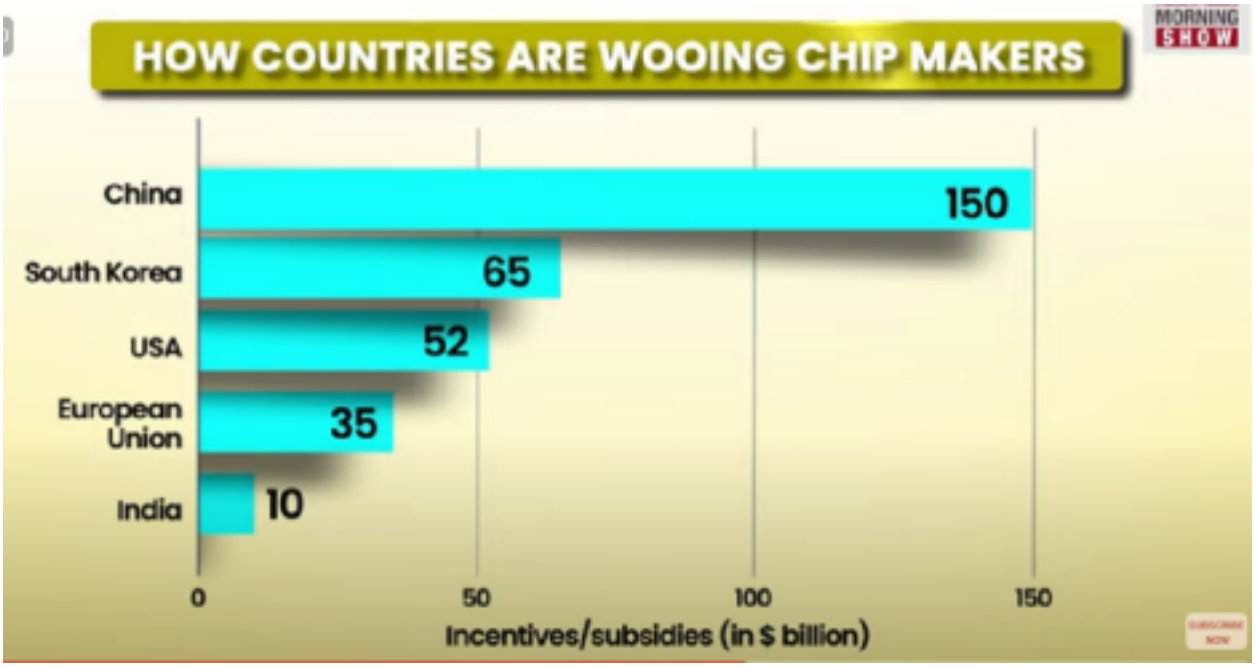


Fig3 Money spent by different countries to attract companies to set up factories in semiconductor supply chain.

Suggestive Actions: Based on the above findings, The statements of experts such as the chair of Vedanta, Anil Agarwal, Raghuram Rajan, and Christopher Miller, a professor, seem to be a step in the right direction. We believe that it is best that the $10 billion should be used in enhancing India's Assembly line setup instead of trying to go for a complete indigenous development or trying to compete with Japan or China or Dutch in their fields of Monopoly. This argument is also supported by the fact that China had spent a lot of its money on mushroom companies that couldn't provide the results but ended up consuming government resources and China even with 15 times India's investment, couldn't achieve the indignity it aspired and is still far from it. Thus, India should invest to enhance something that it already knows (i.e, ATMP[4]) and teach people how to design Chips down the line for indignity if required. But in the current situation, No country has the resources to domesticate a semiconductor supply chain and thus India should focus more on ATMP and training future generations of semiconductor design.

4. Environmental challenges

For Both Australia, which is going to mine a lot of these minerals, as well as India, the setup of the semiconductor supply chain poses a major threat to the environment. While Mining alone creates a lot of pollution, the ATMP setup requires large amounts of pure water to even function. So the Environmental impact of these new factories is also a challenge that Indian Government has yet to answer.

Suggestive Actions: While environmental challenges and pollution of water remains a concern for all supply chains, attempts should be made to build these new factories across expandable and renewable power supplies, as its not a s

(ii) Measures taken by the government to establish FABS in India

The Indian government has implemented several policies and tax benefits to promote the growth of the semiconductor industry in India. The policies aim to incentivize domestic manufacturing of semiconductors, reduce import dependence, and provide infrastructure and financial support to semiconductor companies.

One such policy is the establishment of Special Economic Zones (SEZs) that offer tax benefits such as duty-free import of goods and equipment, income tax exemptions for a certain period, and exemption from excise and customs duties. The government has also launched the Production Linked Incentive (PLI) Scheme, which provides incentives to companies on incremental sales over the base year, subject to meeting certain investment and production targets.

The Modified Special Incentive Package Scheme (M-SIPS) provides financial incentives to semiconductor companies for setting up manufacturing units in India, including capital subsidies and reimbursement of countervailing duty or excise duty for capital equipment. The Electronics Manufacturing Clusters (EMCs) scheme provides infrastructure and logistics support to electronics manufacturing units, including semiconductor companies.

The Indian government also provides several tax incentives to the semiconductor industry, including income tax exemption for the first five years of operation and a 50% reduction in income tax for the next five years. The government also provides investment-linked tax

[4] ATMP -assembly, testing, marking, and packaging

incentives, which allow semiconductor companies to claim a deduction of 15% of the total investment made in a year.

These policies and tax benefits are a step in the right direction to promote the growth of the semiconductor industry in India. However, there is a need for a more comprehensive and targeted policy approach to address the challenges faced by the Indian semiconductor industry and further, promote its growth.

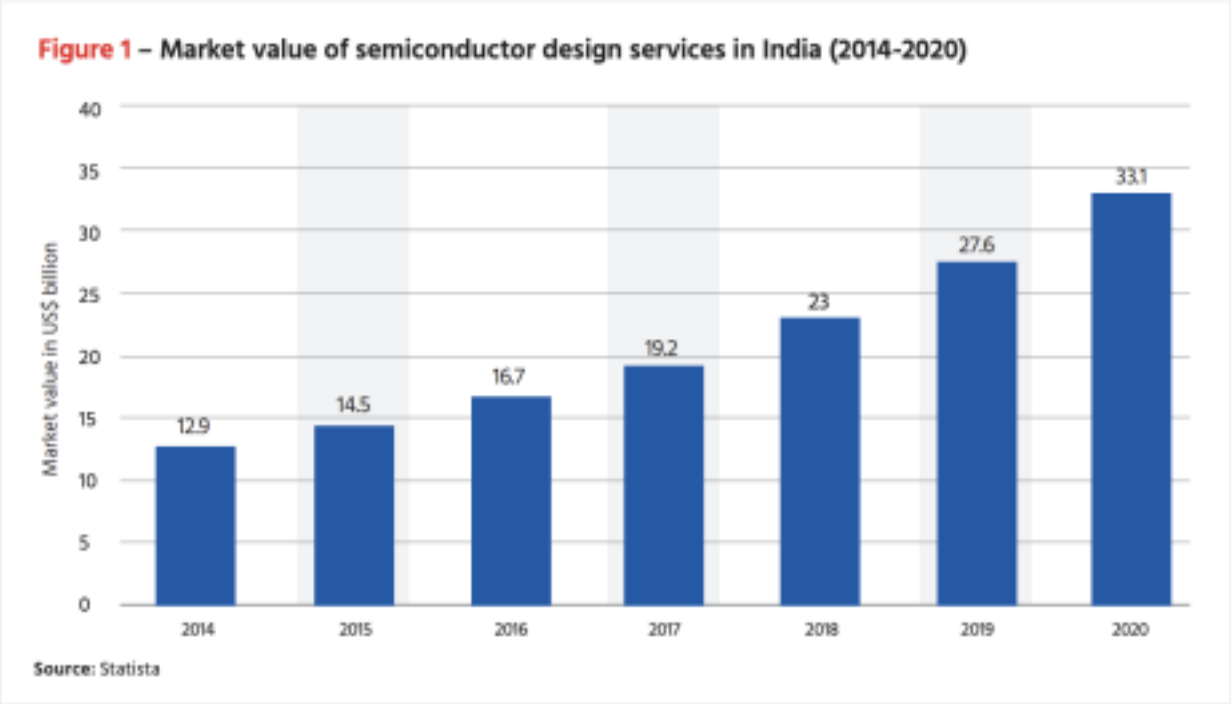


Fig4 Market value of semiconductor design services in India

In conclusion, the Indian government has taken several steps to incentivize the growth of the semiconductor industry in India. These policies and tax benefits aim to reduce import dependence, promote domestic manufacturing, and provide infrastructure and financial support to semiconductor companies. However, further policy measures may be necessary to address the challenges faced by the industry and achieve sustained growth.

While these measures have been effective in encouraging investment and domestic manufacturing, they have not yet led to the establishment of semiconductor fabs in India.

The lack of fabs in India remains a significant challenge for the growth of the semiconductor industry in the country. The cost of establishing fabs is high, and India lacks the necessary infrastructure and skilled workforce. Additionally, the global semiconductor industry is dominated by a few major players, making it difficult for new entrants to establish themselves.

Despite these challenges, the Indian government's policies and tax incentives have played a crucial role in promoting the growth of the semiconductor industry in India. With continued support and targeted policy measures, the Indian semiconductor industry has the potential to become a significant player in the global market.

India's efforts to establish itself as a major player in the semiconductor industry have been ongoing and the government has taken several measures to encourage the establishment of semiconductor fabs in the country. One example of a successful partnership between an Indian

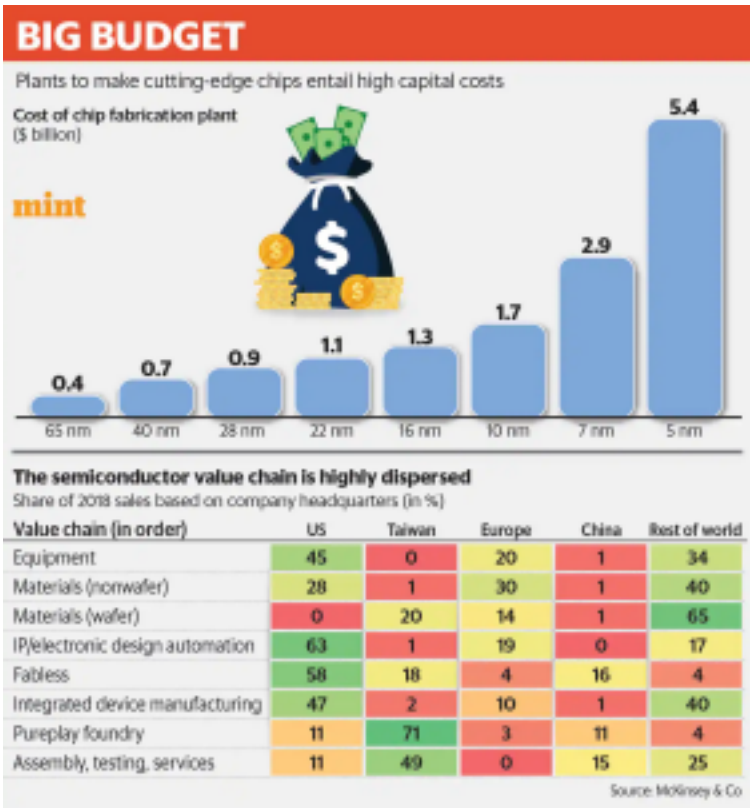
and foreign company in the semiconductor industry is the joint venture between Vedanta and Foxconn. Vedanta is a multinational mining company that leverages its expertise in mining and refining minerals to establish a robust semiconductor supply chain in India, while Foxconn provides expertise in electronics manufacturing. This joint venture was announced in 2020, and it aims to produce electronic products, including semiconductor chips, in India.

Fig5 Signing event between Vedanta and government of Gujarat.

However, setting up and operating semiconductor fabs in India poses significant challenges for both Indian and foreign companies. One of the primary challenges is the lack of infrastructure, including reliable power supply and transportation networks. The high cost of setting up semiconductor fabs in India is also a major challenge. The regulatory environment in India is complex and can be a hurdle for companies to navigate. These challenges were evident in the joint venture between Intel and the Indian government-owned company Semiconductor Complex Limited (SCL). The partnership was aimed at establishing a semiconductor fabrication facility in India but faced significant challenges and was eventually terminated in 2014. One of the main challenges was the lack of infrastructure, particularly in terms of power supply and transportation networks.

To address these challenges, the Indian government has taken several measures. In 2020, the government announced a $6.6 billion incentive package to encourage companies to set up semiconductor fabs in India. The package includes financial incentives such as subsidies and tax exemptions, as well as the provision of land and infrastructure at discounted rates. The government has also launched the Electronics Manufacturing Cluster (EMC) scheme, which aims to provide infrastructure such as power supply, water, and road connectivity to electronics manufacturing clusters across the country.

Another example of a successful partnership in the semiconductor industry is the collaboration between Applied Materials and the Indian Institute of Technology Bombay (IIT Bombay). Applied Materials, a leading supplier of equipment and services to the semiconductor industry, partnered with IIT Bombay in 2013 to establish a joint research lab focused on developing advanced technologies for the semiconductor industry. The lab has produced significant research outcomes and has been successful in attracting talent and investment to India's semiconductor industry.



Value chain (in order)	US	Taiwan	Europe	China	Rest of world
Equipment	45	0	20	1	34
Materials (nonwafer)	28	1	30	1	40
Materials (wafer)	0	20	14	1	65
IP/electronic design automation	63	1	19	0	17
Fabless	58	18	4	16	4
Integrated device manufacturing	47	2	10	1	40
Pureplay foundry	11	71	3	11	4
Assembly, testing, services	11	49	0	15	25

Fig6 Cost of chip fabrication plant versus feature size.

Result

In conclusion, India's efforts to establish a semiconductor industry are ongoing, and partnerships between Indian and foreign companies play a crucial role in achieving this goal. The joint venture between Vedanta and Foxconn demonstrates the potential of such partnerships, leveraging the strengths of each partner to establish a robust semiconductor supply chain in India. By addressing challenges such as lack of infrastructure, high costs, and regulatory hurdles and promoting partnerships between Indian and foreign companies, India can establish a strong semiconductor industry that can compete with other major players in the global market. The government's initiatives such as the incentive package and EMC scheme are steps in the right direction to overcome these challenges and make India an attractive destination for semiconductor fabs.

7. Conclusion

In conclusion, this paper highlights the need for research into India's progress in the field of semiconductors, particularly in the context of the Quad initiative. The paper identifies the major challenges faced by India in establishing a semiconductor supply chain, including trust issues, red tape, lack of facilities and incentives, and environmental challenges. The research methodology proposed includes a mixed-methods approach to analyze the measures taken by the Indian government to establish semiconductor FABS in India and a qualitative approach to identify the major challenges facing the Quad initiative. The findings suggest that India has significant untapped potential in terms of human capital, but also faces significant challenges in establishing a semiconductor supply chain. Addressing these challenges will be critical for India to become a major player in the global semiconductor industry and to enhance its participation in the Quad's supply chain.

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