JAPAN-SOUTH KOREA TRADE WAR AND ITS IMPLICATIONS ON INTERNATIONAL TRADE OF SEMICONDUCTORS

A Dissertation submitted to the National University of Advanced Legal Studies, Kochi in partial fulfilment of the requirements for the award of LL.M Degree in International Trade Law

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DECLARATION

I, declare that this dissertation titled '**Japan-South Korea Trade War and Its Implications On International Trade of Semiconductors**' researched and submitted by me to The National University of Advanced Legal Studies in partial fulfilment of the requirement for the award of the Degree of Master of Laws in International Trade Law, under the guidance and supervision of Asst. Prof. Hari S. Nayar, is an original, bonafide and legitimate work. It has been pursued academic interest. This work or any type thereof has not been submitted by me or anyone else for the award of another degree of either this University or any other university.

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CERTIFICATION

This is to certify that Ms. SRUTHI P ANAND, REG NO: LM0220018 has submitted her Dissertation titled, '**Japan-South Korea Trade War and Its Implications On International Trade of Semiconductors'**, in partial fulfilment of the requirement for the award of Degree of Masters of Laws in International Trade Law to the National University of Advanced Legal Studies, Kochi under my guidance and supervision. It is also affirmed that the dissertation submitted by her is original, bona fide and genuine.

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LIST OF ABBREVIATIONS

A*STAR - Agency for Science, Technology and Research

AI – Artificial Intelligence

ASML – Abstract State Machine Language

ATMP – Assembly, Testing, Marking and Packaging

CAGR – Compound Annual Growth Rate

CO_2 – Carbon Dioxide

COCOM - Coordination Committee for Multilateral Export Controls

DAO – Discrete, Analog and Other

DPP - Draft Defence Procurement

DRAM – Dynamic Random Access Memory

EDA – Electronic Device Automation

EMC – Electronic Manufacturing Clusters

ESDM – Electronics System Design and Manufacturing

EUV – Extreme Ultraviolet Lithography

FDI – Foreign Direct Investment

FTA – Free Trade Agreement

GATT – General Agreement on Trade & Tariff

GDP – Gross Domestic Product

GPS - Geo positioning by satellites

GSC – Global Supply Chain

GSOMIA - General Security of Military Information Agreement

GST – Goods & Services Tax

IC – Integrated Circuit

IDM – Integrated Device Manufacturer

IESA - India Electronics and Semiconductor Association

IMEC - Interuniversity Microelectronics Centre

IP – Intellectual Property

ITA – Information Technology Agreement

JSR – Japan Synthetic Rubber

LCD – Liquid Crystal Display

LED – Light Emitting Diode

MNC – Multi-national Company

MOTIE – Ministry of Trade, Industry and Energy

MSIPS - Modified Special Incentive Package Scheme

NAND – NOT AND (a Boolean operator and logic gate)

NITI Ayog – National Institution for Transforming India

ODA - Official Development Assistance

OECD – Organisation for Economic Cooperation and Development

OEM – Original Equipment Manufacturer

OSAT – Outsourced semiconductor assembly and test

PC – Personal Computer

PLI – Production Linked Incentive

R&D – Research & Development

SCM – Subsidies and Countervailing Measures

SCPA – Semiconductor Chip Protection Act

TRIPS – Trade Related Aspects of Intellectual Property Rights

TSMC – Taiwan Semiconductor Manufacturing Company

UNCTAD – United Nations Conference on Trade and Development

UV – Ultraviolet

WTO – World Trade Organisation

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CHAPTER - 1

INTRODUCTION

1.1: BACKGROUND AND INTRODUCTION

Technology is taking over all areas of human life. With the recent proliferation of disruptive technology like Artificial intelligence, technology is advancing and older technologies are becoming obsolete within a negligible span of time. Semiconductors are the foundation of all technological devices. It is the semiconductor chips that are used to store and transfer data. Semiconductors have also gained strategical importance as it is slowly gaining primacy in global warfare and defence. The demand for semiconductors is spread across various fields. It is inevitable in almost all domains of human life be it economic, financial, healthcare, entertainment, tourism etc. Semiconductor chips are produced after a catena of complex scientific procedures. It takes years of research, huge capital and microscopic perfection to create the tiny chip that we see in almost all electronic devices.

A semiconductor is a tiny electronic device composed of elemental compounds with electrical properties (both insulators and conductors) that stores data, processes the same and performs analytical and logic operations which is the functional basis for information and communication technology.[1] From production to supply, semiconductor goods travel across multiple borders to finally reach the hands of its consumers. These chains of activities that take place at different parts of the world constitute the global supply chain (GSC) of semiconductors. At every stop in the supply chain, value addition takes place. Value addition includes the various stages from production to supply till it reaches the end consumer. Various countries have specialised in various activities of semiconductor manufacture. For instance, Taiwan dominates the supply chain in manufacture whereas many USA companies have specialised in semiconductor chip designing.

Japan and South Korea hold substantial share in the semiconductor supply chain. Both countries have specialised in areas where they enjoy comparative advantage. Being neighbours, the economies of both countries are interconnected. Both countries are dependent on each other for goods and services. Coming to the domain of semiconductor trade, both

[1] Measuring distortions in international markets The semiconductor value chain, (2019), https://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=TAD/TC(2019)9/FINAL&docLanguage=En.

countries contribute substantially to each other's economies through raw materials and equipment supply. South Korea is one among the world's largest producer of semiconductors and a huge quantity of chemicals for its production is imported by South Korea from Japan. South Korea, Japan, China and Taiwan are the big 4 Asian players in the global semiconductor market. Nearly 60% of the global semiconductor sales take place in Asia Pacific.[2] The major South Korean semiconductor manufacturers include Samsung and SK Hynx. Japan dominates the market using high end technology for manufacturing of pure elements which serve as raw materials for semiconductor industry. The semiconductor supply chain is nourished by the value additions made across borders by Japan and South Korea.[3] Hence it is an inevitable fact that any conflict between these two nations will surely reflect in the global semiconductor value chain. It will have an impact on the world's technology trade as well.

Japan and South Korea share a history complicated by colonisation of Korean peninsula by Japan before and during World Wars. The Korean population was exploited by Japanese imperial military for slavery, forced prostitution and forced labour. It was only in 1965 that both the countries entered into normalization treaty adhering to which Japan paid compensations to the victims of Japanese colonial rule. But the conflict was not resolved fully and it took a different shape in years to come. Down the line from 1965, occasional dialogues between both the countries started adversely affecting the international trade regime. This was primarily because there was a sudden but planned growth in the economies of Japan and South Korea. Presently their economies are ranked 3rd and 12th largest economies in the world.[4] Their economies house many of the world's tech giants.

The trade war between Japan and South Korea is a result of many historical, political and economic causes. There has always been a latent competition between both the economies which is also influenced by the historical reasons. The South Korean politicians and governments often use the anti-Japanese sentiments of Korean people for their political gains in the South Korean democracy. Keeping the political causes aside, weaponisation of international trade for political as well as economic dominance over a particular region or

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[2] Rise of the "Big 4" The semiconductor industry in Asia Pacific, (2020), https://www2.deloitte.com/content/dam/Deloitte/cn/Documents/technology-media-telecommunications/cn-tmt-rise-of-the-big-4-en-082820.pdf.

[3] *Id.*

[4] CALEB SILVER, *Investopedia*, THE TOP 25 ECONOMIES IN THE WORLD , https://www.investopedia.com/insights/worlds-top-economies/.

country is a substantial issue discussed in the dissertation. When the production of critical goods is vested in the hands of a few dominant cum developed countries, they hold superior power over the countries which lack production capacity. Hence by controlling or restricting the supply of essential goods or by threatening to do the same, dominant countries can control even the sovereign authorities of weaker nations.

In the case of Japan-South Korea trade war, Japan could be seen as enjoying economic superiority over South Korea. That is why Japan was able to shake the stable semiconductor industry of South Korea by restricting the export of three critical chemicals to South Korea. On a deeper analysis of the economy and developmental plans of South Korea, it can be understood that South Korea has been taking both express and latent measures to reduce its trade dependence on Japan since its independence. Hence, even though the Japan-South Korea trade war had adverse effects on both the economies, the economic loss caused as a result of the trade war is negligent when compared to what could have been the loss if South Korea was fully dependent on Japan for all critical chemicals.

USA dominates the areas of chip design and production in the global semiconductor supply chain. Many US headquartered firms have entered into outbound semiconductor deals with firms located in Japan and South Korea to manufacture their designs. Both Japan and South Korea are close allies of USA whereby USA is able to build a bulwark against the dominance of China and North Korea in the Asian region as well. Realising the importance of controlling the disputes between Japan and South Korea, in 2015, President Barack Obama of USA pressurized both the countries to enter into a final settlement. But in 2017, the then president of South Korea invalidated the settlement demanding further negotiations. But Japan denied the claims of South Korea stating that the claims were already settled. The matter became worse when the Supreme Court of South Korea made a decision that ordered several Japanese companies, including Mitsubishi Heavy Industries to make compensations to the families of South Koreans who were ill-treated and forced to work in their factories during World War II. Non-payment from the part of the Japanese companies led to seizure of shares held by these companies in their joint ventures with South Korean companies. Japan retaliated by removing the name of South Korea from the 'White list' of trading partners. Japan also came up with norms that adversely affected smooth trade between these two nations. Rather than analysing the effects of trade war on both the economies, the study tries to find out the general effects of such trade war on the supply chain of critical goods. In the case of Japan-South Korea trade war, the effects of trade war on the semiconductor GSC are studied. The peculiarity of the semiconductor GSC is studied. Afterwards, a detailed analysis of the cause of the trade war is conducted. The peculiar features of the GSC and the causes of the trade war are studies in detail to frame solutions for the adverse effects of trade war. The prospective solutions include de-concentration of the trade war by introducing new players into the supply chain. The opportunities available for India who doesn't have its own semiconductor production plant are looked over. After delineating the opportunities for India in the semiconductor GSC, the steps which need to be taken by India to take advantage of the opportunities are discussed.

1.2: STATEMENT OF PROBLEM

Twenty first century is called the era of technology. Semiconductors play an inevitable role in all the advanced information and communication technologies. With its increased propensity to act both as insulator (at room temperature) and conductor (controlled conductivity on doping), it has become a major determinant of the speed and efficiency of microprocessors or chips. They are most commonly used in flat panel displays (computer, mobile phones etc), LEDs, Digital cameras, Diode lasers, GPS (Geo positioning by satellites), optical storage etc.[5] Provided the wide variety of uses of semiconductors, it is clear that all the major market players have invested intensively in the R&D and hence semiconductor industry has become the most R&D-intensive industry in the international market.[6] Japan and South Korea together hold approximately 25% of the global semiconductor revenue.[7] The production of semiconductors is a continuous process taking place cross borders with resource sharing and technical contributions by market players mainly concentrated in East Asia. The emergence of the trade war between these two nations has tempted them to move ahead with friction without having a balance in trade relations. As both these nations are looking for alternate trade partners and other viable means of overcoming the dependence on each other for resource sharing, new trade opportunities are created for countries which have not yet carved a niche for themselves in the global semiconductor supply chain.

Trade wars have become common in this era of trade liberalisation. Weaponisation of trade for political gains affects the normal life of people when trade of essential goods are involved. Even though WTO and GATT have put forth norms to control/eliminate trade

[5] Md. Atikur Rahman, *A Review on Semiconductors Including Applications and Temperature Effects in Semiconductors*, AM. SCI. RES. J. ENG. TECHNOL. SCI. ASRJETS, https://core.ac.uk/download/pdf/235049651.pdf.
[6] Measuring distortions in international markets The semiconductor value chain, *supra* note 1.
[7] Rise of the "Big 4" The semiconductor industry in Asia Pacific, *supra* note 2.

restricting practices, countries still undertake such practices for political and economic benefits. Critical goods like semiconductor materials and other technological products are associated with national strategy and security as well. Hence countries compete to dominate the areas involving technologies. As free trade and economic growth are projected as merits of globalisation, increased economic competition between nations should be perceived as a demerit of globalisation. Trade wars result from competition between dominant nations in the supply chain to distort the trade of rival/target nation. Controlling economies through trade is often interpreted as neo-colonialism by scholars. Dominance thrives where there is power disparity. Power disparity is caused by economic factors. These economic factors include capital to undertake production, availability of resources and the like. Disparity between nations in these economic factors is caused by trade. That is, since the wake of globalisation, trade has been promoting competition over cooperation owing to dumping, trade wars and other trade distorting practices. The study analyses the impacts of the trade war on the semiconductor GSC along with a brief discussion of the general economic effects of trade war on trade. The peculiarity of the semiconductor supply chain is its regional specialisation. The pros and cons of the same is explained elaborately to understand the nature of the semiconductor GSC inorder to frame measures to curb future trade wars also.

The study aims to understand the relevance and nitty-gritty of global semiconductor trade. The trade relations between Japan and South Korea are studied and the causes and consequences of the trade war are explored. The new trade opportunities created as a result of the trade war are analysed. Based on the findings, a framework could be developed on how India could exploit the opportunities in the supply chain to penetrate the global semiconductor market.

1.3: RESEARCH OBJECTIVES

The study attempts to identify the causes of the Japan-South Korea trade war, it's implications on global semiconductor supply chain, and how India could use the lessons learnt from the trade war to emerge as a leading player in the global trade of semiconductors.

1.4: HYPOTHESIS

With increase in friction and reduced cooperation between Japan and South Korea, developing countries like India which have unexploited labour potential and rare earth resources can take up the role of a prominent contributor in the global semiconductor supply chain.

1.5: METHODOLOGY

The methodology employed in this research is purely doctrinal.

1.6: RESEARCH QUESTIONS

1. What is the relevance of semiconductors in global trade of 21st century?
2. What are the peculiarities of the global semiconductor supply chain?
3. What are the causes of Japan-South Korea trade war?
4. What are the effects of the Japan-South Korea trade war on global semiconductor supply chain?
5. What are the measures that could be adopted to reduce the effects of trade war on global supply chains (w.r.t semiconductor GSC) ?
6. What are the new global trade opportunities evolved out of Japan-South Korea trade war for countries like India that still remains as a consumer nation in the supply chain?

1.7: OUTLINE OF CHAPTERS

I. INTRODUCTION

This chapter shall provide a brief introduction to the area of study, its relevance and significance, the research problem, research questions, and literature review conducted concerning this research.

II. ANALYSIS OF INTERNATIONAL TRADE OF SEMICONDUCTORS AND THE GLOBAL VALUE CHAIN

This chapter covers a detailed study of the characteristics of international semiconductor supply chain and its key players. History of semiconductors beginning from the invention of point-contact transistor and the general process of semiconductor manufacture is also covered in this chapter. The various business models existing in the GSC is discussed in detail. The effects of trade liberalisation on the global semiconductor are critically analysed.

III. HISTORICAL OVERVIEW OF JAPAN – SOUTH KOREA TRADE RELATIONS

The colonial history shared by Japan and South Korea is expounded in this chapter. A comprehensive study of the market situation, trade relations of both the nations and influence of Japanese colonial rule over South Korea's economy are undertaken. The effects of globalisation on Japan-South Korea relations are critically analysed.

IV. JAPAN-SOUTH KOREA TRADE WAR AND THE NEW GLOBAL TRADE OPPORTUNITIES

The causes of the Japan-South Korea trade war are delineated in this chapter. The effects of the trade war on the GSC of semiconductors are described in this chapter. A brief note on the political tug of war related to the trade war is also included.

V. INDIA IN INTERNATIONAL TRADE REGIME OF COMMUNICATION ELECTRONICS AND SEMICONDUCTOR SUPPLY CHAIN

The chapter includes a comprehensive study of the various trends in India's semiconductor and electronics industry. The recent government policies that aim to give thrust to semiconductor industry in India is covered in this chapter. The various changes that need to be brought about in the Indian economy so that it could strengthen its semiconductor industry are also discussed in this chapter.

VI. FINDINGS, SUGGESTIONS AND CONCLUSION

This chapter contains the major findings of the Researcher. Also provides some relevant suggestions to tackle the identified issues. It also discusses the various steps that should be adopted by India to boost domestic semiconductor production.

1.8: LITERATURE REVIEW

In the article titled “Weaponized Interdependence: How Global Economic Networks Shape State Coercion”, Henry Farell and Abraham L. Newman discusses about how dominant nations weaponise trade interdependence for strategic advantage. It also discusses how countries could use structural advantages and chokepoint effect to dominate certain areas through coercive means. The various dimensions of how state power is affected by globalisation could be understood from this article. According to the authors, power assymetries are created by complex interdependence which is an aftermath of globalisation. Weaponised interdependence is analysed by focussing on United States, its dominance in the international regime and its foreign relations.

In the article “Can memories of the Japan-Korea dispute on “Comfort Women” resolve the issue”, Gabriel Jonsson discusses about the unresolved issue of comfort women between Japan and South Korea. The atrocities suffered by Korean women under the Japanese imperial rule were brutal. Till date, Japan has not tendered an official apology as well as the legal responsibility of the issue still remains as a question. Even though many attempts of resolutions, negotiations and treaties took place, the chance for a comprehensive and conclusive solution involving all the stakeholders seems bleak. The comfort women and forced labour issues are the main reason for persistence of anti-Japanese sentiments among the local Koreans. The recent Japan-South Korea trade war is also influenced by the unresolved issues of their colonial past.

“Strengthening the Global Semiconductor Supply Chain in an uncertain era” is a comprehensive report that contains a detailed study of the international semiconductor industry and its trends. Authored by Antonio Varas, Raj Varadarajan, Jimmy Goodrich, Falan Yinug, the report critically analyses the various trends in the supply chain and the risks associated with it. It also extrapolates the growth of the semiconductor industry along with providing relevant statistical data on the same. The issues faced by the stakeholders in the supply chain are explained in detail in the article. The authors also gave suggestions for strengthening the global semiconductor supply chain in order to satisfy the consumer markets spread across the globe.

The OECD Trade Policy Paper No.234 titled “Measuring distortions in international markets: The semiconductor value chain” gives a detailed idea about the functioning of the semiconductor industry. From R&D to commercialisation of product, the complete list of activities involved in the manufacture of semiconductor chips is explained in detail in the OECD report. Importance of technology transfer in semiconductor industry and how the new entrants could jump right into upgraded technology by skipping older methods of production are expounded in this paper. No domestic semiconductor industry can grow in the supply chain without adequate government funds. The importance of government funds and subsidies and the role it plays in building the infrastructure necessary for semiconductor manufacture are also highlighted in the paper.

In the article titled "The evolution of business models in a disrupted value chain", Ulrich Naeher, Sakae Suzuki and Bill Wiseman discusses about the various business models persisting in the global semiconductor supply chain. These business models include IDM, fablite design firms, foundries or fabs and OSATs. The trends in the growth of these business models are analysed in this article. The authors opined that IDMs have grown below the industry average whereas foundries and design firms have grown above the same. The article also discusses how outsourcing has led to diversification and consequential specialisation in the supply chain. It also points out various reasons associated with outsourcing that have led to the tremendous growth of the supply chain. According to the authors, increasing capital productivity through careful planning and execution of investments has led to consistent value creation by the companies in the supply chain.

Leon Radomsky, in his article titled "Sixteen years after the passage of the U.S. Semiconductor chip protection act: Is international protection working?" explains how the SCPA Act being one of the first statutes dealing with chip piracy revolutionised the IP protection of semiconductor chips. The provisions of the Act are discussed in detail by the author. Sui generis kind of protection was the need of the hour when chip privacy thrived in the US semiconductor industry during its nascent stage. Many nations copied the SCPA Act while making their own legislations. The article analyses the effects of the Act on chip piracy and provides suggestions for further changes in the legal framework of USA to improve mask work protection.

The article "Japan-South Korea Economic Relations Grow Stronger in a Globalized Environment" is authored by Hidehiko Mukoyama who is Senior Economist at the Centre for Pacific Business Studies at Japan Research Institute. The author analyses the trade relations of South Korea and Japan from perspectives of both the nations. Major economic events in the shared history of both nations like the South Korea's trade deficit and Asian currency crisis are explained in the article to find out the basic nature of the trade relations between the nations. The author precisely portrayed the economic interdependence existing between the nations. The relevance of Economic Partnership Agreement in abridging the trade tensions between the two nations are highlight by the author.

The article "Japanese Colonialism and Korean Development: A Critique", co-authored by Stephan Haggard, David Kang and Chung-IN Moon aims to challenge the revisionist perspective of Japan's colonial rule benefitting South Korea. According to the authors, the revisionist glorified the Japanese imperial rule over Korea. Revisionist tried to depict growth of South Korean economy under Japanese colonial rule. The article statistically and factually proves that South Korean agricultural and human resource sectors were not given much attention during the colonial period. The Japanese bureaucracy exploited the Korean labour force and focused only on the growth of Korean industries like heavy industries which would benefit Japan in the long run. The article emphasises the adverse effects of colonialism on the colony's economy. The author also criticised the revisionists who analysed only a miniscule portion of the bigger picture of Japanese imperial rule to reach a conclusion which glorified Japan.

Atul Kohli in his article "Where do high growth political economies come from? The Japanese lineage of Korea's "Developmental state" demonstrates the effects of the three-state society of South Korea which evolved during the colonial period. The state of Korean economy and society under the Japanese rule is examined in the article. The success of the export-oriented policy adopted by South Korea post-independence is discussed by the author.

"Japan-South Korea's Rivalry: The Semiconductor Industry Instrumentalization and its Implication for the Future of Japan-South Korea Economic Interdependence" authored by Loïc dumas examines the causes behind the Japan-South Korea trade war. According to the author, Japan put restrictions on the export of critical chemicals to South Korea to coerce the nation for Japan's political gains. The article also highlights the decreasing dependence of South Korea over Japan for semiconductor raw materials which might adversely affect the export revenue earned by Japan. As South Korean partnership with Chinese mainland is growing, South Korea's trade war with Japan can turn into new opportunities for china to expand trade with South Korea.

CHAPTER - 2

ANALYSIS OF INTERNATIONAL TRADE OF SEMICONDUCTORS AND THE GLOBAL VALUE CHAIN

2.1. INTRODUCTION

Post World War II, the world nations began to focus on improving their economies through trade and foreign investments. Less importance was given to the fields of science and technology. Yet associations of researchers and communities of scholars in the United States pursued intense research to upgrade the invention of telephonic communication device by Graham bell. This led to the invention of transistors which revolutionised the mode of communication during the 1950s. The invention did not receive much hype, yet it had a profound impact on the area of communication technology. The journey which began from transistors saw various technological developments down the line which includes radio, television, communication satellites, internet, compact computers and mobile phones. It has now reached a point where Artificial intelligence has begun to create artificial intelligence.[8] The most fascinating fact is that the underlying idea which has made all these technological revolutions possible is the semiconductor devices. Semiconductors are elements like Silicon, Germanium, and Tin etc which contain single species of atoms. Semiconductor devices are mainly a combination of transistors, resistors and capacitors fabricated on a wafer made from pure semiconductor element mainly Silicon.[9]

Semiconductor industry is capital intensive in nature. A significant portion of this capital is expensed to meet the R&D requirements. This accounts to 22% of annual semiconductor sales to electronic device makers. Around 26% of the invested capital is used to meet the capital expenditure.[10] The R&D intensive nature and huge requirement of capital led to the specialisation of global semiconductor supply chain.[11] Specialisation in a supply chain means

[8] DOM GALEON, *FUTURISM*, GOOGLE'S ARTIFICIAL INTELLIGENCE BUILT AN AI THAT OUTPERFORMS ANY MADE BY HUMANS (2017), https://futurism.com/google-artificial-intelligence-built-ai.

[9] 5 RICHARD C. JAEGER, INTRODUCTION TO MICROELECTRONIC FABRICATION (2 ed.).

[10] ANTONIO VARAS et al., *STRENGTHENING THE GLOBAL SEMICONDUCTOR SUPPLY CHAIN IN AN UNCERTAIN ERA* (2021), https://www.semiconductors.org/strengthening-the-global-semiconductor-supply-chain-in-an-uncertain-era/.

[11] SAIF M KHAN, ALEXANDER MANN & DAHLIA PETERSON, *THE SEMICONDUCTOR SUPPLY CHAIN: ASSESSING NATIONAL COMPETITIVENESS* (2021), https://cset.georgetown.edu/wp-content/uploads/The-Semiconductor-Supply-Chain-Issue-Brief.pdf.

that different regions or geographic locations specialise in a particular activity according to comparative advantage.[12]

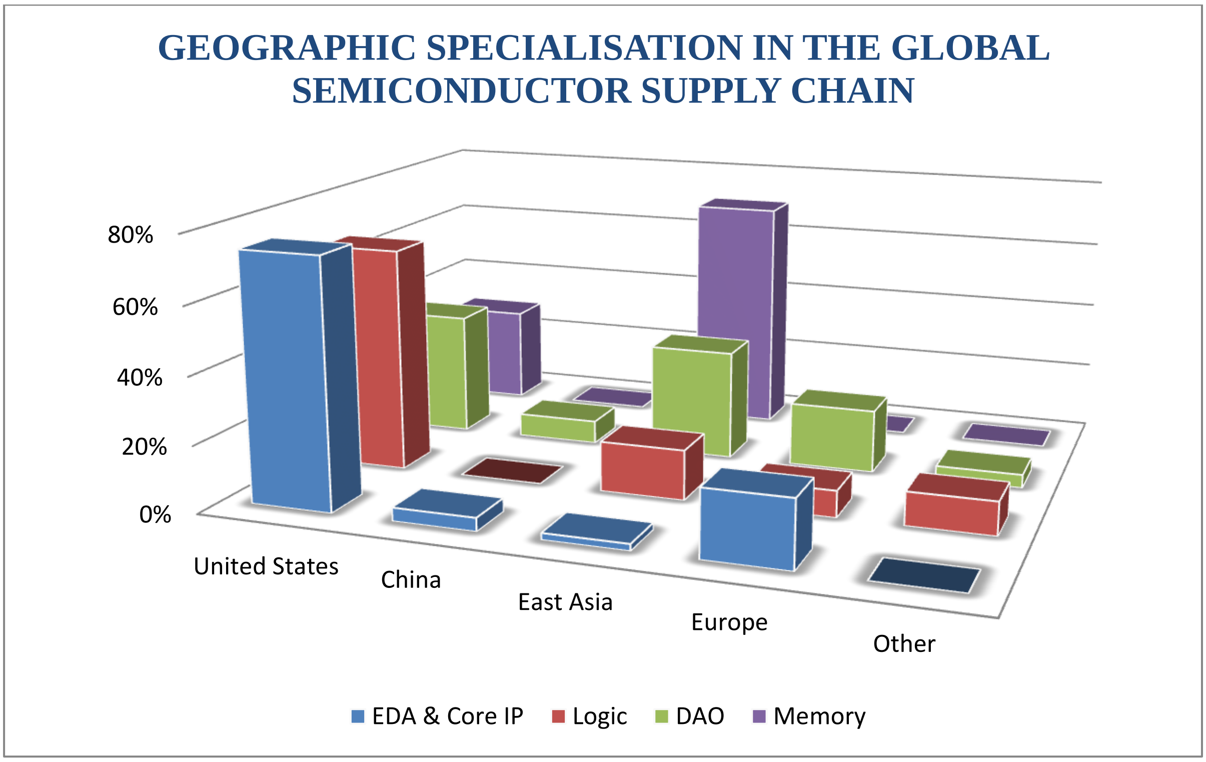

FIGURE 2.1[13]

[12] Id "The United States and its allies are global semiconductor supply chain leaders, while China lags. The U.S. semiconductor industry contributes 39 percent of the total value of the global semiconductor supply chain. U.S.- allied nations and regions—Japan, Europe (especially the Netherlands, the United Kingdom, and Germany), Taiwan, and South Korea—collectively contribute another 53 percent. Together, these countries and regions enjoy a competitive advantage in virtually every supply chain segment. While contributing only 6 percent, China is quickly developing capabilities across many segments and could attempt to reconfigure supply chains in its favor, impacting national and international security."

[13] VARAS et al., *supra* note 3.

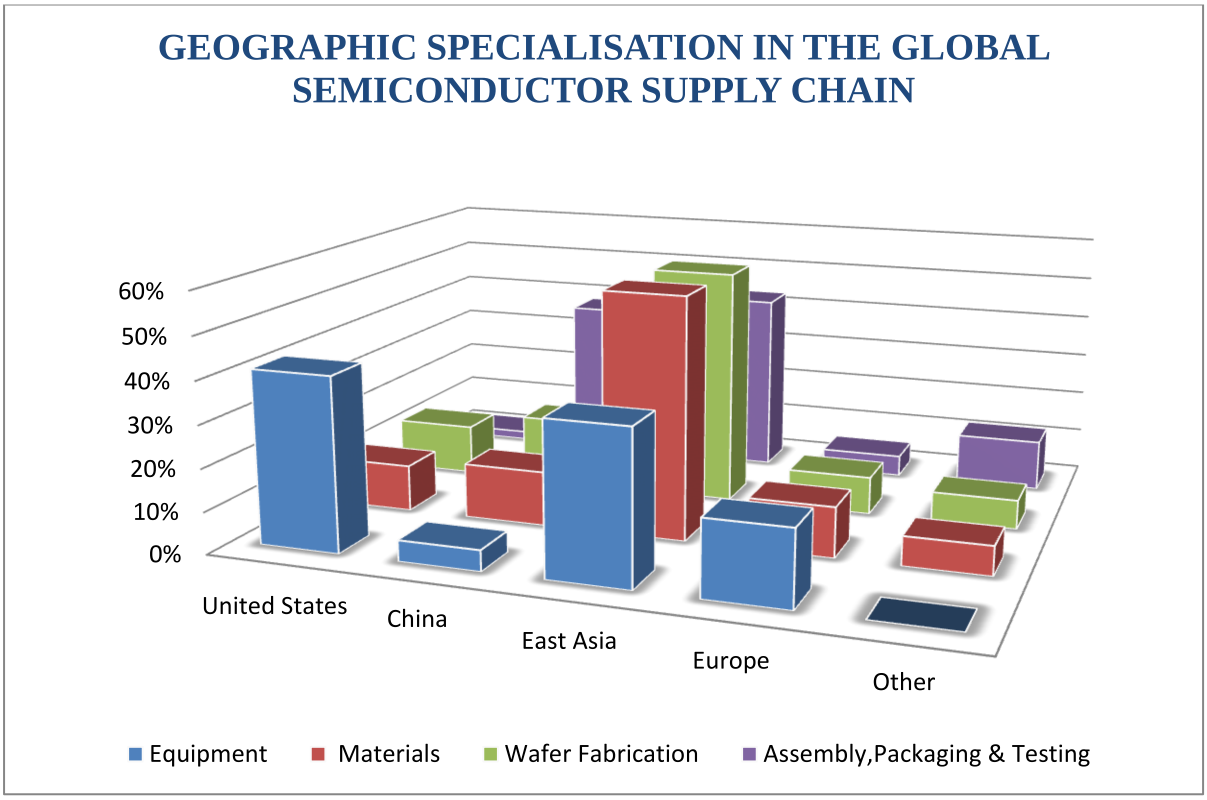

FIGURE 2.2[14]

From the statistics provided in Figure 1.1 and 1.2, it is clear that United States has enormously contributed to the development of the semiconductor technology and supply chain as we see it today. The core activities with tremendous contribution from US in the form of innovation, capital and infrastructure include Electronic Design Automation, core Intellectual property, Logic and manufacturing equipments. The major East Asian players in the semiconductor supply chain include Japan, South Korea, and Taiwan. East Asian players have an inevitable contribution in equipments manufacturing and production of semiconductors through the process of wafer fabrication combined with efficient and cost effective assembling, packaging and testing of inventory. China has an edge over other players in assembly and packaging. It is pertinent to note that the contribution of American firms are in the areas of innovation and chip design whereas the Asian region is more focused on the production of semiconductors and deployment of the products into the market. That is, through innovation the American firms are coming up with newer nuances of technological integration in semiconductors to meet the consumer demands. And these technological advancements in semiconductor devices like AI, 5G and the like are brought to

[14] *Id.*

the hands of the consumers by the manufacturing firms concentrated in the Asian region.[15] This seemingly complicated yet structurally efficient semiconductor supply chain is dependent on the free movement of goods and services cross borders. The regional specialisation within the supply chain is the main reason for cost effective supply of semiconductors all over the globe. This has led to the evolution of digital economy which is the drive behind the growth of artificial intelligence. Semiconductors are the roots which firmly hold technological advancements like smart phones, GPS, super computers, AI and the like which has revolutionised the way we live on the planet.

2.2. HISTORY OF SEMICONDUCTOR SUPPLY CHAIN

Seventy five years back, the world never would have imagined communicating to a person located antipode to the caller through video chat. Those communication technology advancements began with a single discovery; the discovery of semiconductor transistors that took place at Bell laboratories decades back. The invention of semiconductor transistor was preceded by the invention of solid-state transistor by Ferdinand Braun in 1874. The device was highly unstable due to its point contact based configuration. The development of quantum mechanism which opened the gate to in depth understanding of the electronic band structure and consequential properties of solid substances brought a new light to transistor technology. Solids were categorised as insulators, conductors and semi-conductors and detailed study of electronic structure of solids were undertook by scientist after the invention of electron microscope. Inefficiency of vacuum tubes and need for improvements in radar technology during World War II led to extended research in solid state rectifiers. In 1946, at Bell laboratories a team was organised under the leadership of Bill Shockley and Stanley Morgan. In 1947, the team developed a working transistor which was improved to a working point-contact transistor. The team patented their findings. From point contact, scientist Brattain painted metal strips over the semiconductor material (germanium) instead of conduction through electrolyte. This improved the device without altering tis configuration.

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[15] Nathan Associates Inc., *BEYOND BORDERS THE GLOBAL SEMICONDUCTOR VALUE CHAIN* (2016), https://www.semiconductors.org/wp-content/uploads/2018/06/SIA-Beyond-Borders-Report-FINAL-June-7.pdf. "The industry is uniquely structured to derive maximum benefit from the diverse and varied skills of human resources and locational advantages of participating countries. Canada, European countries, and the United States tend to specialize in semiconductor design, along with high-end manufacturing. Japan, the United States, and some European countries specialize in supplying equipment and raw materials. China, Taiwan, Malaysia and other Asian countries tend to specialize in manufacturing, assembling, testing and packaging. Canada, China, Germany, India, Israel, Singapore, South Korea, the United Kingdom, and the United States are all major hubs for semiconductor R&D. Major semiconductor companies have located facilities in countries as far flung as Costa Rica, Latvia, Mexico, South Africa, and Vietnam."

Scientist Shockley who was not part of this improvement was working in conductivity and amplification. He developed the theory of bipolar junction transistor. Later the whole team including Shockley successfully developed the npn junction transistor. Pure semiconductor crystals were needed to make such transistors. Hence the process of zone refining was developed by Bell labs. Germanium was melted to separate the impurities in the melt retrieving pure crystals. Silicon required higher temperature when compared to Germanium. Hence, pure silicon could not be obtained using this technique. A slight modification of the refining apparatus made purification of Silicon much easier leading to proliferation of Silicon over germanium as the semiconductor material in the transistor. Also, germanium was prone to becoming intrinsic at lower temperatures when compared to Silicon. Hence, silicon became the raw material for the production of chips in the global semiconductor industry.[16]

Gordon Teal, member of the team that invented npn junction transistor joined a research company which later became Texas Industries. He continued his research on transistors. Tokyo Tsushin Kogyo was the company formed in Japan by Masaru Ibuka and Akio Morita. They licensed transistor technology and began production of radio. They commercialised all-transistor radio which was one of the first successful commercialisation of transistors. The company was later renamed as Sony. Shockley broke up from Bell labs research team and started Shockley semiconductors which even though unsuccessful in its later journey led to the growth of Silicon Valley.[17]

Gordon Moore and Robert Noyce, who initially worked at Shockley semiconductors later went on to establish Fairchild Semiconductors and Intel. Texas Instruments developed mesa transistors. These transistors were used by Kilby of Texas instruments to develop integrated circuits. Fairchild Semiconductors made possible the thin film metal interconnection. Integrated circuits where vapour deposited metal connections were developed by Bob Noyce. Planar process for transistors was developed at Fairchild lab and used for making integrated circuits. The applications of photoresist technology and electron beam lithography which are integral processes in semiconductor manufacturing were developed along with improvements in integrated circuit production.[18] More about these processes are discussed in later part of this chapter. With reduction in chip size over the years along with increase in number of

[16] WILLIAM BRINKMAN, WILLIAM W TROUTMAN & D E HAGGAN, *A HISTORY OF THE INVENTION OF THE TRANSISTOR AND WHERE IT WILL LEAD US*, 32 IEEE JOURNAL OF SOLID-STATE CIRCUITS (1997), https://www.researchgate.net/publication/2977642.
[17] *Id.*
[18] *Id.*

transistors per wafer for a chip has increased the processor speed and efficiency of chips. This has also led to an exceptional increase in computational power down the line.

2.3. COMPOSITION AND PRODUCTION OF SEMICONDUCTORS

Semiconductor devices are predominantly chips which have integrated circuits (primarily transistors and resistors connected to each other layered on a thin wafer material made out of semiconductor material. Silicon is the most commonly used semiconductor material to make chips. The semiconductor devices can be classified mainly into three types on the basis of functionality: Logic, Memory, and Discrete and analog components.[19]

Logic chips undertake computational activities using mathematics. It mainly uses binary codes 0 and 1.[20] Microprocessors[21], General purpose logic and Microcontrollers use this mechanism to control the operations of the semiconductor device. Unlike a logic gate the function of which is predetermined at the time of manufacture itself, a general purpose logic, as the name itself suggests, has no fixed function but has inbuilt ability to custom itself according to need like the field programmable gate arrays. Microprocessors use already stored information to do computational activities in advanced semiconductor devices. Microcontrollers use a combination of processors, memory and programmable peripherals to perform complex computational tasks.[22]

Memory is crucial for the functioning of a semiconductor device. Complex computational activities carried out by microprocessors and the like use information stored in the memory. Most common types of memory used in semiconductor devices include DRAM and NAND. DRAM is a type of volatile memory. Volatile memory is that type of memory which is lost when there is no power passing through the device. That is, constant refreshment of memory is a necessity in case of DRAM or else the memory will be lost permanently. In DRAM, each bit (basic unit of data) is stored on a capacitor. Capacitor controls the flow of electricity in a circuit. NAND is a type of flash memory. Flash memory is a non-volatile memory which can retain data even when power is switched off. It is characterised by high speed, efficiency,

[19] ANTONIO VARAS ET AL., *STERNGTHENING THE GLOBAL SEMICONDUCTOR SUPPLY CHAIN IN AN UNCERTAIN ERA*.

[20] NATIONAL COUNCIL OF EDUCATIONAL RESEARCH AND TRAINING, 2006, PHYSICS PART I (1 ed. 2006), https://ncert.nic.in/ncerts/l/leph206.pdf.

[21] *Id.* “The microprocessor is an IC that processes all information in a computer, like keeping track of what keys are pressed, running programmes, games etc.”

[22] PETER WILSON, THE CIRCUIT DESIGNER’S COMPANION (4 ed.).

compact nature and minimum power consumption. NAND is used for permanent storage of data and hence is inevitable in electronic data storage devices.[23]

Discrete components mainly include diodes and junction transistors.[24] These discrete components perform a single function.[25] Analog components in semiconducting devices perform the function of production and transformation of analog signals into digital signals by altering the characteristics of the signal like amplitude, frequency and the like.[26]

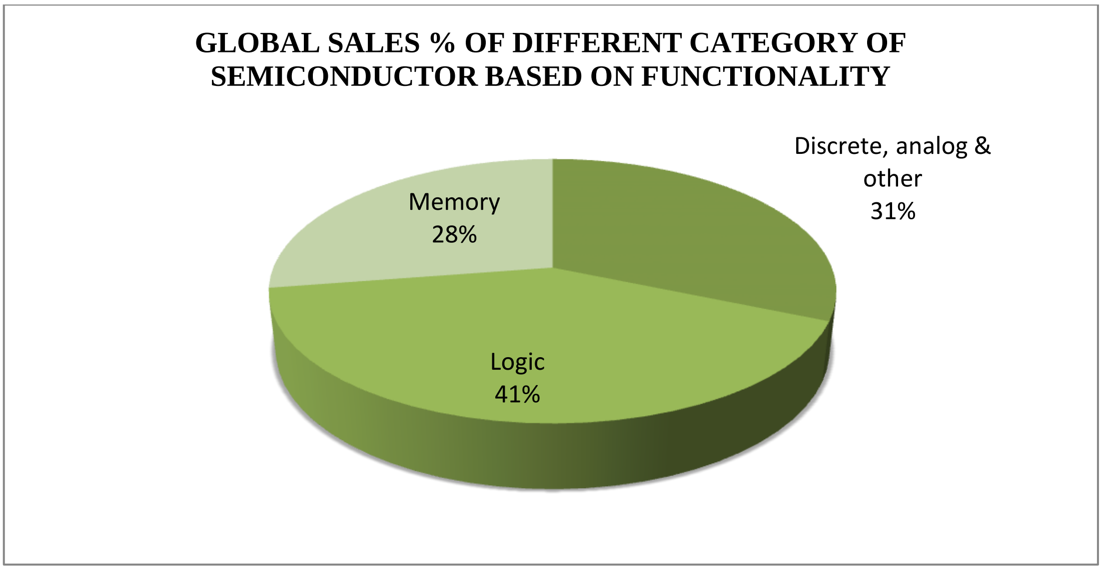

FIGURE 2.3[27]

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[23] Ham Hamsa, Ananth A.G & Thangadurai Natarajan, *A Study of Semiconductor Memory Technology by Comparing Volatile and Non-Volatile Memories*, 10 JOURNAL OF ADVANCED RESEARCH IN DYNAMICAL AND CONTROL SYSTEMS (2018).
[24] Tiago Busarello, José Pomilio & Marcelo Simoes, *Semiconductor Diodes and Transistors*15–48 (2017).
[25] RobbieDunion, *Your guide to discrete semiconductors* (2018), https://www.rs-online.com/designspark/how-do-discrete-semiconductors-differ-from-other-semiconductors.
[26] Geisha A. Legazpi, *What Is an Analog Semiconductor? (with picture)*, https://www.infobloom.com/what-is-an-analog-semiconductor.htm.
[27] VARAS et al., *supra* note 3.

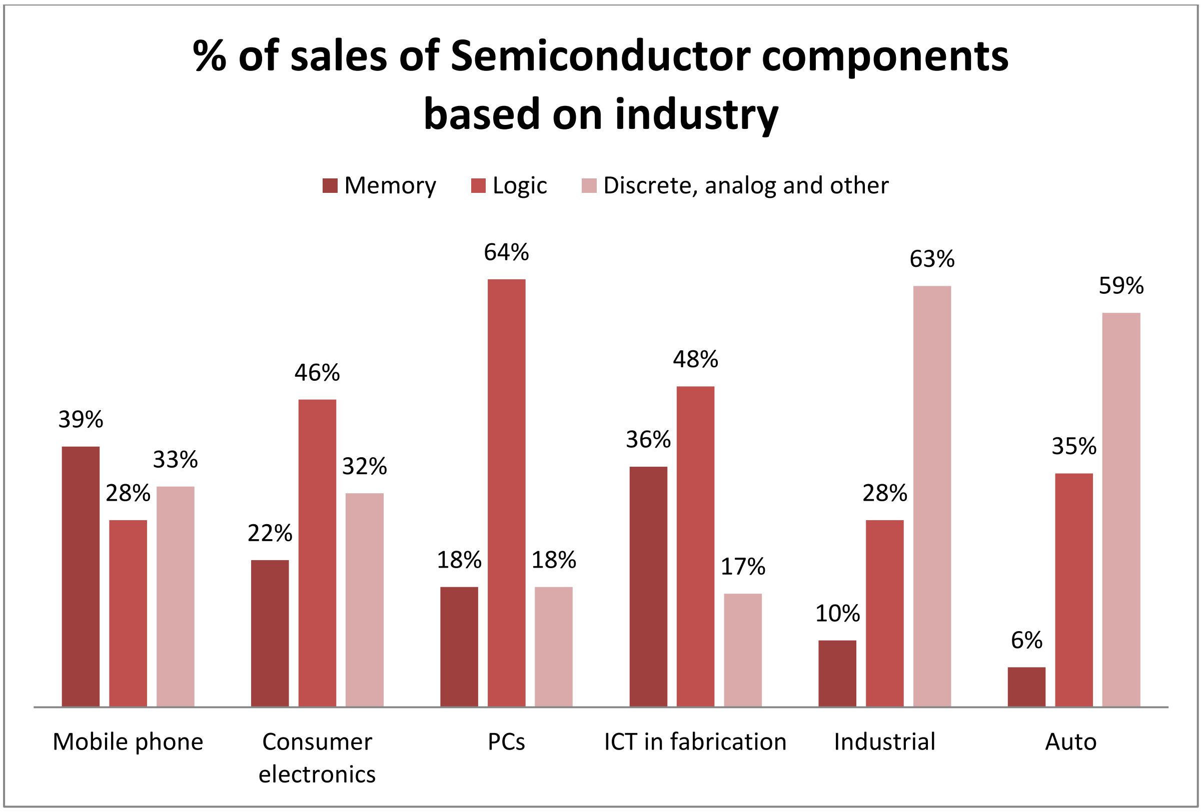

FIGURE 2.4[28]

The statistics provided above gives a detailed idea about the trend in the sales of various semiconductor components based on functionality. All these semiconductor components are inevitable for the functioning of the industry as these components work together complementing each other in semiconductor devices. For instance, a PC needs a combination of all the 3 components: memory, logic and discrete and analog components to function.

The integrated circuits in our laptops and cellular phones are made out of pure silicon crystals. Silicon is the second most abundant element in the earth's crust. Silicon has the ability to act both as a conductor and insulator in room temperature. It is easy to isolate pure silicon when it is available as a compound with oxygen. Hence, sand which is silicon dioxide is the best raw material from which pure silicon could be isolated. Sand is heated with carbon at an extremely high temperature to remove the oxygen molecule as CO_2 from Silicon dioxide to obtain elemental silicon. Silicon crystals need to be extremely pure in order to make chips out of it. Hence high production standards are ensured. Silicon wafers are

[28] *Id.*

fabricated from the extremely pure mono-crystalline silicon bar called boules. This is the first step in the wafer fabrication process. Chips are made from these silicon wafers.[29]

Layout and Design: Numerous transistors are connected to each other in order to build complex circuits like microcontrollers and crypto chips on the semiconductor wafer the surface of which measures only a few square millimetres in size. The structure of these chips is highly complicated and an intense research is needed to design the components on the chip. The design process includes exposition of the chip's function, defining its physical and chemical properties, creating a framework for integration of the specific purpose individual transistors on the chip and constructing a 3-dimensional architecture of the various layers of circuits on the wafer. This 3-dimensional copy of the prospective structure of a chip is transferred to photo masks. These photo masks act as templates for further fabrication of the chip. The transistors and other components which are to be built on a chip are microscopic in size and a template or blueprint (photo mask) ensures that the design is reproduced on the chip without any errors. The fab or foundry is the manufacturing plants where wafer fabrication takes place. The fabrication process should be carried out in a clean room with stable temperature and humidity levels. A clean room is one in which no more than one particle of dust larger than 0.5 micrometres are allowed in approximately 10 litres of air. This mandates a highly complicated and refined infrastructure for fabs with adequate ventilation complemented by an efficient filtration and air supply systems.[30]

Chips are manufactured on Silicon wafers. Thousands of chips could be made from just one wafer. These wafers are usually circular in shape which adds to the easiness in production. The wafer fabrication consists of the following steps:

1. Oxidation and coating: Layers of insulating and conducting materials are built on the surface of the wafer through oxidation under high temperature (around 1000 degree Celsius). This results in the creation of a non-conductive layer on the surface of the wafer. A photoresist material is used to coat the wafer. A light sensitive layer develops on the wafer.

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[29] Dr. Seth P. Bates, *Silicon Wafer Processing* (2000), https://jupiter.math.nctu.edu.tw/~weng/courses/IC_2007/PROJECT_MATH_CLASS1/4_PROCESS_FLOW/Silicon_Wafer_Processing.pdf.

[30] Semiconductor Technology from A to Z, , https://www.halbleiter.org/pdf/en/Semiconductor%20Technology/Semiconductor%20Technology%20from%20A%20to%20Z.pdf.

2. Lithography: The integrated circuit designs are mapped on a glass plate called photo mask. This is transferred from the photomask to the photoresist using ultraviolet rays. The wafer surface could be divided into exposed part and unexposed part after passage of UV rays. The layer of oxide is revealed through the exposed parts.
3. Etching: Etching is the process of removal of the exposed parts or parts which are not covered by the photoresist.
4. Doping: Impurity atoms like arsenic are introduced into the exposed parts thereby altering the conductivity of the wafer. This is done using an ion implanter.
5. Metal deposition and etching: The wafer undergoes series of oxidation, coating, etching and removal of photoresist residues. This results in the creation of new connections among the conductive layers, thereby integrating the transistors on the chip.
6. Completed chip: Individual chips on the wafer are separated by certain amount of space known as the scribe line. The size of a completed chip ranges from 1 sq.mm. to a few sq.cm. Assembling is done by packaging the individual chips and attaching terminals to it. These chips could be mounted on circuit boards. Cutting edge technology is essential in every stage of wafer fabrication as maintenance of high quality production is essential throughout the production process.[31]

PURE SILICON ⟶ LITHOGRAPHY ⟶ ETCHING ⟶ DOPING

COMPLETED CHIP ⟵ METAL DEPOSTION AND ETCHING

Nodes are used to denote the advancements in semiconductor technology. The technical meaning of the term "node" is the size of the transistor gates in the electronic circuits. It's usually measured in nanometres. Over time this definition of node became obsolete. As the size of the chip reduces, the distance to be travelled by the electrons to conduct electricity decreases which increases the efficiency of the chip. Efficiency of the chip increases as the number of transistors packed in a single chip increases. According to Moore's law, the number of transistors in a logic chip doubles every 18 to 24 months.[32]

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[31] *Id.*
[32] IoT opportunity in the world of semiconductor companies, (2018), https://www2.deloitte.com/content/dam/Deloitte/us/Documents/technology/us-semiconductor-internet-of-things.pdf.

2.4. LEADING ECONOMIES AND COMPANIES IN THE SUPPLY CHAIN

Initially the semiconductor firms were vertically integrated firms. They needed to engage in all activities of production of semiconductor chips beginning from wafer manufacture to market supply of product. Advancement of technology and reduction in size of chips led to increased complexity of semiconductor manufacture. Also capital intensive nature of semiconductor production led to the evolution of specialised firms in the semiconductor supply chain. Presently, there are companies which specialise in particular areas of production and firms which engage in all stages of production. There are mainly four types of business model in the semiconductor supply chain.[33]

1. Integrated device manufacturers

   They are vertically integrated throughout the supply chain. They perform activities like wafer fabrication, assembly, packaging, designing and the like. A different species of IDMs are characterised by absence of fabs. Most of those fablite models outsource wafer production to fabs located elsewhere. During the nascent stage of the semiconductor industry, IDMs dominated the supply chain. But with increase in the capital requirements of production led to the separation of fabs from design and assembly, packaging and testing; thereby giving birth to foundries, design firms and OSATs. Nowadays, firms which focus on memory and DAO products follow the IDM business model. It mainly manufactures general purpose components and requires less capital when compared to foundries.[34]

2. Fabless design firm

   Fabless firms usually specialise in Designing of integrated circuits of chips. They generally outsource fabrication to specialised fabs and assembly and packaging to OSATs. With rise in demand for semiconductors, the capital intensive nature of the production process resulted in the exit of firms which couldn't cope up with the capital requirement. Fabless firms normally engage in the realm of logic chips. Exceptions are Intel and Samsung. Power and performance capabilities were

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[33] Associates Inc., *supra* note 8.

[34] *Id.* "IDMs had the largest revenue share of the semiconductor industry in 2014. However, while IDMs will continue to play an important role, the fabless-foundry model is gradually becoming a larger portion of the industry as technology changes and products become even more complex. Between 2009 and 2014, fabless, foundry, and OSAT companies have shown a higher compound annual growth rate (CAGR) than IDMs In the past decade, IDMs have been acquiring more characteristics of the fabless-foundry model. Several IDMs contract with other companies to manufacture chips while performing all other remaining tasks internally. This is commonly called fab-lite. Many IDMs become fab-lite due to the constant and costly need to upgrade manufacturing facilities to keep up with technological advances."

increased by the evolution of Artificial intelligence and high-performance computing.[35]

3. Foundries: Fabless firms outsource the production activities to Foundries or fabs. The large capital requirements of semiconductor production led to the evolution of specialised fabs. Diversification of risk is a major benefit of sepcialisation in the supply chain. Most of the firms only take outsourced work. A few firms with huge capital undertake production for themselves along with outsourced work.[36]
4. Outsourced assembly and test companies (OSATs): Assembly, packaging and testing are undertaken by OSATs for IDMs and fablite business models. OSATs are characterised by lower capital requirement. It uses lower skilled labour to carry out the activities. Initially semiconductor firms in USA used to outsource assembly and packaging to small firms in Asia which led to the gradual growth of OSATs as a specialised area in the supply chain. OSATs evolved after the development of fablite model of business.[37]

   The scale requirement of fabs is a hindrance to the entry of new market players in the area of production of semiconductors. Design firms are required to invest hugely in research and development but the capital requirement is lower when compared to fabs.

[35] Breándán Ó Uallacháin, *Restructuring the American Semiconductor Industry: Vertical Integration of Design Houses and Wafer Fabricators*, 87 NULL 217–237 (1997).
[36] ULRICH NAEHER, SAKAE SUZUKI & BILL WISEMAN, *THE EVOLUTION OF BUSINESS MODELS IN A DISRUPTED VALUE CHAIN*, https://www.mckinsey.com/~/media/mckinsey/dotcom/client_service/semiconductors/pdfs/mosc_1_business_models.ashx.
[37] *Id.*

FIGURE 2.5: % OF TOTAL IDM INDUSTRY[38]

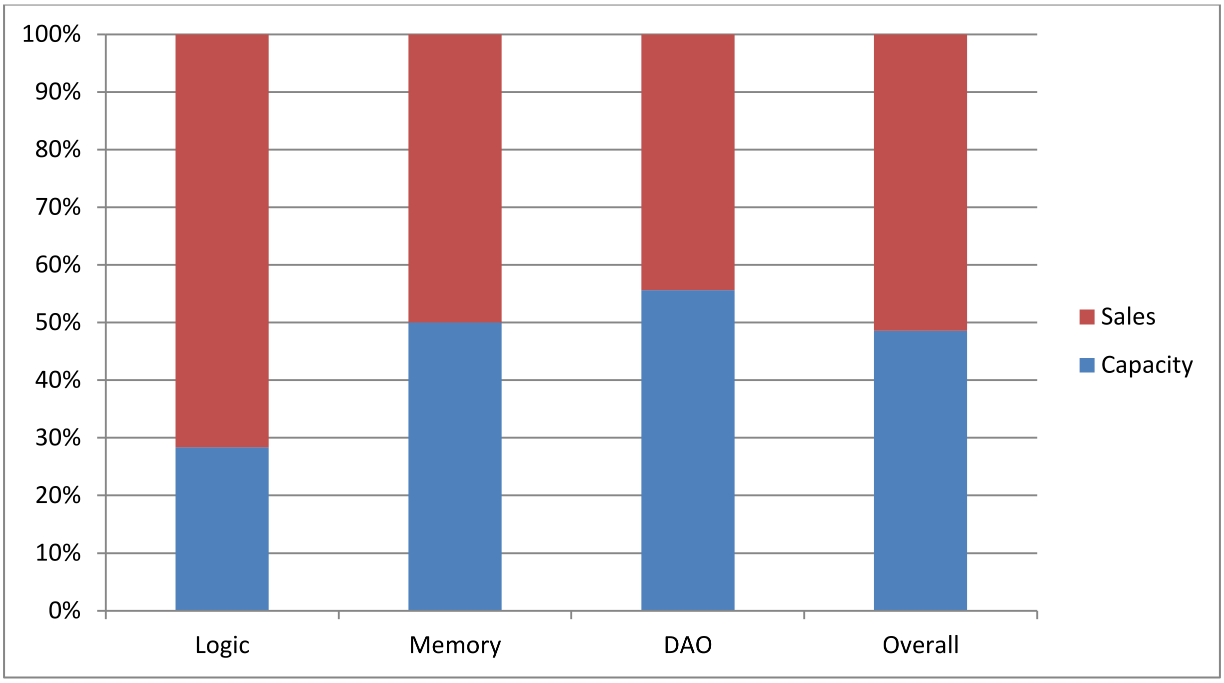
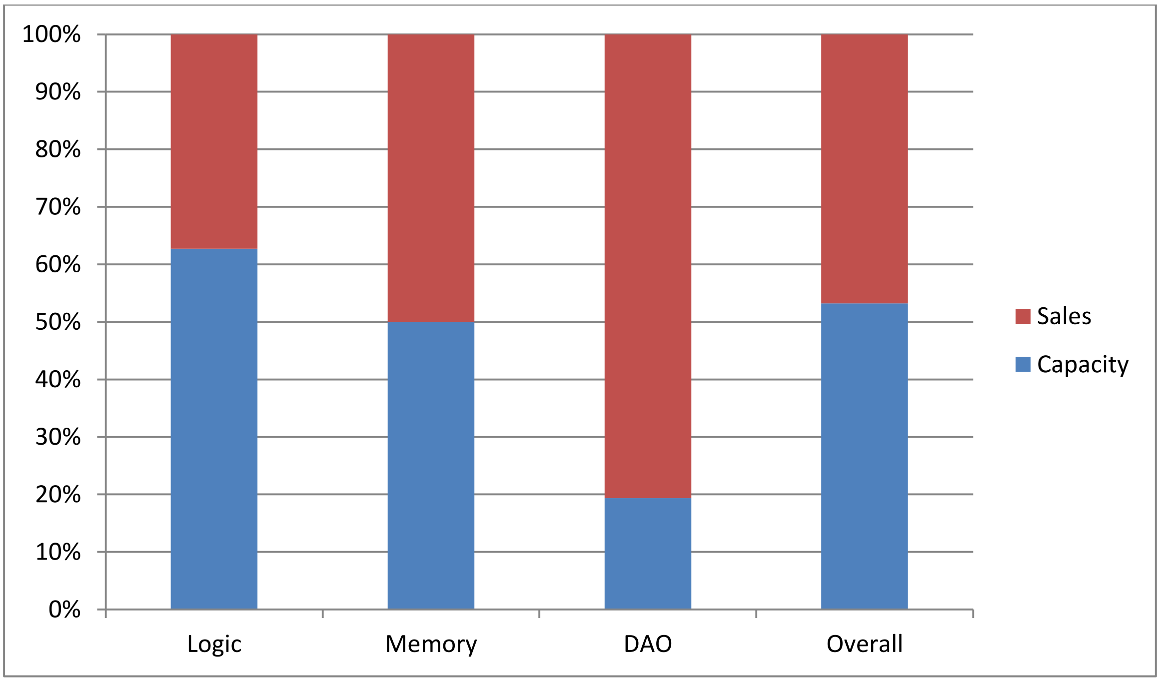


FIGURE 2.6: COMBINED % OF INDUSTRY OF OTHER BUSINESS MODELS[39]



The semiconductor supply chain dynamics could be understood through the following illustration: the process of designing chips begins with patent registration of the design. It is followed by creation of software for designing chip. The design is developed by a design

[38] VARAS et al., *supra* note 3.
[39] *Id.*

firm. The chip with a specific design is selected by an original equipment manufacturer (OEM) to function its device. Most of these activities are carried out by firms concentrated in US. OEMs that undertake scaled research are also found in Japan and Europe. The production of chips is outsourced by US designing firms to a Taiwanese fab. The chips thus produced are assembled, packaged and tested in an OSAT located in China or Vietnam. The chip is then affixed on the circuit board of a smart phone in an electronic firm in China which assembles the parts of a mobile phone. This smart phone is shipped to countries like USA where consumer demand is high. The semiconductor chip travels through different continents before reaching the consumer as an integral part of any electronic device.

2.5. EFFECTS OF TRADE LIBERALISATION AND INTERNATIONAL POLITICS IN THE SUPPLY CHAIN

The growth of the supply chain is attributed to government funded R&D at the initial stages of development and free cross border movement of goods and services. Comparative cost advantage enjoyed by the dominant players in the supply chain led to a considerable reduction in the price of the product at the hands of the consumer. The demand for consumer electronics is spread across the globe. This mandates an unrestricted movement of goods from one location to another. Shipping of goods from foundries to OSATs located at two ends of the globe is possible only with free trade. Cross border exchange of resources is inevitable for the efficient functioning of the supply chain. Upward and downward movement of work in progress inventories leads to subsequent value addition throughout the supply chain. Trade liberalisation has thus played a substantial role in the structuring of the semiconductor supply chain.[40] Without free trade, dominant firms in the supply chain would

[40] LOVE PATRICK & RALPH LATTIMORE, INTERNATIONAL TRADE FREE, FAIR AND OPEN? (2009), https://www.oecd-ilibrary.org/docserver/9789264060265-10-en.pdf?expires=1634229627&id=id&accname=guest&checksum=C6AE830D13F48147A78B4F33C5C24BF7. "Trade liberalisation also allows the most productive firms to expand into the bigger markets it creates. The least productive firms will not only be unable to profit from the new opportunities, they may be forced out of business completely by competition from new companies. It can be argued that the higher level of productivity of firms that export has little to do with trade in itself since the firms that take advantage of the new opportunities have to be more dynamic and more productive in their traditional markets to begin with. In other words, there is a kind of self-selection of exporting firms…..Specialisation therefore takes place among firms rather than within firms. Trade expands potential markets, and these larger markets mean that a firm can specialise more narrowly and still find enough customers. The result is a deeper division of labour, and this means that even a firm from a small country can prosper in activities where its home market is restricted. But even firms in large countries take advantage of the international division of labour to reduce costs and expand sales. The extent to which a country or a firm can benefit from global value chains depends on how much it costs to trade, not only in financial terms such as tariffs, but in the time it takes to transport goods or deal with the paperwork………Trade liberalisation also facilitates the import of cheaper foreign-produced intermediate goods and services……..The optimal balance between intellectual property protection and technology diffusion may shift in the direction of intellectual property protection if efficient markets for innovations are developed. In

not have succeeded in achieving comparative advantage in semiconductor production. Free trade agreements and bilateral treaties along with the norms set by World Trade Organisation have contributed to the evolution of the supply chain.

The World Trade Organization's Information Technology Agreement (ITA) was concluded in the Ministerial Declaration on Trade in Information Technology Products. It came into effect on 1st July 1997. The agreement was modified in 2015.[41] Import duties on information technology products were eliminated or significantly reduced by the signatories to the agreement. There are six categories of goods specifically enlisted in the agreement as duty free goods. They are semiconductors, semiconductor manufacturing equipment, software equipment, computers, scientific equipment and telecommunication equipment. Countries that export the goods mentioned earlier do not need to incur expenses as import duties. This helps the semiconductor firms to significantly reduce their transaction costs. Thereby the companies can increase their revenues along with expanding their business to new markets. The agreement provides for annual product review whereby new products which are a result of technological innovations find pace in the import duty eliminated category. The ITA agreement is one of its kind and the most successful trade agreement when compared to its counterparts. Semiconductors accounted for 32% of the global trade of ITA products in 2015 which is larger than all other products traded under the agreement. Before framing of the ITA agreement, advanced semiconductors were subjected to higher amounts of tariffs when compared to other general semiconductor products. The issue of non-uniform classification was solved by the modification of the ITA agreement in 2015. Reduction or elimination in tariffs and import duties as a result of the ITA agreement considerably reduced the cost of manufacture of semiconductor (inclusive of the R&D expenses) making the product much cheaper. As semiconductor work-in-progress goods travel across many borders during the process of value addition, reduction/elimination of tariffs also eliminates compliance procedures associated with various national laws as well as administrative costs.[42] The ITA has been a great global initiative in spurring international trade of semiconductors. By promoting cross-border flow of semiconductor products through its complex supply chain, it increased global employment opportunities, penetration of newer companies into export

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that case the innovator can realise the market value of the innovation directly through licensing. Trade in innovations enables innovation to be separated from production and allows the division of labour between R&D firms and manufacturers across countries, and R&D becomes a traded service."

[41] Stephan Nolte, Cornelis Keijzer & Vladymyr Dedobbeleer, *The Expansion of the Information Technology Agreement: An Economic Assessment*, https://trade.ec.europa.eu/doclib/docs/2016/april/tradoc_154430.pdf.

[42] *Id.*

operations, economic growth and geographical connectivity. Semiconductor firms and research institutions are able to spend money on research and innovations instead of tariff and administrative costs. Consumers are now able to afford to newer technologies and advanced semiconductors like AI, health care and diagnostics technologies etc.

Significance of the SCM agreement: Normally, government's grant subsidies to its domestic industries helping them to enter and conquer foreign markets without heavy capital burdens on their shoulder. That helps those firms to achieve an unfair competitive advantage in the supply chain. Government funds have been a major contributor to the growth of the global semiconductor industry. But unfair support offered by various national governments to its domestic semiconductor manufacturers distorts supply chain dynamics owing to domination of the supply chain by subsidised firms. The SCM agreement comes with measure to eliminate/reduce government induced subsidies curbing the unfair competitive advantage of companies in the supply chain. This helps companies and research institutions to compete on the basis of innovations and quality of work rather than funds allotted by their respective national governments. The SCM agreement expressly prohibits two types of unfair subsidies. They are export promotion and import substitution subsidies. Actionable subsidies are those which cause harm to one's own domestic industry. Signatories of the SCM agreement can charge countervailing duties on actionable subsidies. The agreement also provides exception to non-actionable subsidies, for example: R&D activities. The member nations have the duty to inform fellow members (signatories of the agreement) about the subsidies prevailing in its territory. This helps nations to understand the subsidy mechanisms existing in different nations along with increasing transparency under the SCM agreement.[43]

WTO's Trade Facilitation Agreement and Agreement on Technical Barriers to Trade ensure unrestricted yet regulated flow of semiconductor goods cross-borders as semiconductor supply chain is unevenly distributed geographically. The Trade Related Aspects of Intellectual Property (TRIPS) Agreement provides for international protection of scientific and technological inventions through patents and designs. It mandates minimum national IP procedures for signatories. The WTO dispute settlement body deals has jurisdiction over the TRIPS agreement and non-compliance of the TRIPS agreement by member states call for trade sanctions. Strong foundation for international IP protection was laid down by the TRIPS agreement. This ensures technological progress as more companies will come forward to

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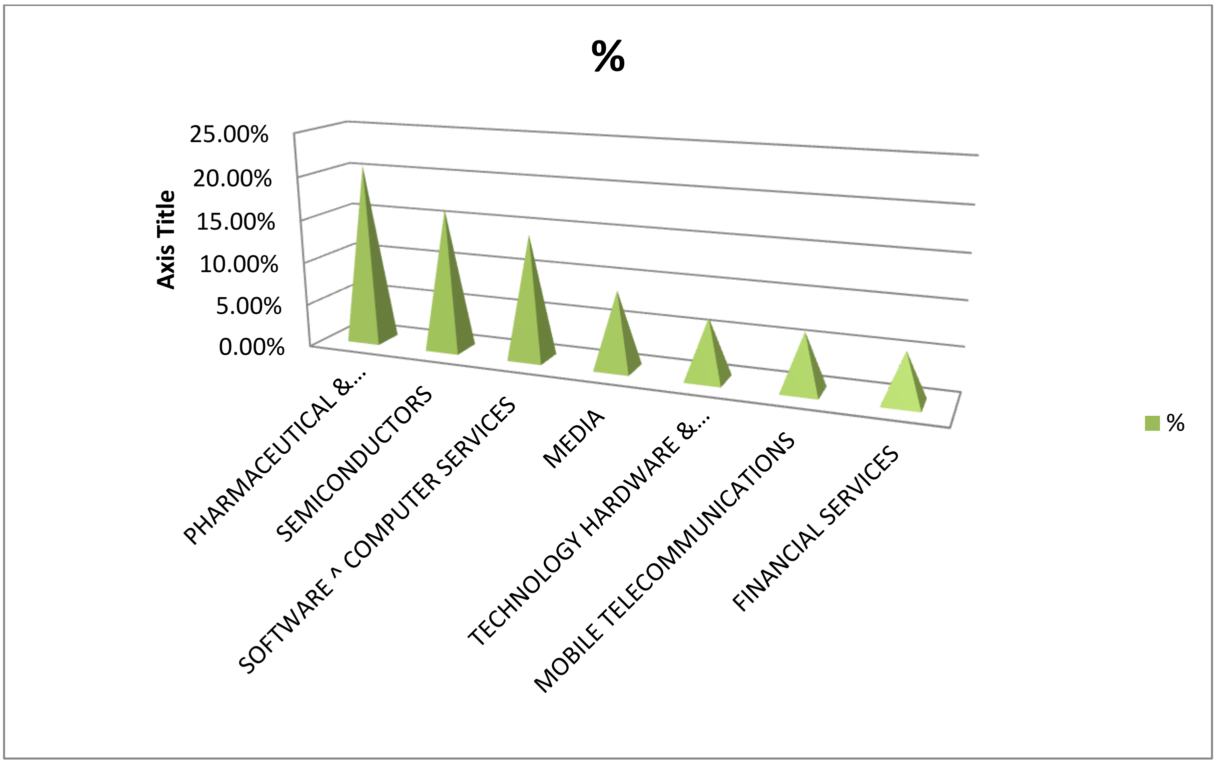
[43] ALAN O SYKES, *SUBSIDIES AND COUNTERVAILING MEASURES*, JOHN M. OLIN LAW & ECONOMICS WORKING PAPER NO. 186 (2003), : http://www.law.uchicago.edu/Lawecon/index.html.

invest in R&D. Those companies are ensured of returns as their intellectual properties are adequately protected at the international regime. Three main areas covered by the TRIPS agreement which is highly relevant in the semiconductor industry are[44]:

a) Restriction on compulsory licensing of semiconductors
b) Provision for protection of integrated circuits layout designs
c) Trade secrets

FIGURE 2.7: R&D Expenditure as a percentage of sales in various industries[45]



Compulsory licensing is dealt under Article 31 of the TRIPS agreement[46]. Under compulsory licensing, the government can assign the patent to some entity or individual other than the patent owner to manufacture and make commercially available a particular product or process. Certain restrictions on the application of compulsory licensing provisions have been laid down by TRIPS itself. Authorisation from the patent owner is a mandate for the application of compulsory licensing provisions. But during national emergency, cases of extreme urgency and public non-commercial use, the government can grant patent to a third

[44] SEMICONDUCTORS & THE WORLD TRADE ORGANIZATION, (2020), https://www.semiconductors.org/wp-content/uploads/2020/11/The-WTO-and-the-Semiconductor-Industry-Nov-2020_2.pdf.
[45] *Id.*
[46] AGREEMENT ON TRADE-RELATED ASPECTS OF INTELLECTUAL PROPERTY RIGHTS, , https://www.wto.org/english/docs_e/legal_e/27-trips.pdf.

party without the patent owner's authorisation. Under Article 31(c)[47], the government can use compulsory licensing of semiconductor technology only for its own use in defence and the like. This safeguards the semiconductor patents from reaching third parties through compulsory licensing.

Mask work or semiconductor layout design is the digital topography of integrated circuits. Article 35 of the TRIPS agreement provides for the protection of semiconductor layout design.[48] During the 1970-80s, chip piracy was a common phenomenon in USA where companies would copy the layout design of its competitor's chip. No intellectual property protection was offered to chip design back then resulting in huge loss to companies that undertook scaled research. The US government then passed the Semiconductor Chip Protection Act of 1984.[49] TRIPS agreement gave a global recognition to the need and methods of IP protection to chip design. Even though TRIPS allows reverse engineering, the TRIPS negotiations had concluded reverse engineering to require intellectual ability which qualifies it as an exception.[50]

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[47] *Id.* "Where the law of a Member allows for other use of the subject matter of a patent without the authorization of the right holder, including use by the government or third parties authorized by the government, the following provisions shall be respected: (c) the scope and duration of such use shall be limited to the purpose for which it was authorized, and in the case of semi-conductor technology shall only be for public non-commercial use or to remedy a practice determined after judicial or administrative process to be anti-competitive;"

[48] *Id.* "Members agree to provide protection to the layout-designs (topographies) of integrated circuits (referred to in this Agreement as "layout-designs") in accordance with Articles 2 through 7 (other than paragraph 3 of Article 6), Article 12 and paragraph 3 of Article 16 of the Treaty on Intellectual Property in Respect of Integrated Circuits and, in addition, to comply with the following provisions."

[49] LEON RADOMSKY, *SIXTEEN YEARS AFTER THE PASSAGE OF THE U.S. SEMICONDUCTOR CHIP PROTECTION ACT: IS INTERNATIONAL PROTECTION WORKING?*, 15 BERKELEY TECHNOLOGY LAW JOURNAL (2000). "The SCPA authorizes the owner of a "mask work" to reproduce the mask work, to import or distribute a semiconductor chip product in which the mask work is embodied, and to induce another to do the same for a period of ten years. In other words, one can resell chips purchased from the manufacturer without further SCPA liability, but one cannot copy such chips. Protection under the SCPA commences on the date that the mask work is either registered with the U.S. copyright office or is commercially exploited anywhere in the world, whichever occurs first. The mask work falls into the public domain if it is not registered within two years from the date of first commercial exploitation. A "maskwork", according to the SCPA is a series of related images, however fixed or encoded- (A) having or representing the pre-determined, three dimensional pattern of metallic, insulating, or semiconductor material present or removed from the layers of a semiconductor chip product: and (B) in which series the relation of the images to one another is that each image has the pattern of the surface of one form of the semiconductor chip product".

[50] Walaiwan Mathurotpreechakun, *Equilibrium of Intellectual Property Rights Under Fair Use: Case Study of Copyright Law and Trade Secrets Law Derivation of Reverse Engineering in Developing Countries*, 6 INTERNATIONAL JOURNAL OF CRIME, LAW AND SOCIAL ISSUES (2019), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3546322. "The practice of reverse engineering is allowed under exceptional circumstances in accordance with Article 7 of the TRIPS Agreement (1994), which strikes a balance between public interests and the holder of rights. However, from the producer's perspectives, there should be strict intellectual property legal mechanisms in place. This reflects the views of the developed countries to prevent the benefiting and utilization of intellectual properties; this can be perceived as an attempt to control the flow and exchange of information. On the other hand, from the developing countries' points of

Trade secrets were recognised as an intellectual property for the first time through TRIPS agreement. Trade secrets are a substantial business asset in the semiconductor industry. The high R&D intensive semiconductor industry requires protection of its research findings so that research institutions and companies are assured of legal rights over their intellectual property. Then only will the research community continue its quest on innovations. Manufacturing techniques, chemical composition of key ingredients, software source code, business strategies, design of chips and the like occupy the list of items in the semiconductor trade for which normally trade secrets are registered. Research community prefers protection of technology through trade secrets over that of patents as most of the innovations in the semiconductor industry stay in the market for a short time span after which newer innovations/technology take the stage. Trade secrets are one of the most important business assets of any company that undertakes semiconductor manufacture. This is because the economic value of those trade secrets is huge when compared to other physical assets and the competitive advantage that such companies enjoy in the supply chain roots from their trade secrets. Hence companies/manufacturers in the semiconductor supply chain cannot afford to lose its trade secrets to its competitors.[51]

The strategies adopted by WTO to curb market distorting practices by dominant market players and their respective national governments have played a key role in the growth of semiconductor sales globally. Nevertheless areas like trade secrets are vulnerable and needs more planned protection internationally as often developing and least developed countries have weaker IPR laws. Many governments force foreign investors to share their technology and resources with the domestic companies, use nationalised data storage mechanisms etc. This could be regarded as a modern version of import substitution. Hence, WTO should formulate more comprehensive and adaptable rules which could prohibit varied versions of prohibited market distortive practices. WTO arbitrators and Ministerial council should not allow norms or practices that restrict the trade of commercial foreign products with semiconductor-enabled encryption.

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view, access to intellectual properties is crucial, and reverse engineering is a useful tool that can be utilized on many technologies. At the same time, this could also lead to intellectual property violation. These factors make the owners of rights complacent in developing new technologies."

[51] Schultz & Lippoldt, *CHAPTER 3. APPROACHES TO THE PROTECTION OF TRADE SECRETS, in* ENQUIRIES INTO INTELLECTUAL PROPERTY'S ECONOMIC IMPACT (2015), https://www.oecd.org/sti/ieconomy/Chapter3-KBC2-IP.pdf. "

2.6.AN ANALYSIS OF THE ROLE OF US, CHINA, SOUTH KOREA, JAPAN AND TAIWAN IN THE SUPPLY CHAIN

There are 6 major regions in the semiconductor supply chain. They are (US, South Korea, Japan, Mainland China, Taiwan and Europe. Each region contributes around 8% or more value addition in the supply chain as per recent statistics. Most of the design firms are concentrated in USA. As of 2019, semiconductors are the fifth largest exported material in the United States. Many of those design firms have recently expanded their network by establishing joint ventures or wholly owned companies in countries where cheap skilled labour is available like India. It is pertinent to note here that over 20% of global semiconductor design engineers are located in India.[52] Most of the semiconductor manufacture is concentrated in Taiwan at the TSMC. Few high efficiency fabs are located in South Korea as well. Automotive and industrial automation is a key specialisation of Europe in the semiconductor supply chain. Consumer electronics is a major area of specialisation of Japan along with automotive and industrial automation. Similarly, South Korea has gained edge in smart phone manufacture as well as consumer electronics.[53]

Regional specialisation in the semiconductor supply chain evolved out of the comparative advantage enjoyed by the dominant regions in the supply chain. Transfer of tacit knowledge is a necessity for the development of the semiconductor industry. Hence, institutional collaboration between universities and semiconductor companies helps in pooling of resources and expanding the knowledge base in the industry. Years of intense research that led to scientific breakthrough and the transfer of that knowledge to various regions in the globe contributed to the expansion of the semiconductor industry. Transformation of those scientific breakthroughs into devices that has commercial application created the semiconductor industry of which we are a part (as consumers). It is noteworthy that government funded projects at the nascent stages of industry development in countries like USA, Taiwan and South Korea paced the growth of the global semiconductor industry.[54]

The interuniversity microelectronics centre (IMEC) situated in Belgium focuses on Nano electronics research and digital technologies. Singapore's Agency for Science, Technology and Research (A*STAR) is a leading research centre in Singapore responsible for planning

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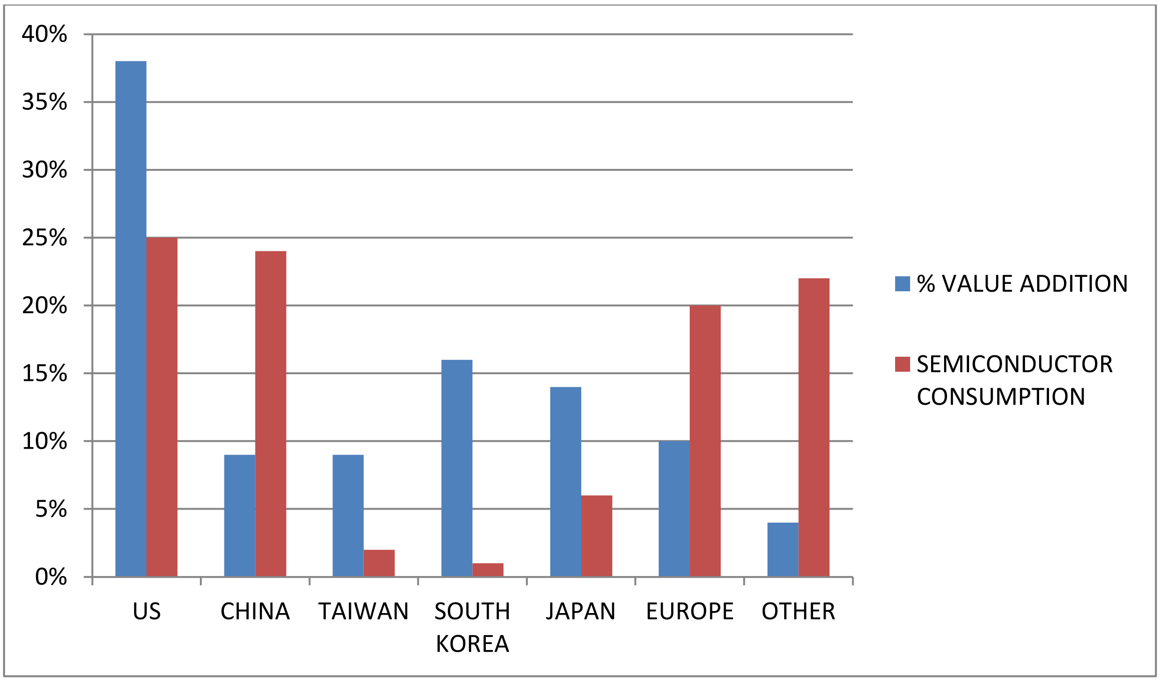
[52] VARAS et al., *supra* note 3.
[53] Associates Inc., *supra* note 8.
[54] Meng-Fan Chang et al., *The role of government policy in the building of a global semiconductor industry*, 4 NATURE ELECTRONICS 230–233 (2021).

and devising joint research with global companies in areas of power electronics, 5G radio frequency technologies etc.[55]

The graph below shows that US contributes significantly in terms of value addition in the supply chain. In regions like China and Europe, consumption exceeds value addition. In Taiwan and South Korea, the % of consumption of chips is negligible when compared to value addition. Most of the efficient design firms are located in USA and that contributes to increased % of value addition by US in the supply chain. A large % of foreigners who migrate to US for computer and allied sciences education stays in US after graduation and contributes to the large community of high skilled engineers working in design firms in USA. Nevertheless, Asia is the hub of manufacturing firms that receive substantial funding from respective governments. During the 1970s, Taiwanese government began investing in building its domestic semiconductor industry. Incentives from government played a major role in evolution of Taiwan as a major semiconductor manufacturing hub in the supply chain. The foundry model of semiconductor firm evolved in Taiwan when the country began specialising in manufacture over R&D.[56] OSAT firms specialises in labour intensive assembly, packaging and testing. Normally, the capital expenditure: annual revenue ratio of OSAT companies is around 2% lower than that of fabs. Large scale OSAT firms can be found in China, Singapore and Taiwan. New players have been entering the OSAT business model, notably Malaysia. With technological advancements in logistics and delivery services, OSAT firms have to modify their existing structure to meet the demands of the industry.[57]

[55] SEMICONDUCTOR RESEARCH OPPORTUNITIES, (2017), https://eps.ieee.org/images/files/Roadmap/SIA-SRC-Vision-Report-3.30.17.pdf.
[56] CHIA WEN LEE, ROGER HAYTER & DAVID EDGIGTON, *Large and latecomer firms: The Taiwan semiconductor manufacturing company and Taiwan's electronics industry*, 101 TIJDSCHRIFT VOOR ECONOMISCHE EN SOCIALE GEOGRAFIE 177–198 (2010).
[57] VARAS et al., *supra* note 3.

FIGURE 2.8: % OF VALUE ADDITION BY REGION IN THE SEMICONDUCTOR COMPARED TO THE CONSUMPTION RATE[58]



[58] *Id.*

CHAPTER – 3

HISTORICAL OVERVIEW OF JAPAN-SOUTH KOREA TRADE RELATIONS

3.1. COLONIAL HISTORY

The Korean peninsula (hereafter referred to as Korea) was a colony of the Japanese imperial rule from 1910-1945. Before the Mongol invasion of Korea and Japan during the 1200s, there were exchanges of trade, culture, and art between the two geographically close territories. The Mongol invasion distorted trade between the two regions and led to the emergence of Japanese pirates that frequently attacked coastal areas of China and Korea. In 1404, China's Ming Dynasty helped Japan by suppressing the pirates, making japan its tributary nation. This led to the establishment of a more substantial diplomatic relation between Japan and China. Toyotomi Hideyoshi gained control over Japan and fought a war with Korea and China to seize the same. Even though he lost the war against the combined power of Korea and China, the successor of Toyotomi resumed trade with Korea. He negotiated for the opening of embassies in Korea and Japan, whereby Korean embassies were opened near Tokyo.

During the 1800s, Japan began to transform into a modern capitalist state under the influence of western countries. It became victorious in the Sino-Japanese War of 1894- 1895 and the Russo-Japanese War of 1904-1905, expanding its imperial rule to other territories. Korea became its protectorate under the threat of military power.[59]

Abdication of King Kojong of Korea and disbanding the Korean army gradually led to Japan's colonial rule over the Korean peninsula. The Governor-General of Korea assumed the highest title of power in Korea and was appointed by Japan. The use of Japanese language was forced throughout the Korean peninsula by the Japanese. Consequently, it was

[59] YOUNG ICK LEW, BRIEF HISTORY OF KOREA —A BIRD'S-EYEVIEW— (2000), https://www.koreasociety.org/images/pdf/KoreanStudies/Monographs_GeneralReading/BRIEF%20HISTORY%20OF%20KOREA.pdf.

introduced into the Korean school curriculum as well. The Japanese military police became the regular police force of Korea and controlled law enforcement.[60]

The death of King Kojong in 1919 gave birth to a new movement for independence in Korea. This led to the formation of a provincial government in exile in Korea. Assimilation of Koreans under the Government in exile gradually began. During the 1930s, Koreans were forced to work as slaves for Japanese lords and even forced to adopt Japanese names. During the Second World War, Koreans were forced to do military conscription. In the 1940s, Japan accepted the Potsdam declaration that aimed to surrender Japanese armed forces after World war II.[61] This led to the formation of the Republic of Korea in the South and the Democratic People's Republic of Korea in the North of the Korean peninsula. In 1950s, war broke out between South Korea and North Korea whereby South Korea captured North Korea. United Nations and USA supported South Korea. China backed North Korean forces in the Korean War. In 1953, the war ended, and peace was restored between the two neighboring nations.

Park Chong Hui, the new president of South Korea, initiated five-year economic plan. But war reparation from the Japanese was needed to fund the development plan. The US undertook deliberations with Japan and South Korea to enter into a treaty to normalise their relations. After that, in 1965, both the countries signed the **normalization treaty** that made all previous treaties invalid and gave a new path to Japan-South Korea trade relations.[62] Japan also recognized South Korea as the legitimate Government of the Korean peninsula. Japan donated US dollars 800 million to boost the South Korean economy. Japan highly influenced the economic development of South Korea through financial and technological assistance.

3.2. TRADE DEVELOPMENTS IN THE POST-INDEPENDENCE PERIOD

A plethora of studies were conducted mainly by East Asian scholars to understand the effects of Japanese colonial rule on the economic development of South Korea. Japanese imperial Government enacted policies that were skewed in line with the development of industries in Korea that were beneficial to the Japanese economy. On comparison of Taiwan and Korea during the period of Japanese rule over Korea, Taiwan showed more economic and human

[60] *Id.*
[61] Hugh Borton, *Occupation Policies in Japan and Korea*, 255 SAGE PUBL. INC 146–155.
[62] Shigeru Oda, *The Normalization of Relations between Japan and the Republic of Korea*, 61 AM. J. INT. LAW 35–56.

resource developments.[63] Japan stringently restricted the development of indigenous businesses in Korea and promoted heavy industries and military investments. Agriculture was not given much attention until Japan was affected by food riots in 1919, and Koreans were forced to cultivate rice to feed the Japanese population.[64] Japan exported its technology and machinery to Korea to increase rice production exponentially as other resources like land and labour were limited.[65] Despite increased rice production, the price of rice items exported from Korea to Japan was substantially low, thereby limiting the overall gain made by the Korean economy.[66]

The Japanese imperial rule over Korea from 1910 to 1945 was followed by significant historical events: the Second World War, US occupation followed by war with North Korea. Hence the claim that Japanese investments in Korea and organizational continuity post-independence benefited South Korea to develop its economy is rather hard to prove. South Korea witnessed Land reforms and labour liberations post-independence, which drastically relieved its economy from distortions caused by Japanese colonial rule to a great extent. After gaining political independence from Japanese rule Korea remained predominantly an agricultural economy, but the then nationalist Government gave human resource development a significant thrust. Indeed, Japanese investments in Korea, mainly in areas of infrastructure and heavy industries, have contributed to the economic development of independent Korea to a greater extend. It is similar to the British contribution of railway lines in colonial India. Mining and manufacturing industries saw a gradual increase in production compared to other activities like agriculture and fisheries during the 1930s when Japanese colonial rule was at its peak in Korea.[67]

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[63] Mick Moore, *Agriculture in Taiwan and South Korea : The Minimalist State*, 15 IDS BULL. SUSSEX (1984), https://core.ac.uk/download/pdf/43541514.pdf.

[64] CHANG YUN-SHIK AND STEVEN HUGH LEE, TRANSFORMATIONS IN TWENTIETH CENTURY KOREA (2006). "In addition, to survive, poor peasants were often forced to market their crops, a great portion of which went to Japan, constituting a phenomenon which Korean scholars term "famine export" (kia such'ul) (Cho 1979). Thus in early colonial Korea, market expansion and increased commercialization did not qualitatively transform agriculture. Instead, as Brenner (1977) points out for early modern Poland, the growth of surplus extraction in response to the market, without transformation of the mode of production, only intensified use of – indeed "used up" – labor power."

[65] Atul Kohli, *Where do high growth political economies come from? The Japanese lineage of Korea's "developmental state"*, 22 WORLD DEV. 1269–1293 (1994).

[66] Suh Sang-Chul, *Growth and Structural Changes in the Korean Economy, 1910–1940*, COUNCIL EAST ASIAN STUD. HARV. UNIV. DISTRIB. HARV. UNIV. PRESS 1978.

[67] Tamio Hattori & Yukihito Sato, *A COMPARATIVE STUDY OF DEVELOPMENT MECHANISMS IN KOREA AND TAIWAN: INTRODUCTORY ANALYSIS*, XXXV DEV. ECON. 341–57 (1997)....... "Industrialisation in Korea also lagged behind. Looking back on the period during which both countries were colonies of Japan, industrialisation was progressing during the 1930s and the Korean peninsula was developing ahead of

Table 3.1: Distribution of net commodity product by industrial origin based on product prices in 1936.[68]

	AGRICULTURE AND FISHERIES	MINING	MANUFACTURING
1910-15	95.2	1.3	3.5
1916-21	93.1	1.4	5.5
1922-27	90.2	1.2	8.6
1928-33	87.4	2.0	10.6
1934-39	75.6	5.8	18.3
1940	69.7	8.3	22.0

A majority of Korean farmers cultivated non-rice crops. But the Japanese Government invested technologically only in rice cultivation.[69] It is pertinent to note that Japanese imperial policies made Korean manufacturing industries export-oriented, which did not contribute much to the Korean economy as export prices were always low.[70]

In capital-intensive heavy industries, most of the firms were owned by Japanese elites or were Korean-Japanese joint ventures where the Japanese held the majority of shares. From the table below, it is clear that Japanese elites dominated even lighter industries like the textile industry.

Table 3.2: Comparison of Korean and Japanese ownership in various industries during the 1940s.[71]

	KOREAN %	JAPANESE %
METALLURGY	2	98

Taiwan……. Also, most of the manufacturing enterprises including SMEs in prewar Korea was owned and managed by Japanese."

[68] STEPHAN HAGGARD, DAVID KANG & CHUNG-IN MOON*, *Japanese Colonialism and Korean Development: A Critique*, 25 1997 ELSEVIER SCI. LTD 867–881 (1997).

[69] Mitsuhiko Kimura, *Colonial Development of Modern Industry in Korea, 1910-1939/40*, 2 JPN. REV. TOKYO (2018).

[70] , *supra* note 5.

[71] CHUNG-IN MOON*, *supra* note 10.

MACHINERY	42	58
CHEMICALS	Less Than 1%	100
ELECTRICITY AND GAS	----	100
CERAMICS	----	100
TEXTILES	15	85
LUMBER AND WOOD	10	90
FOODSTUFFS	7	93
PRINTING PUBLISHING	43	57
OTHER	6	92
TOTAL	6	94

There is no conclusive proof to show that the contributions of Japanese military rule backed the economic growth attained by South Korea in the 21st century. Post-independence, in 1965, South Korea and Japan entered into normalisation treaty whereby trade and diplomatic relations were re-established between the two countries. This starkly contributed to the surge in South Korea's economic growth. During the 1960s, the South Korean economy lagged behind the Japanese economy. The then Japanese Government agreed to the payment of Official Development Assistance (ODA) to South Korea. The economic assistance was mainly channeled by the Korean Government for the development of the manufacturing sector. It also received war compensation from Japan, which the South Korean Government used to rebuild its war-torn economy. A catena of financial aid from Japan recreated the economic subordination of South Korea to Japan. South Korea received substantial imports from Japan even after the official termination of ODA. Most Korean firms obtained high-end technical know-how and machinery from Japanese firms through joint ventures and technical collaborations. The South Korean Government opened the frontiers of its economy for globalization due to the Asian Currency Crisis of 1997[72]. Many foreign firms slowly built plants and manufacturing units in South Korea as a result of globalization. Gradually import dependency of South Korea over Japan began to decline, whereas Japanese investments in Korean firms increased drastically. Japan and USA mainly retained the total trade value of South Korea. The country was irretrievably dependent on the Japanese imports, so much so

[72] , *supra* note 6. “The Korean economy was severely affected by the 1997 financial crisis. The banking system was unable to repay its large external debt or to maintain the stability of the currency.”

that the total value of imports was the largest with Japan. These included Integrated circuits and other semiconductor devices.[73]

After the normalization of the South Korean-Japanese relations in 1966, the Korean Government passed the 'Law on foreign capital importation.' During the 1980s, inward FDI from Japan to South Korea increased gradually, superseding that of the USA. The Japanese companies adopted the practice of entering into a technical cooperation contract with Korean companies. In the later stages of cooperation, the Japanese companies became equity shareholders or joint venture holders with the Korean companies. Sumitomo Corporation and Samsung SDI entered into alliance for the manufacture of picture tubes of color television.[74]

Overdependence of the South Korean economy over economic contributions from Japan led to the creation of a trade imbalance between the two countries. The South Korean Government made several attempts to equalize the trade balance between the nations. It adopted the Import Diversification Program in 1978 to limit the importation of selected items from countries with a trade deficit. Another attempt was the First Five Year Plan in 1986. Through the plan, Korea promoted exports over imports to achieve a trade surplus in which it succeeded. It also announced local production of import substitutes to overcome its dependency on Japanese imports, mainly in the manufacturing sector. Through the second 5 year plan enacted by the Government in 1992, many Korean firms in the manufacturing industry were able to introduce high-end technology. In 1999, to attain OECD membership, the Korean Government altered its foreign trade policy and abolished the import diversification program and trade restrictions on imports from Japan. Export processing became a profitable activity that was boosted by globalization which began post-world war. Many Korean manufacturing companies imported intermediate goods from Japan, added value to the same, and exported them to third-world countries.[75]

After the Asian currency crisis, the Korean Government diverted its focus from Japan to China, rapidly growing to the extent that it surpassed Japan's economy in 2010. The long-term trade relationship between Japan and South Korea after the adoption of the normalisation treaty in 1965 started to distort when China entered as a front runner in

[73] William E. James, *TRADE RELATIONS OF KOREA AND JAPAN: MOVING FROM CONFLICT TO COOPERATION* (2001), https://www.eastwestcenter.org/sites/default/files/private/ECONwp011.pdf.
[74] Françoise Nicolas, Stephen Thomsen & Mi-Hyun Bang, *Lessons from Investment Policy Reform in Korea*, OECD PUBL. (2013), http://dx.doi.org/10.1787/5k4376zqcpf1-en.
[75] *Id.*

international trade.[76] Still, South Korea remained exclusively dependent on Japan for intermediate goods produced using high-end technology. The below-given graph depicts the change in South Korea's trade dependency on Japan from 1995 to 2020.

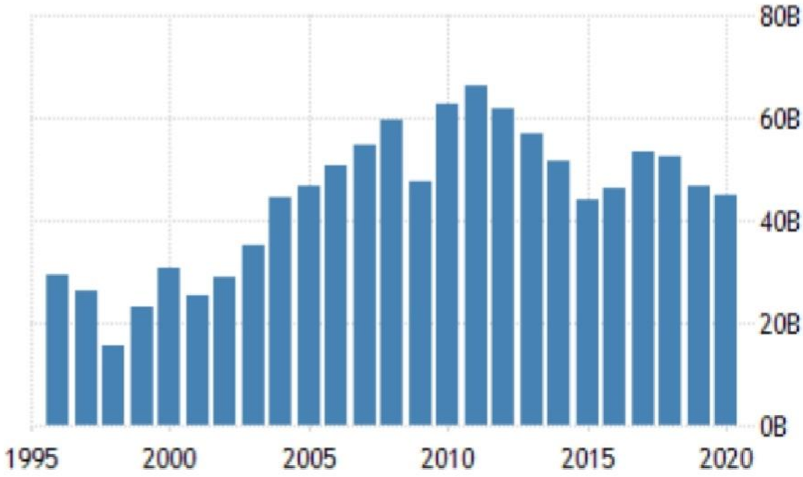

FIGURE 3.1[77] : Graph showing the trends in Japanese exports to South Korea

It is pertinent to note that over the years, as South Korea began to adopt policies promoting exports to third world countries over imports from Japan, there is a gradual decrease in the trade dependency of South Korea over Japan. With the evolution of China as a market leader in the East Asian region since the 1990s, the Japanese economy lost its charm down the line. It was forced to invest in high-end technology over industrial manufacturing to uphold its economic prominence in international trade.[78]

[76] Cheong Young-rok, *IMPACT OF CHINA ON SOUTH KOREA'S ECONOMY*. http://keia.org/sites/default/files/publications/09.Cheong.pdfhttp://keia.org/sites/default/files/publications/09.Cheong.pdf
[77]Graph adopted from https://tradingeconomics.com/south-korea/exports/japan
[78] , *supra* note 18.

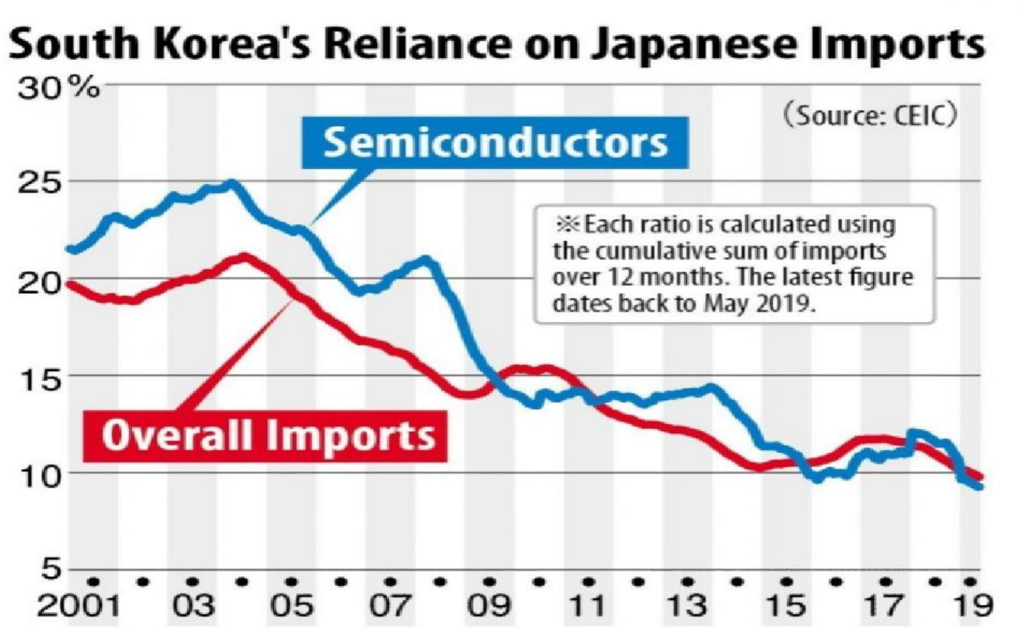

FIGURE 3.2[79]: Graph showing comparison of semiconductor imports and overall imports from Japan to South Korea

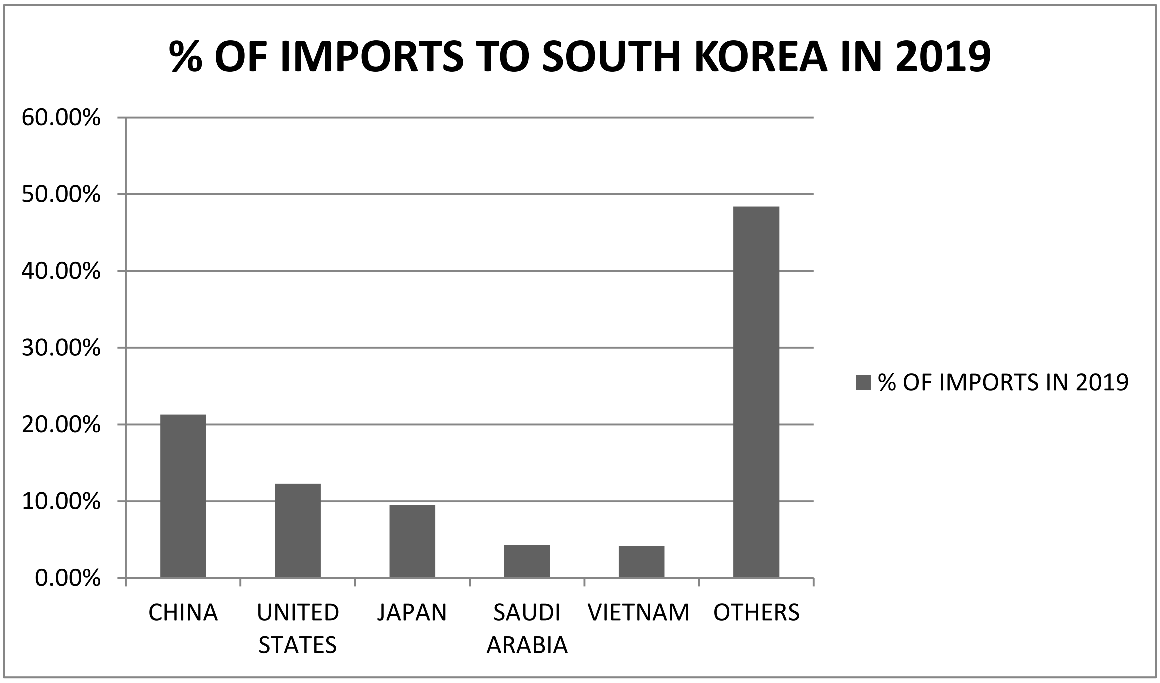

FIGURE 3.3 [80] : Graph showing % of imports to South Korea in 2019

[79] Graph adopted from - Hideo Tamura, *JAPANForward*, JAPAN BEEFS UP EXPORT CONTROLS TO COUNTER SOUTH KOREA'S POLITICAL MANEUVERING , https://japan-forward.com/japan-beefs-up-export-controls-to-counter-south-koreas-political-maneuvering/.

A combined analysis of Graph 3.2 and Graph 3.3 shows that down the line with the evolution of Chinese economy, the trade dependence of South Korea over Japan has drastically reduced. Yet Japan continues to act as a significant source of intermediate goods to South Korea, depicted in Graph 3.3. Due to the many free trade agreements signed between the two nations, Japanese FDI to South Korea has built a stable foundation for their trade relations. Frequent earthquakes and improvements in Korean infrastructure have motivated Japanese entrepreneurs to shift their manufacturing plants to South Korea. That on the one side firmly establishes the dependency of South Korea over Japan. In contrast, South Korea's policies aimed at achieving self-sufficiency and trade with China, on the other hand, have the effect of reducing the same.[81]

3.3: EFFECT OF GLOBALISATION ON JAPAN-SOUTH KOREA TRADE RELATIONS

The South Korean Government fully opened the domestic market to foreign investments. That was a severe blow on the face of Japan as more foreign investments in Korea meant lesser trade dependency on Japan. The South Korean Government promoted more FTAs with European countries, thereby diverting its cross-border transactions with Japan to the European and trans-pacific region. Major South Korean firms shifted their production location to labor-intensive countries with low costs of production like China. The South Korean Government entered into numerous FTAs post the Asian currency crisis in 1997 to expand its export market coupled with overseas production and development of an adequately skilled workforce led to the rapid growth of the South Korean economy. Post Lehman Shock, the Chinese Government undertook policies to expand infrastructure investment. It also adopted measures to provide impetus to consumer spending. The Jiadian Xiaxiang project was one such measure whereby the Chinese Government stimulated the domestic production of LCD televisions. Thus, South Korean companies became the primary source of semiconductor materials for the local Chinese LCD television manufacturers. That increased the export dependency of South Korea on China by the end of 2010.[82]

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[80] % of imports to South Korea in 2019, , COMTRADE .Graph prepared from the statistics published on Comtrade.

[81] , *supra* note 18.

[82] Hidehiko Mukoyama, *Japan-South Korea Economic Relations Grow Stronger in a Globalized Environment*, XII PAC. BUS. IND. (2012), https://www.jri.co.jp/MediaLibrary/file/english/periodical/rim/2012/43.pdf.

The prominent feature of Japan-South Korea trade relations is the economic dependency created by the trade deficit on the South Korean side. Even though that was the case, there was a yearly increase in trade between both nations. But the entry of China as a significant trading partners of South Korea channelled the lion's share of South Korean exports to China, which reduced the export dependency on Japan. When compared to the Chinese market, market penetration is difficult with regard to the Japanese market, making it difficult for South Korean firms to increase their market shares in Japan.[83]

Japanese exports to South Korea increased every year during the 2000s to feed the manufacturing industries of South Korea even though South Korean exports to Japan decrease considerably from 2007, which is marked by Chinese expansion to the global consumer electronics industry. JSR Corporation is one such company on which the semiconductor industry in South Korea is highly reliant on photoresists, fluorinated polyamides, and the like.[84] On the other hand, Japanese imports from South Korea decreased mainly due to the adoption of overseas production by Japanese firms. The increase in Japanese exports to South Korea and a decrease in imports added to the rise in trade deficit on the South Korean side.

The trade deficit has always hindered the furtherance of trade relations between Japan and South Korea. After the failure of the Import Diversification Program, South Korean Government altered its strategy for curbing the growing trade deficit of South Korea with Japan. The South Korean Government is now actively boosting and structuring its domestic manufacturing sector to attain self-sufficiency and reduce dependence on Japanese imports.[85] It is also working towards the promotion of exports to Japan. It has endeavoured into an exchange of Know-how mainly with trading partners in the semiconductor supply chain like the USA.

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[83] *Id.*

[84] [N]BUSINESS, , HOW A SMALL JAPANESE RUBBER COMPANY BECAME THE LIFEBLOOD OF THE TECH INDUSTRY (2019), https://www.thenationalnews.com/business/technology/how-a-small-japanese-rubber-company-became-the-lifeblood-of-the-tech-industry-1.900865. "It's a matter of survival: Korean corporations now depend on Japan for over 90 per cent of all the fluorinated polyimide and resists they need, and 44 per cent of hydrogen fluoride requirements, Societe Generale estimates."

[85] Kwan S. Kim, *THE 1997 FINANCIAL CRISIS AND GOVERNANCE: THE CASE OF SOUTH KOREA*. https://kellogg.nd.edu/sites/default/files/old_files/documents/272.pdf "Nevertheless, thanks to the relentless export drive by a few chaebols and the government's drive for structural reform, the export of semiconductors, automobiles, ships, and machinery continued upward trends, particularly to countries in Southeast Asia. Coupled with some success in inducing foreign direct investment, the country's trade surpluses since late 1998 have been accompanied by increased imports for the first time since the crisis. Purchases of foreign plants and equipment by local companies accounted largely for increased imports. This should promote Korea's growth potential and export industry and is thus viewed as a welcome sign for an economic turnaround."

The growth of the semiconductor industry in South Korea should be attributed to the technological know-how acquired by the South Korean companies from their Japanese counterparts. Most of the high-end technology associated with electronics and semiconductors was first developed or introduced into the Asian continent by Japan. Mass production of the same by the Japanese firms results in market creation in neighboring countries like South Korea. South Korean firms invest in those techs introduced by Japan and start local production of the same. The South Korean economy gradually becomes the global leader in the large-scale production of those techs. This pattern in acquiring technology and production strategy compels South Korea to import essential intermediate goods solely from Japan. Large scale investment and mass production of semiconductor devices make South Korea dependent on imported goods produced using high-end technology in Japan. South Korea also essentially imports steel and iron from Japan to produce machinery, mainly semiconductor manufacturing equipment.[86]

After the mass earthquake in Japan in 2011, many South Korean companies started to procure resources from Europe and other ASEAN countries. FTAs entered into by South Korea and Europe has also enabled South Korea to expand trade with Europe, thereby reducing its ties with Japan. Also, the international growth of South Korean companies like Samsung Electronics and S K Hynx has increased Japanese investments in South Korea, thereby reducing the trade deficit on the South Korean side. It is pertinent to note that FTA entered into by South Korea with Europe enables Japan to produce goods locally in South Korea and export it to Europe under a South Korean tag to take advantage of tariff reductions available to South Korea. Hence, it could be concluded that the South Korean economy is growing post-globalization of its markets at a tremendous pace when compared to the Japanese economy. Yet both the countries remain interdependent in trade, especially in the global semiconductor supply chain.[87]

But in 2018, a ruling against Japanese companies (Nippon Steel & Sumitomo Metal and Mitsubishi Heavy Industries) by the Supreme Court of South Korea shook the unhealed wounds of Korean colonization by Japan. That triggered what is infamously known as the Japan-South Korea trade war. It is elaborately dealt with in Chapter 4.

[86] , *supra* note 24.
[87] *Id.*

CHAPTER - 4

JAPAN – SOUTH KOREA TRADE WAR AND THE NEW GLOBAL TRADE OPPORTUNITIES

4.1: CAUSES OF THE TRADE WAR

Following the adoption of the normalization treaty in 1965, the diplomatic relations between Japan and South Korea became stronger. The semiconductor industry of South Korea started to develop during 1960 by procuring technology and resources from Japan.[88] In 1987, South Korea entered into an export control system upon USA's request.[89] It also adopted a Memorandum on Technical Data Protection with the US. South Korean Government established a Coordination Committee for Multilateral Export Controls (COCOM), and grant of certificates for import of strategic materials were initiated.[90] Under this system, maintaining a White List of trading partners came into practice. On a similar note, Japan also adopted the practice of "White List." In 2019, South Korea removed Japan from its white list of trading partners. This was a countermeasure against the export restrictions imposed by Japan on three chemical components crucial to South Korea's semiconductor industry.[91]

The trade war between Japan and South Korea originated from the unresolved issues of colonial past. As explained in Chapter 3, South Korea was colonized by Japan for around

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[88] Wonhyuk Lim, *The Development of Korea's Electronics Industry During Its Formative Years (1966-1979)* (2016). "the government decided to allow Goldstar's TV production in December 1965 under the condition that the localization rate exceed 50%, and that the imports of TV components be funded through foreign currency earned by exporting other electronic products such as radios (based on an export-import link system). In 1966, Goldstar developed the first domestic black-and-white TV model, VD-191, though a technical alliance with Japan's Hitachi…….. until 1966, there was no systematic strategy to promote the electronics industry in Korea………During the formative years, Korea's electronics industry went from assembling relatively basic products like radios to producing more sophisticated products like color TVs and raised technological capabilities to such a degree that it could realistically think about developing core components like semiconductors. After the formative years, Korea's electronics industry entered a period of rapid rise (1980-1992), during which the government shifted its focus from consumer electronics to information and communications technology (ICT) and Korean firms diversified their products and developed core components and materials by greatly expanding R&D."

[89] Jaewon Lee, *SOUTH KOREA'S EXPORT CONTROL SYSTEM* (2013), https://www.sipri.org/sites/default/files/files/misc/SIPRIBP1311.pdf. "Beginning in the early 1950s, industrialized Western countries formulated restrictive measures to control exports of military and dual-use items to the Communist bloc, with the United States taking a leading role. The efforts were realized with the establishment of the Coordinating Committee for Multilateral Export Control (COCOM).

[90] *Id.* "Japan was the only Asian country to participate. COCOM had little concern with exports from other Asian countries such as South Korea, Singapore and Taiwan because they were not capable of producing commodities that were controlled under the regime……. The USA thus approached South Korea on a bilateral basis to ask it to comply with the COCOM guidelines in order to avoid a weakening of the effect of the existing multilateral containment policy."

[91] *Jaejun Sung, THE DIPLOMATIC CONFLICT BETWEEN SOUTH KOREA AND JAPAN: HAS THE CANDLELIGHT REVOLUTION BECOME THE CURSE OF LIBERAL DEMOCRACY?, UNISCI J. (2020).*

forty decades. The Japanese firms exploited South Korean workers by forcing them to work in inhuman conditions. The Japanese military captured South Korean people and transported them to Japan as forced labour and comfort women. The term "Comfort women" denotes women and children who were forced into sexual slavery by the Japanese military. After adopting the normalization treaty in 1965, the Japanese Government compensated the victims of Japanese imperial rule, mainly surviving comfort women. In 1995, Japan created the Asian Women Fund to bring closure to the compensation claims raised by Korean victims. Most of the money was donated by private individuals, which triggered the South Korean people to refuse the compensation demanding money from the Japanese Government.[92]

In 2015, the then US President initiated a conclusive settlement between Japan and South Korea, resulting in an agreement for the final and irreversible settlement of the 'Comfort Women' issue.[93] In 2017, the issue resurfaced when South Korean President Moon Jae In demanded renegotiation of compensation. In 2018, South Korea demanded an apology from the side of Japan against the atrocities that Koreans had to suffer during Japanese imperial rule. Later the Shinzo Abe government of Japan threatened South Korea of cutting trade ties.[94]

In the second half of 2018, the Supreme Court of South Korea ordered Japanese firms located in South Korea (mainly Mitsubishi Heavy Industries and Nippon Steel) to compensate the South Korean citizens who were mistreated as forced labour by these companies during World War II. Dissatisfied with the state of affairs, the Japanese Government published statement of discontent against South Korea. The Japanese companies in respective courts filed appeals, but all the appeals were rejected. In 2019, the Supreme Court of South Korea ordered seizure of shared held by Nippon Steel in a South Korean company-based joint venture with POSCO. This was followed by a similar decision by the court for the seizure of IP assets of Mitsubishi Heavy Industries.[95]

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[92] Gabriel Jonsson, Can the Japan-Korea Dispute on "Comfort Women" be Resolved?*, 46 KOREA OBS. (2015), https://www.diva-portal.org/smash/get/diva2:882170/FULLTEXT01.pdf.
[93] Id.
[94] Aiden Chang, *THE ISSUE OF COMFORT WOMEN AND LIANCOURT ROCKS DISPUTE: UNRESOLVED ISSUES FOR ADVANCING U.S.-SOUTH KOREA-JAPAN TRILATERAL RELATIONSHIP*, https://jscholarship.library.jhu.edu/bitstream/handle/1774.2/63316/CHANG-THESIS-2020.pdf?sequence=1.
[95] Prakash Panneerselvam, Changing Dynamics of Regional Trade and Cooperation: A Case of Japan and South Korea, 19 ARTHA-J. SOC. SCI. 1–20 (2020).

4.2: TRADE RESTRICTIONS ADOPTED BY JAPAN AND SOUTH KOREA

In July 2019, the Japanese Government imposed export restrictions on military-specific and dual-use items. It also imposed catch all controls for other items exported to South Korea. It altered the licensing policies. Every foreign exporter has to get the license approved after every 90 days, whereas earlier, the review period was one week. Every license had a validity period of 6 months, whereas it was three years before the change in trade policies. The Japanese Government cited security reasons for the imposition of trade controls.[96] The Japanese Government mandated the submission of 9 documents, whereas earlier, it was only 2 types of documents.[97]

In comparison, the South Korean Government claimed the trade restrictions as economic retaliation undertaken by the Japanese Government against the ruling passed by the Supreme Court of South Korea. The Japanese Ministry of Economy, trade, and Industry later removed South Korea from the 'White List of Trading Partners.' It also mandated individual export licenses for three critical items used by South Korea to produce semiconductors instead of the General Bulk Export License.[98] They are fluorinated polyimide, Photoresist (EUV), and Hydrogen Fluoride. Japanese Government alleged misappropriation of Hydrogen Fluoride by South Korea. The diplomatic relations between both the countries began to crumble, and deliberations on the same were conducted by the WTO dispute council. South Korea was demoted to Group B under the revised Japanese export control system. Every Japanese exporter had to get an export contract approved for each strategic item he exported to South Korea, making the export process time-consuming. Trade with South Korea was much easier when it was given preferential treatment under the White List. Later, South Korea also removed Japan from its White List, taking away the preferences given to Japan in cross-border trade.[99]

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[96] KYODO NEWS, *Japan nixes South Korea proposal for panel over export control rules* (2020), https://english.kyodonews.net/news/2020/06/98f5e6e4a50b-japan-nixes-s-korea-proposal-for-panel-over-export-control-rules.html.

[97] Yang-Hee Kim, *Interactions between Japan's "weaponized interdependence" and Korea's responses: "decoupling from Japan" vs. "decoupling from Japanese firms"*, INT. TRADE POLIT. DEV., https://www.emerald.com/insight/content/doi/10.1108/ITPD-11-2020-0082/full/html#sec003.

[98] WorldECR, *Changes to Japan's export licensing system* (2012), https://www.worldecr.com/wp-content/uploads/WorldECR-Japan-export-licensing-article.pdf.

[99] Sangho Shin, *The Korea-Japan trade dispute: non-tariff barriers*, IOWA STATE UNIV., https://www.econ.iastate.edu/files/events/files/jmp_sangho_shin.pdf.

The peculiarity of the global semiconductor supply chain is that only a few countries have achieved a nearly monopolistic status due to large-scale production concentrated in a few companies. For instance, the large-scale production of Wafers in TSMC located in Taiwan makes Taiwan an inevitable Fab in the supply chain. During the initial manufacturing stages, substantial capital investments make it challenging to bring new firms into the supply chain. The interdependence of South Korea and Japan is long-established and very difficult to uproot. The trade war not only crumbled their diplomatic relations but also affected the global semiconductor trade.

4.3: GLOBAL SEMICONDUCTOR INDUSTRY POST 2019 TRADE WAR

South Korea tops the list of memory device producers in the global semiconductor supply chain. Samsung and S K Hynix are the leading Korean companies, which hold more than 60% share in the supply chain.[100] It is pertinent to note that any distortion in the global demand for memory devices makes those two Korean giants vulnerable. The year 2019 was marked by the oversupply of NAND and flash memory, which reduced the average selling prices of the memory devices, thereby reducing the revenue of Samsung and S K Hynix.[101] The decline in revenue from a reduction in average market price occurred when Japan had implemented export control on specific chemical components inevitable for memory chip production. As explained in the previous chapter, South Korea is highly dependent on Japanese firms for semiconductor manufacturing equipment and intermediate goods like chemical components used to produce wafers. The important South Korean firm that supplies equipment is Semes. As already mentioned in the second chapter, the country is dependent on ASML (Netherlands) and American companies for the supply of equipment used in semiconductor manufacture.

Japan stands in a much better position in the global semiconductor supply chain when compared to South Korea. Japan has Integrated Device Manufacturers as well as Equipment manufacturing firms. Hence it enjoys a dominant position in the global supply chain provided that it often depends on international sources for Silicon and high-end technological equipment.

[100] SAM KIM, *Bloomberg Businessweek*, SOUTH KOREA AND TAIWAN'S CHIP POWER RATTLES THE U.S. AND CHINA (2021).
[101] GARTNER, , GARTNER SAYS WORLDWIDE SEMICONDUCTOR REVENUE DECLINED 11.9% IN 2019 (2020), https://www.gartner.com/en/newsroom/press-releases/2020-01-14-gartner-says-worldwide-semiconductor-revenue-declined-11-point-9-percent-in-2019.

The role played by South Korea and Japan in the supply chain is interdependent and complementary. As Japan supplies the chemicals necessary to manufacture memory devices, South Korea is dependent on imports from Japan. Meanwhile, Japan is not highly reliant on South Korea for memory devices, making Japan dominant in the supply chain. Before implementing trade restrictions on Japanese exports to South Korea, the period from July 2018 – July 2019 witnessed a total import rate of 42.9% Hydrogen Fluoride from Japan to South Korea. This was reduced to 9% from July 2019 through June 2020 after the imposition of export controls. Even though the rate increased to 14% during July 2020 – May 2021, the general trend is a decline in trade dependence of South Korea on Japan for the import of Hydrogen Fluoride.[102]

China is also another vital hydrogen fluoride supplier of South Korea. Acid grade fluorspar is a primer in the production of Hydrogen Fluoride. More than 60 % of the global Fluorspar production takes place in China. Fluorspar is chemically treated to produce Hydrogen Fluoride. Japan imports Chinese Hydrogen Fluoride. Japan uses this to manufacture Fluorinated Polyimide. It is pertinent to note that even when China dominates the global production of Fluorspar, it cannot refine all the Hydrogen Fluoride so produced to use it in semiconductor manufacturing by South Korea. The high-quality Hydrogen Fluoride is made in Japan using high-end technology, and hence, China cannot entirely displace Japan from South Korea's list of trading partners.

Since establishing a semiconductor industry in South Korea, the country largely depended on Japan for essential chemicals. This was because Japan produced high-quality chemicals using high-end technology. South Korean companies found it cost-effective to import chemicals from Japan rather than manufacturing them locally in South Korea. Also, Japan lies close to South Korea, making the transportation of chemicals easier. The normalization treaty had considerably improved the trade relations between the two countries when the semiconductor industry was at its initial stages in South Korea. The free trade agreement signed between the US and Japan forced Japan to control its dominance in the global semiconductor trade. This channeled opportunities towards South Korea, granting the country a dominant position in large-scale wafer manufacturing. Even though Japan is gradually losing its dominance in the supply chain, it retains its prominence in areas like equipment and technology.

[102] , *supra* note 10.

Down the line, the global semiconductor supply chain is now dispersed around the globe, with few countries specializing in few activities. Japan is lead in IDMs and equipment manufacturing. Japanese firms like Tokyo Electron, Hitachi High-Technologies, and Dainippon Screen dominates the total equipment market. Japan also dominated the global production of specific key components in semiconductor manufacture like cellulose triacetate film, cathode material, anode material.

Japanese firms also dominate the international market of EUV photoresist chemicals, an integral component of the modern 7 nanometres memory chips manufactured by Samsung and S K Hynix. Semiconductor manufacturing firms take months to choose the apt photoresist. It collects samples of photoresists from photoresist manufacturers. It selects a model, and the photoresist manufacturer refines the chosen model. On refining the chosen photoresist material, the semiconductor manufacturer tests the quality of the same. On successful testing by the semiconductor manufacturer, the photoresist manufacturer undertakes large-scale production of the same to meet the total demand of the semiconductor manufacturer. The whole process, from sending samples to semiconductor firms to large-scale production of photoresist, takes months to complete. Hence finding substitutes for Japanese photoresist manufacturers in the short run is a near-impossible task. Also, the short shelf life of photoresist material which is a maximum of 6 months makes it difficult to stock the same. The use of photoresist is already explained in Chapter 2. South Korea also exclusively depends on Japanese imports of Fluorinated polyimides.

South Korean firms play an inevitable role in the global semiconductor supply chain through the large-scale production and supply of memory chips.[103] Economic, political, and geographical situations which adversely affect South Korean firms could cause distortions in the global supply chain. The trade war between Japan and South Korea poses a challenge as both the firms act complementary in the supply chain. Apple, Lenovo, Dell, and HP Inc are a few MNCs that procure semiconductor devices from South Korean firms. As South Korean firms have grown to claim firm positions in the supply chain, it is to an extent necessary to find or introduce alternate semiconductor suppliers to the supply chain.

[103] Nobuya Takasugi, *KOREA'S SEMICONDUCTOR INDUSTRY* (2019), https://lib.kotra.or.kr/pyxis-api/1/digital-files/c16960f0-0e7b-018a-e053-b46464899664. ""Korea, highly competent in processing technology and ready to make swift decisions for future investment takes up over half of overall global market value. Being part of world's technological frontier, Korea is keeping distance from follower countries to remain competitive. Korea, which occupies over 63 percent of the world's memory chips market, has a lead in DRAM (72.3 percent) and NAND (49.5 percent) business."

4.4: IMPACT OF TRADE WAR ON COMPANIES IN THE SEMICONDUCTOR SUPPLY CHAIN

The South Korean semiconductor industry leaders Samsung[104] and S K Hynix are adversely affected by the trade war. Foonsung is the only firm in all of South Korea that produces refined Hydrogen Fluoride. It is already a trading partner of Samsung and S K Hynix. But it is pertinent to note that Foonsung lacks the industrial capacity to displace Japanese imports of Hydrogen Fluoride. S K Materials[105] and Soulbrain are also South Korean manufacturers of Hydrogen Fluoride[106], but their plant capacity is lower than that of Foonsung. Showa Denko KK and Kanto Denka Kogyo are the most important suppliers of Hydrogen Fluoride to South Korea. Both these companies are Japanese and supply gaseous Hydrogen Fluoride. Japanese companies Stella Chemifa and Morita Chemicals also provide refined Hydrogen Fluoride to South Korean companies but in liquid form. These companies are mainly dependent on demand from South Korea as South Korea holds a significant share in the global production of semiconductors. Kolon industries and SKC are the two South Korean companies that manufacture Fluorinated polyimides. SKC is a subsidiary company of S K Hynix. Daikin Chemical and Sumimoto are the Japanese companies that export fluorinated polyimides to South Korea.[107]

South Korean companies like Dongjin semiconductors and Dongwoo produce photoresist materials. DuPont (headquartered in the USA) also has photoresist manufacturing plants in South Korea. But all these photoresist manufacturers do not produce EUV photoresist chemicals used by Samsung and S K Hynix to manufacture most modern memory chips. Two national companies in Japan manufacture EUV photoresist chemicals. Also, Japanese firms JSR Corporation and Tokyo Ohara Kogyo manufacture high-quality photoresist. These two firms form a strong trade relation with Samsung and S K Hynix. That is so because the JSR

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[104] Id 1 "After meeting with a number of Japanese companies based on this strategy, Samsung decided to set up a joint venture with Sanyo Electric in final products such as TVs and another joint venture with NEC in major parts and components such as vacuum tubes and cathode-ray tubes as well as telecommunications equipment. In January 1969, the Samsung Group established Samsung Electronics. Its business objectives stated in the articles of association included the manufacture of not only final electronic products but also basic components such as semiconductors and telecommunications equipment as well, clearly demonstrating its intention to pursue vertical integration and diversification in due course.

[105] SONG KYOUNG-SON, *Pure-enough hydrogen fluoride produced by SK Materials* (2020).

[106] Tetsuo Sakabe, *NNA BUSINESS NEWS*, SAMSUNG SWITCHING SOURCE OF HYDROGEN FLUORIDE FROM JAPAN TO CHINA DUE TO TOKYO'S EXPORT CURBS .

[107] LOÏC DUMAS, *JAPAN-SOUTH KOREA'S RIVALRY: The Semiconductor Industry Instrumentalization and its Implication for the Future of Japan-South Korea Economic Interdependence*, https://www.iris-france.org/wp-content/uploads/2021/03/Asia-Focus-157.pdf.

Corporation and Tokyo Ohara Kogyo depend on the demand from Samsung and S K Hynix for their revenue as EUV photoresists are mainly used by the latter in the supply chain. Also, the lack of substitutes for EUV photoresist suppliers other than these two Japanese firms makes Samsung and S K Hynix dependent on them for the production of photoresist. Fujifilm Electronic Materials, Sumimoto chemicals, and Shin-Etsu Chemicals are the other Japanese manufacturers of Photoresist. But they manufacture older versions of photoresist yet depend on demand from South Korea for revenue.[108]

Refined Hydrogen Flouride, Fluorinated polyimides, and EUV photoresist chemicals are the most critical products traded between South Korea and Japan with regard to semiconductor manufacture. Both countries are critically dependent on each other in the trade of these products as their role in the semiconductor supply chain is complementary and interdependent.[109]

Even though there was a decline in the revenue earned by Samsung and S K Hynix during 2019 owing to the reduction in the market demand of DRAM (Dynamic Random Access Memory Semiconductors) [explained in Chapter 3], the year 2020 saw a spike in demand and revenue even when trade war continued. This shows that the trade war has not affected the semiconductor business at the South Korean end. Even though sudden trade restrictions shook the industry, South Korea was able to safeguard its semiconductor industry from shattering for many reasons, which are expounded later in this chapter. Since 2019 the general market trend in the global semiconductor industry shows an increase in demand for DRAM and NAND flash memory even when trade restrictions associated with Trade War are persisting on South Korean and Japanese sides.

[108] *Id.*

[109] Shin, *supra* note 12.

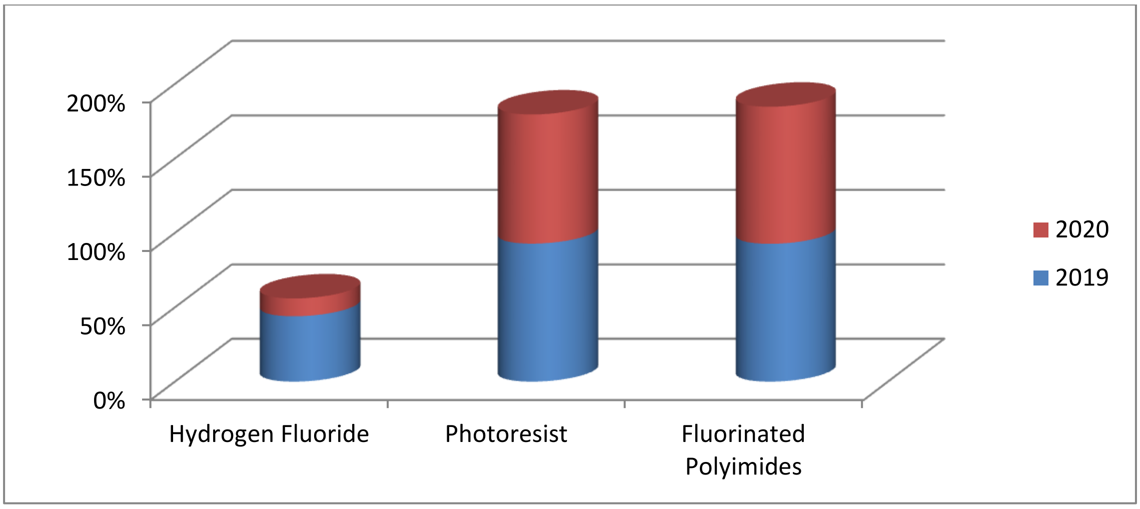

FIGURE 4.1: Reliance of South Korea on Japanese imports of specific semiconductor materials.[110]

In the second half of 2019, when the Japanese Government imposed restrictions on trade with South Korea, the South Korean Government immediately initiated measures to counteract the Japanese move to distort the South Korean semiconductor industry. The South Korean Ministry of Trade, Industry and Energy (MOTIE) began implementing "Countermeasures to Enhance the Competitiveness of Materials, Parts, and Equipment." The program zeroed in to procure and stabilize the supply of critical components in the semiconductor industry and strengthen the domestic semiconductor supply chain.[111] Items were listed, the collection of which was to be stabilized. Those items were called leading items. The Ministry also initiated plans to immediately procure the essential leading items from alternate sources and invest in R&D of the same. The South Korean Government diverted its focus from Japanese exports to the local manufacturers, which can grow its production to meet the demand persisting in the domestic semiconductor industry. Over time, the South Korean Government added new items to the list of leading items, enabling South Korea to reduce export dependency on Japan.[112]

South Korea began to reduce export ties with Japan by adopting import diversification, localization, and building new trade ties with third-country firms. Resources could be procured through four routes:

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[110] DUMAS, *supra* note 20.

[111] KOREA IT NEWS, , SOUTH KOREAN GOVERNMENTS COMES UP WITH A MEASURE TO STRENGTHEN COMPETITIVE EDGE OF MATERIALS, PARTS, AND EQUIPMENT INDUSTRIES .

[112] GEP INSIGHT DRIVES INNOVATION, , CAN SOUTH KOREA DREAM OF A SELF-RELIANT SEMICONDUCTOR CHEMICALS SUPPLY CHAIN? CAN SOUTH KOREA DREAM OF A SELF-RELIANT SEMICONDUCTOR CHEMICALS SUPPLY CHAIN? .

1. Building ties with Japanese firms located outside Japan

2. They are obtaining resources from third-country firms

3. Venturing with Japanese establishments in South Korea

4. Venturing with non-Japanese establishments in South Korea.

In the case of Hydrogen Fluoride, Japanese sources like Morita are substituted by Chinese and Taiwanese companies. South Korean enterprise Soulbrain has started production of high-quality Hydrogen Fluoride locally. This is connected to the success of "Fect," a joint venture between Soulbrain and Stella Chemifa (Japanese company) in producing low-quality Hydrogen Fluoride. South Korea also began to procure EUV- photoresist materials from a Joint venture company of JSR Corporation and IMEC (Belgian). DuPont, an American company, entered the EUV-photoresist chemical production by modernizing its existing photoresist manufacturing plants in South Korea.[113]

The decision of the South Korean Government and semiconductor firms to diversify their sources was a smart move as it ensures the long term growth of its semiconductor industry without being affected by any future deepening of trade restrictions by Japan. The import diversification and localization strategies have enabled Samsung and S K Hynix to continue their production level without distortion even when a trade war persists. It is also pertinent to note that Japan allowed the export of specific key components to South Korea during the trade war as exports of those particular components like EUV-photoresist to South Korea is a significant source of revenue for Japan. The most important consequence of the trade war to Japan is that new competitors for Japanese firms entered the supply chain. These competitors include DuPont, which ventured into EUV-photoresist chemical production, and few local South Korean firms, which expanded production with the help of financial aid from the Government to meet the local demand for critical components during the trade war. It also paved the way for third-country firms to enter into the global semiconductor supply chain.[114]

4.4: GLOBAL SEMICONDUCTOR POLITICS AND THE TRADE WAR

The Japanese Government put forth many reasons for the imposition of export controls over South Korea. These reasons are as follows:

1. The reluctance of the South Korean Government to regulate catch-all controls.

[113] , *supra* note 10.
[114] PULSE by Maeil Business News Korea, , DUPONT TO INJECT $28 MN TO BUILD PHOTORESIST PRODUCTION LINE IN S. KOREA , https://pulsenews.co.kr/view.php?year=2020&no=32269.

2. Misappropriation of the High-quality Hydrogen Fluoride of which Japan is the only producer in the world.
3. Illegal shipment of goods from Japan to South Korea.

Japan also claims that the South Korean Government misunderstood the export restrictions as retaliation against the South Korean Supreme Court's order against Japanese companies for Forced labour during World War II. According to Japan, the South Korean Government failed to regulate the trade of chemicals imported from Japan appropriately. Hence, Japan, which was the main source of those chemicals globally, was forced to curb South Korean misappropriation of the chemicals. Therefore Japan adopted the stand that the export restrictions complied with the WTO GATT Article 21.[115] It claimed that Japan's export restrictions were an attempt to protect its security interests associated with catch-all controls over conventional weapons. It demanded the withdrawal of the WTO complaint by South Korea and initiation of deliberations between the two nations to resolve the dispute. Few months after the negotiations in WTO, Japan eased the trade restrictions and removed Photoresist EUV from the category of items traded on obtaining an individual license. It was reinstated in the Special General Bulk License List.

The following reasons are cited by scholars for the gradual easing of export restrictions by Japan.

1. The Supreme Court of South Korea has not yet executed its order against the Japanese companies in South Korea.
2. Japan did not want to distort the global semiconductor supply chain as it will adversely affect the revenue earned by the Japanese economy.
3. Japan did not want the global community to interpret the restriction on the three key semiconductor components being driven by the ideological nationalism of Japanese Prime Minister Shinzo Abe and his supporters.[116]

Many factors point to a conclusion that Japan restricted the export of the three components: Hydrogen Fluoride, EUV-Photoresist chemicals, and Fluorinated Polyimides to South Korea mainly for political reasons associated with ideological nationalism.[117] Firstly, Japan did not

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[115] The General Agreement on Tariffs and Trade (GATT 1947) (Article XVIII — XXXVIII), .

[116] , *supra* note 10.

[117] East Asia Forum Economics, Politics and Public Policy in East Asia and the Pacific, , IS JAPAN WEAPONISING TRADE AGAINST SOUTH KOREA? (2019), https://www.eastasiaforum.org/2019/11/22/is-japan-weaponising-trade-against-south-korea/.

revoke the trade restrictions even when South Korea adopted measures to rectify the claims made against South Korea by Japan. Also, Japan claimed that only Hydrogen Fluoride was illegally exported to South Korea. Hence its action of imposing controls over the export of the other two chemicals is not justified. These three chemicals are critical to South Korea's semiconductor industry, and hence restrictions placed by Japan on the export of the same aim to choke the South Korean semiconductor exports.[118] It is also pertinent to note that the export curbs imposed by Japan immediately followed the decision of the Supreme Court of South Korea.

The semiconductor industry is the backbone of the South Korean economy.[119] Electrical machinery and equipment constituted 28% of the total exports of South Korea as of July 2021.[120] South Korean exports to Japan (5% of total exports) decreased whereas the percentages of exports to other Asian trading partners like Vietnam (9% of total exports), Hong Kong (6% of total exports), Taiwan (3% of total exports) and India (3% of total exports) increased.[121] Semiconductor stands as the second-largest item exported by South Korea, the first being Heavy industry products.[122] As of July 2021, China continues as the most significant source of South Korea, followed by the USA and EU. The percentage of imports from Japan to South Korea has declined since 2018, and the trend continues even in

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[118] Henry Farrell & Abraham L. Newman, *Weaponized Interdependence: How Global Economic Networks Shape State Coercion*, 44 INT. SECUR. 42–79 (2019). "the "**chokepoint effect**," and involves privileged states' capacity to limit or penalize use of hubs by third parties (e.g., other states or private actors). Because hubs offer extraordinary efficiency benefits, and because it is extremely difficult to circumvent them, states that can control hubs have considerable coercive power, and states or other actors that are denied access to hubs can suffer substantial consequences………..states' variable ability to employ these forms of coercion will depend on the combination of the structure of the underlying network and the domestic institutions of the states attempting to use them. States that have jurisdictional control over network hubs and enjoy sufficient institutional capacity will be able to deploy both panopticon and chokepoint effects. Variation in domestic institutions in terms of capacity and key norms may limit their ability to use these coercive tools even when they have territorial or jurisdictional claims over hubs. Where control over key hubs is spread across a small number of states, these states may need to coordinate with one another to exploit **weaponized interdependence**. States that lack access to, or control over, network hubs will not be able to exert such forms of coercion."

[119] Id 3 "Korea is the second largest semiconductor producer (taking up 21.5 percent of the market share) behind the United States and spends the most for semiconductor manufacturing equipment (USD 34.5 billion in 2017). Korea's semiconductor exports totaled USD 97.9 billion in 2017, demonstrating that semiconductors are the most valuable source of income for Korea. On top of that, Korea is the world's No. 1 memory semiconductor exporter, dominating over 60 percent of the global market.

[120] https://tradingeconomics.com/south-korea/exports

[121] Id

[122] Id

2021 July.[123] South Korea succeeded to a greater extent in diversifying its import and export partners and reducing trade dependence on Japan.

South Korea will not replace Japanese exports in areas of capital goods and high-end technology, both of which require substantial capital investments. Japan continues to be far more advanced in scientific developments and technology when compared to South Korea. Hence, both countries continue to be interdependent in semiconductor trade, but the dependency rate has declined on both sides. Cooperative trade has turned into competitive trade whereby Japan has begun to lose its competitive advantage in the supply chain with the entry of new suppliers. In comparison, South Korea managed to sustain its semiconductor industry by adopting import diversification, localization, and resorting to the WTO dispute resolution forum.

Scholars and media also perceive the trade war as an attempt by Japan to overpower South Korea in the global semiconductor trade. The control on exports imposed by the Japanese Government is compared with the trade restrictions on China and Huawei imposed by the Donald Trump administration. The USA is one of the greatest allies of Japan, both in economic and security partnerships.[124] With South Korea increasing trade ties with China and Japan and the USA collaborating to develop EUV-photoresist materials, the trade war could also be perceived as a weaponisation of trade by Japan backed by the USA. The USA is a party to the General Security of Military Information Agreement (GSOMIA), which the South Korean Government decided to terminate as a countermeasure to Japanese export controls.[125]

With the incorporation of new firms, the global supply chain will become more competitive. Countries like Japan which enjoyed near-monopoly, are gradually losing the same. And more unknown firms are encouraged to venture into the supply chain. Countries like India who has not yet ventured into large-scale semiconductor production, will now get an opportunity to channel its abundant human resource and landscape into semiconductor production.

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[123] https://tradingeconomics.com/south-korea/imports-from-japan

[124] 112 YUKA FUKUNAGA, JAPAN'S TRADE POLICY IN THE MIDST OF UNCERTAINITY (2020), https://www.ifri.org/sites/default/files/atoms/files/asie_visions_fukanaga_japan_trade_policy_complet_2020.pdf . "

[125] East Asia Forum Economics, Politics and Public Policy in East Asia and the Pacific, *supra* note 30.

CHAPTER – 5

INDIA IN INTERNATIONAL TRADE REGIME OF SEMICONDUCTOR ELECTRONICS

5.1: TRENDS IN INDIA'S SEMICONDUCTOR & ELECTRONICS INDUSTRY

The Indian semiconductor industry is in its nascent stage. There is a massive demand for electronic communication devices like smartphones in India as the growing population depends on them more than ever due to covid times. India's economy is projected to be the second-fastest-growing economy globally,[126] which witnessed a growth rate of about 7% in 2019.[127] India's economy is characterized by a relatively stable Rupee, substantial foreign exchange buffer, low crude oil prices, and an underexploited human resource. India has over 2.6 million stem graduates. The infrastructural facilities in India are also advancing with the development of international airports and well-maintained roads, which increases connectivity. It has also achieved political stability and amicable trade relations with countries like Japan, South Korea, and the USA.[128] India has entered into Comprehensive Economic Partnership Agreements and Free Trade Agreements with various nations. This allows India to provide preferential treatment in trade to its trade partners, often without custom duties. The electronics industry is the fastest growing industry in India. The electronic devices consumption rate in India is one of the highest in the world. It saw a surge from USD 69.6 billion in 2012 to USD 400 billion in 2020. Mobile phones are the most consumed electronic good in India.

India is witnessing a population explosion, being the second largest populated country in the world. The rising unemployment rates and underutilized land and human resources have pushed the Government to develop industries that provide new employment opportunities. With this motive in mind, the Government initiated many programs to boost the country's manufacturing sector. It introduced the Skill India Initiative to collaborate with major developed nations to bring advanced knowledge into the country through skill transfer initiatives and internship programs. It also changed hostile FDIs policies to bring in more foreign investments into the country. According to UNCTAD, India is of the top 10 FDI destinations in the world. The Government initiated steps to promote domestic defence

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[126] GAYATRI NAYAK, *THE ECONOMIC TIMES*, INDIA TO BE THE SECOND FASTEST GROWING ECONOMY AFTER CHINA THIS YEAR (2021).
[127] EY, *Tapping into the globally-competitive Indian manufacturing opportunity* (2020).
[128] *Id.*

manufacturing and boost maintenance, repair, and overhaul to increase the efficiency of defence and aviation industries.

As per the Draft Defence Procurement Procedure (DPP) 2020, the Government aims to develop Artificial Intelligence/ Virtual Reality/ Augmented Reality in the defence industry. It also significantly reduced the corporate taxes, which now stand at 17%, one of the lowest in Asia. The corporate tax rate in China is 25%, and Vietnam is 20% as of 2019. In 2017, the Government introduced Goods and Services Tax (GST) into the domestic taxation system, increasing transparency in tax administration. This also paved the way for increased efficiency in domestic supply chains. It also increased the competitiveness of India's manufacturing sector.[129] The Government also implemented digital compliance by introducing electronic filing and verification processes associated with commerce which simplified the regulatory environment in the country. Electronic payment systems also raised with the rise in E-Commerce, which added efficiency and transparency in financial transactions throughout the nation. As of 2020, the Government significantly reduced the procedural complexities associated with internal and cross-border trade compliances. As per the World Bank Ease of Doing Business Report 2019, India stands at the 63rd position whereas it stood in the 142nd position in 2014.

Along with the introduction of GST, the Government also introduced various statutes to strengthen the national legal framework regarding business and commerce.[130]Long-standing successful joint ventures feature the Indian economy. New governmental policies allow manufacturing in nearly every industrial sector through joint ventures. New FDI policies allow 100% equity ownership by foreign firms in Indian businesses. Indian firms are also undertaking contract manufacturing which is a significant contributor to the Indian economy.

India expects to become the 3rd largest producer of Auto components in the world by 2025. It is growing to become a designing hub in the global supply chain owing to its talented pool of engineers. India has an outstanding 1.2 billion telecom subscribers. Electronic vehicles have also begun to find a market in India which will stimulate a need for domestic battery manufacturing. India is dependent on imports to meet the needs of its defense industry. India

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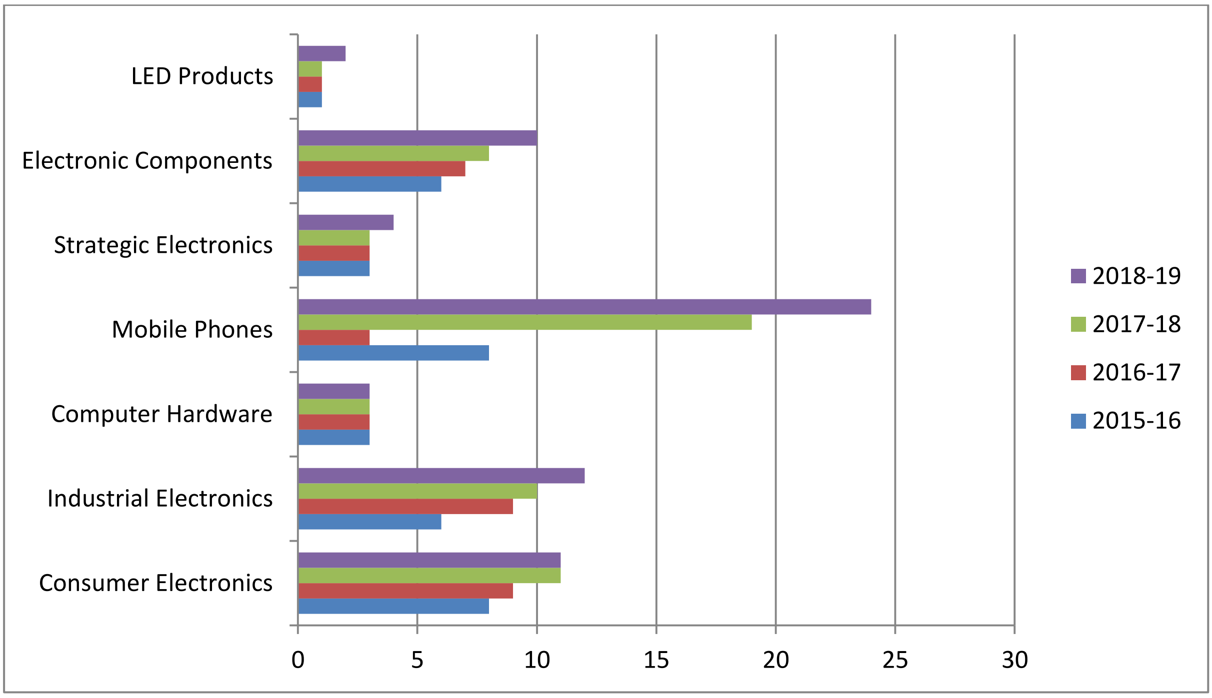
[129] *Id.*
[130] *Id.*

has grown to become the favourite destination of MNCs to set up their R&D centers outside of their home country.[131]

FIGURE 5.1: Indian Electronics Manufacturing Sector in USD Billion[132]



The Indian electronics industry has shown a tremendous increase in the manufacturing of mobile phones when compared to other electronic devices because of an increase in demand for the same. But it is also pertinent to note that most of the parts of mobile phones, including the semiconductor chips, are imported from different countries. Only assembling of these parts takes place in India. Electronic goods worth Rs 3.59 lakh crore between April 2019 and February 2020 were imported by India from China which is approximately 1/3rd of the total imports from China.[133] Japanese companies like Yaskawa Electronics Corporation and Mitsubishi Corporation have been undertaking substantial manufacturing activities in India. These companies own plants in Bengaluru, Chennai, and Delhi NCR. But the recent government policies have been pushing the domestic industry to undertake large-scale manufacture of electronic devices, including semiconductor chips. To support India's nascent chip manufacturing industry, the Government announced financial support of 25% of capital

131 RISHIKESHA T KRISHNAN, *FOUNDING FUEL*, INDIA IS AN R&D HUB FOR MNCS. WILL GLOBAL PROTECTIONISM PLAY SPOILSPORT? , https://www.foundingfuel.com/article/india-is-an-rd-hub-for-mncs-will-global-protectionism-play-spoilsport/.

132 , *supra* note 2.

133 BUSINESS TODAY, , INDIA'S ELECTRONIC EXPORTS CAN RISE 16 FOLD TO $180 BILLION BY 2025 (2021), https://www.businesstoday.in/latest/economy-politics/story/india-electronic-exports-can-rise-16-fold-to-180-billion-by-2025-271716-2020-08-31.

expenditure on the manufacture of essential semiconductor components in India.[134] The Government has been initiating plans to build Modified Electronics Manufacturing Clusters[135] in different states. It has also undertaken Production-Linked Incentive (PLI) scheme for Large Scale Electronics Manufacturing. Production linked incentive system provides customized incentives to semiconductor firms. This will motivate firms to engage in further research and development of their existing activities and step foot in new areas of the semiconductor manufacture process.[136] The PLI scheme is linked with the success of the mobile manufacturing industry in India.[137]

Semiconductors are the second most imported material in India after crude oil and before gold. The Indian economy loses a significant amount of its revenue for its importation. Hence intending to curb the expenses on importation of semiconductors and to increase the GDP, the Government called major private players nationally and globally to venture into semiconductor manufacturing in India. With the various government initiatives, foreign enterprises find it easier to build plants in India over countries like China which already faces political tensions with the USA, Japan, and other international organizations.

5.2: THE CHANGING DYNAMICS OF FOREIGN INVESTMENTS IN THE INDIAN SEMICONDUCTOR INDUSTRY

India Electronics and Semiconductor Association (IESA) is an organization that promotes the manufacture of electronic goods in India. In 2016, the Government of India received 156

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[134] MINISTRY OF ELECTRONICS AND INFORMATION TECHNOLOGY : GOVERNMENT OF INDIA, , SCHEME FOR PROMOTION OF MANUFACTURING OF ELECTRONIC COMPONENTS AND SEMICONDUCTORS (SPECS) , https://www.meity.gov.in/esdm/SPECS. "The scheme will provide financial incentive of 25% on capital expenditure for the identified list of electronic goods that comprise downstream value chain of electronic products, i.e., electronic components, semiconductor/ display fabrication units, ATMP units, specialized sub-assemblies and capital goods for manufacture of aforesaid goods, all of which involve high value added manufacturing. The Scheme will be applicable to investments in new units and expansion of capacity/ modernization and diversification of existing units. Application under the Scheme can be made by any entity registered in India. The capital expenditure will be total of expenditure in plant, machinery, equipment, associated utilities and technology, including for Research & Development (R&D)."

[135] MINISTRY OF ELECTRONICS AND INFORMATION TECHNOLOGY : GOVERNMENT OF INDIA, , MODIFIED ELECTRONICS MANUFACTURING CLUSTERS (EMC 2.0) SCHEME ." ".......with the objective to address the disabilities, by providing support for creation of world class infrastructure along with common facilities and amenities, including Ready Built Factory (RBF) sheds / Plug and Play facilities for attracting major global electronics manufacturers along with their supply chain to set up units in the country. This Scheme will fortify the linkage between domestic and international market by strengthening supply chain responsiveness, consolidation of suppliers, decreased time-to-market, lower logistics costs, etc."

[136] KV KURMANATH, *BUSINESS LINE*, OUTLOOK BRIGHT FOR SEMICONDUCTOR INDUSTRY AS PANDEMIC DRIVES DEMAND , https://www.thehindubusinessline.com/markets/outlook-bright-for-semiconductor-industry-as-pandemic-drives-demand/article34338615.ece.

[137] MINISTRY OF ELECTRONICS AND INFORMATION TECHNOLOGY : GOVERNMENT OF INDIA, , PRODUCTION LINKED INCENTIVE SCHEME (PLI) FOR LARGE SCALE ELECTRONICS MANUFACTURING , https://www.meity.gov.in/esdm/pli.

proposals from foreign MNCs to manufacture electronic goods in India. The Government brought programs like the Make In India initiative, Digital India campaign, Start-up India and Skill India, and National Electronics Policy and National Telecom Policy to promote export and substitute imports with local goods. The Government fixed minimal custom duties on goods that lie outside the purview of the IT Free Trade Agreement. To promote exports of electronic goods, the Government initiated schemes that provide incentives for exporting certain electronic goods in the Focus Products scheme under the Foreign Trade Policy. It also created the Modified Special Incentive Package Scheme (MSIPS) to incentivize electronics hardware manufacturing in India. Greenfield and brownfield Electronic Manufacturing Clusters (EMCs) are also encouraged under the EMC scheme for boosting the manufacture of Electronic devices in India. NITI Ayog advised the Indian Government to penetrate the electronic markets of its partners in free trade agreements to boost electronic exports in India. Electronics export from India is projected to rise from 11.2 Billion USD in 2019-20 to 180 USD Billion by 2025.[138]

Semiconductor consumption in India is growing at a rate of 15%, whereas electronics manufacture is projected to grow at 30% annually until 2025.[139] With the increase in demand for mobile phones, LCD screens, and other electronic devices in this era of IoT, demand for semiconductor chips will also exponentially increase in India. As explained in Chapter 2, large-scale manufacture of chips is preceded by the designing of chips. India is home to significant semiconductor designing units. Designing of chips is carried out in an electronic design automation environment.[140] Engineers in India undertake IC Design and Verification. Many foreign companies have established software firms in India where chips are designed. But these chips are not manufactured in India. Many initiatives by the Indian Government to set up wafer fabrication plants failed mainly due to substantial initial investments peculiar to

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[138] BUSINESS TODAY, *supra* note 8.

[139] NEERAJ BANSAL, *KPMG*, DECODING THE GLOBAL SEMICONDUCTOR SHORTAGE CONUNDRUM .

[140] Himanshu Kushwah & Anil Sethi, *FUTURE OF SEMICONDUCTOR FABRICATION (FAB) INDUSTRIES IN INDIA- OPPORTUNITIES AND CHALLENGES*, 4 INT. J. RES. ENG. TECHNOL. (2015), https://ijret.org/volumes/2015v04/i08/IJRET20150408014.pdf. "Design Units includes the facility of semiconductor chip design under electronic design automation environment. It doesn't involve actual fabrication or packaging of semiconductors wafers. The hardware circuit design is first simulated and after certain design rule checks it's ready for test manufacturing. India has its master hand in design units through many international players which have already setup their base here".

semiconductor firms. Around USD 6-8 Billion is the estimated minimum initial cost to set up a wafer fabrication plant.[141]

In 2015, Infineon, a German semiconductor firm, collaborated with National Skill Development Corporation to share semiconductor knowledge and practice with India. In 2016, the Indian Government allowed 100% FDI equity ownership in the electronics system design manufacturing (ESDM). IESA has also undertaken collaborations with various premier Indian Universities to develop human resources skilled in semiconductor technology. In 2015, it also entered into a Memorandum of cooperation with the Singapore Semiconductor Industry Association to partner in trade and technology endeavors between both nations.[142] In 2016, Electronics Development Fund was established by the Department of Electronics and Information Technology to promote innovation in the industry.[143] Canara Bank manages the fund. Various centers like the National Centre for Flexible Electronics (based at IIT Kanpur), the National Centre for Excellence in Technology for Internal Security (IIT Bombay), and the Centre for Excellence for Internet of Things (Bengaluru) are established by the Government to create a skilled human resource in ESDM. The FDI in the electronic manufacturing sector was the highest till then in 2016, which amounted to US$ 18.34 billion when compared to US$ 1.64 billion in 2014.[144] Many foreign firms like Panasonic Corporation (Japanese), Samsung (South Korean), Freescale (US-based), among others, have initiated substantial investments in the Indian electronics and semiconductor industry.[145] Hence, the Government's plans to promote e-governance, increased connectivity, and growing demand for electronic goods have built an environment conducive to growth for semiconductor firms. As India is looking for opportunities to transform its electronics industry into a manufacturing-led one rather than consumption-driven, it needs further collaboration with already established foreign firms of the global semiconductor supply chain. A manufacturing base in India will allow global electronic companies to meet the demand Indian domestic market and that of the Middle East at a lower transportation cost

[141] BANSAL, *supra* note 14.
[142] DEZAN SHIRA & ASSOCIATES, *INDIA BRIEFINGS*, SETTING UP A SEMICONDUCTOR FABRICATION PLANT IN INDIA: WHAT FOREIGN INVESTORS SHOULD KNOW (2021), https://www.india-briefing.com/news/setting-up-a-semiconductor-fabrication-plant-in-india-what-foreign-investors-should-know-22009.html/.
[143] MINISTRY OF ELECTRONICS AND INFORMATION TECHNOLOGY : GOVERNMENT OF INDIA, , ELECTRONICS DEVELOPMENT FUND (EDF) POLICY .
[144] INDIA BRAND EQUITY FOUNDATION, , SEMICONDUCTOR INDUSTRY IN INDIA (2021), https://www.ibef.org/industry/semiconductors.aspx.
[145] *Id.*

than opening a manufacturing base at other countries like the Philippines, Vietnam, and China.[146]

5.3: THE WAY AHEAD FOR INDIA'S SEMICONDUCTOR INDUSTRY

Semiconductor fabrication plants require facilities like a vast and consistent water supply for production, consistent power supply, significantly high operating costs. It also necessitates constant updation of technology with changing dynamics of the industry. The initial investments required to set up a fabrication plant are also high.[147] Hence, for a developing country like India, overcoming the capital intensive hurdles is the primary task for setting up a front-end fabrication plant. Two consortia in India have initiated activities to set up commercial semiconductor fabrication plants in India at Greater Noida in Uttar and Prantij in Gujarat.[148] The Tata Group recently partnered with Apple by investing ₹5,000 Crores in establishing a mobile phone component manufacturing plant in Tamil Nadu. Intel India has partnered with the Telangana State Government to launch an applied AI research center in Hyderabad.[149]

Most of the major global market players of the semiconductor supply chain have an R&D unit in India. That is because of the talented pool of IT engineers available cheaply in India.[150] Setting up a fabrication plant is a tedious task; the country should begin its semiconductor manufacturing journey by investing in assembly, testing, marking, and packaging (ATMP) and specialty fabs.[151] ATMP sector is less capital intensive when compared to large-scale fabrication plants. Also, as the activities undertaken by ATMC firms are labor-intensive, it will generate more employment opportunities.

According to India Electronics and Semiconductor Association, specialty fab is an area where a country, far behind in semiconductor technology, like India could step foot in. Speciality fabrication plants are sector-specific, like electric vehicles, medical equipment etc. The supply of raw materials is another area where India could achieve progress in the coming

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[146] THE TIMES OF INDIA TECH NEWS, , INDIAN ELECTRONICS AND HARDWARE INDUSTRY TO GROW AT A CAGR O .. READ MORE AT: HTTP://TIMESOFINDIA.INDIATIMES.COM/ARTICLESHOW/51811218.CMS?UTM_SOURCE=CONTENTOFINTEREST&UTM_MEDIUM=TEXT&UTM_CAMPAIGN=CPPST (2016), https://timesofindia.indiatimes.com/tech-news/indian-electronics-and-hardware-industry-to-grow-at-a-cagr-of-13-16-assocham-ey-study/articleshow/51811218.cms.

[147] MAYANK VASHISHT, *ELE TIMES*, SEMICONDUCTORS AND THE INDIAN PREDICAMENT (2021), https://www.eletimes.com/semiconductors-and-the-indian-predicament.

[148] & ASSOCIATES, *supra* note 17.

[149] analyticsindiamag.com, , INDIA IS GETTING READY FOR MASS PRODUCTION OF SEMICONDUCTOR CHIPS (2020).

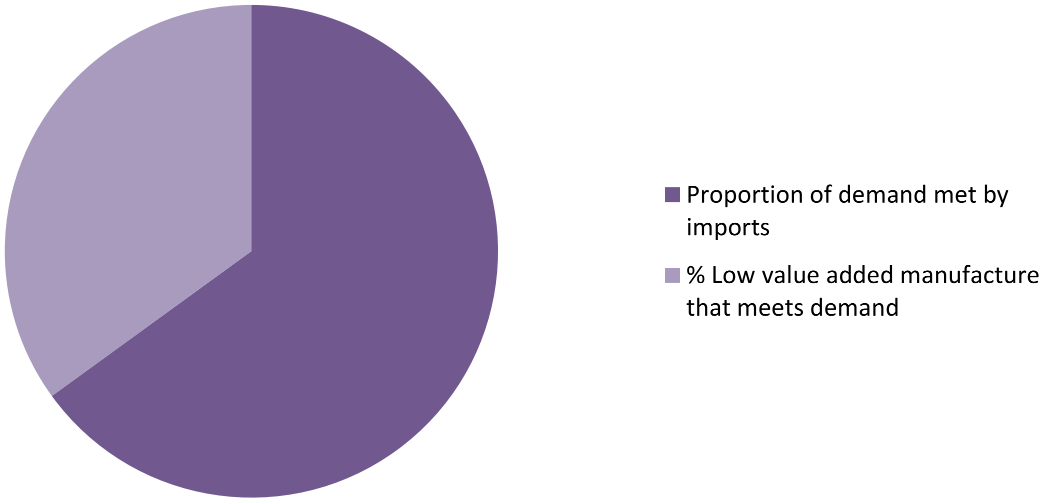
[150] Kushwah and Sethi, *supra* note 15.

[151] VASHISHT, *supra* note 22.

decades. With the introduction of AI and robotics in the global defence and security arena, India is pressured to undertake measures to gain an edge in semiconductor technology.[152]

In 2021 June, the Government called for Expression of Interest from semiconductor firms worldwide interested in undertaking semiconductor wafer manufacturing or setting up device fabrication plants in India.[153] Even though the Government is keen on attracting FDIs and established foreign semiconductor firms to open plants in India, it also faces fierce competition from other low-cost manufacturing destinations like Vietnam. Delay in policy implementation, absence of well-equipped laboratories for testing, and a vast supply-demand gap are major inhibitors of the growth of the Indian semiconductor industry.[154]

FIGURE 5.2: % DEPENDENCY OF INDIA ON IMPORTS TO MEET ITS DOMESTIC DEMAND OF ELECTRONICS PRODUCTS



The pie chart below depicts India's percentage dependency on imports to meet the demand of its domestic electronics industry.[155]

With changing trends in international politics, achieving dominance in semiconductor trade became more strategic than economic. Countries with large-scale semiconductor plants dominate the global economy and have the power to control the global economy. Because of the internet of things and the digital economy, semiconductors became vital to our everyday

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[152] *Id.*
[153] & ASSOCIATES, *supra* note 17.
[154] PRATIK AVINASH JOSHI, *INDIAN ELECTRONICS INDUSTRY -A PERSUASIVE GROWTH ENGINE BEHIND THE SOARING ECONOMY OF INDIA*, IJEEDC (2015).
[155] *Id.*

lives. That is why semiconductor trade is used as a weapon by nations to distort the economy of other nations. As a few countries dominate the semiconductor supply chain, it is easier for them to choke the economy of countries that import semiconductor materials from them. Japan-South Korea trade war could be perceived as one such example where Japan tried to obstruct the production of semiconductors in South Korea by restricting the supply of 3 essential semiconductor components. This is similar to the persisting trade war between the US and China. Hence, India should adopt measures to penetrate the various sectors within the global semiconductor supply chain.

CHAPTER 6

FINDINGS, CONCLUSION AND SUGGESTIONS

6.1: INTRODUCTION

With technology intertwined with our daily life and well-being, be it financial, social, medical or personal, the demand for technological products are on the rise. Semiconductors being the integral component of all the technological goods are one of the most traded material on the planet. The semiconductor supply and production is managed and controlled by the dominant market players in the global semiconductor supply chain. The dominant market players include USA, Japan, South Korea and Taiwan. The world is dependent on these economies for its semiconductor needs. With rise of Artificial intelligence and automatic vehicles, semiconductors have penetrated into all areas of human lives. This makes self-sufficiency in semiconductor technology strategically important for any economy in the world.

After the invention of transistor in the Bell labs in USA, Japanese firm Sony commercialised it through all-transistor radios. Since then there has been no turning back for semiconductor technology. It has superseded petroleum and crude oil in demand. Over the years, the size of semiconductor chips reduced increasing its structural complexity with an exponential increase in its efficiency and data storage capacity. The semiconductor devices are generally classified into logic, memory and discrete and analog components. The production of semiconductor chips begins with derivation of pure silicon from silicon dioxide. Sand is the most commonly used raw material. Wafers are produced using pure silicon crystals. Wafer fabrication is a complex task which involves many sub-tasks. Capital intensive nature of wafer fabrication processes makes it difficult for new entrants into the market without substantial funding. Countries like Taiwan and South Korea which receive subsidies and funds from their respective governments have specialised foundries or wafer fabrication plants. Along with foundries or fabs, the other three business models in semiconductor industry include IDMs, fablite design firms and OSATs.

All business models in the semiconductor industry require unrestricted flow of goods and work in progress inventories to different locations where value addition takes place to finally reach the consumers. The unrestricted flow of goods was made possible through trade liberalisation post World War II. That was made possible by World Trade Organisation and the multilateral treaties reducing/eliminating trade barriers. That led to the growth of GSC of semiconductors. Market players in the GSC specialised in certain activities according to competitive advantages and became dominant players in the supply chain. Specialisation in the supply chain has both merits and demerits.

Merits of specialisation include reduction in the cost of production of semiconductors due to competitive advantage enjoyed by the companies that produce chips. The money thus saved could be channelled by firms to promote R&D to further innovate their products and technology. Hence, R&D ensures advancements in technology along with meeting the dynamic needs of the consumers. Concentration of semiconductor technology and equipment with few dominant market players has its own disadvantaged as well. Semiconductors are now integral in security and defence as drone technology and AI have penetrated modern warfare. As semiconductors have become strategically inevitable for economies, concentration of its production in a few areas in the supply chain gives edge to those economies over other countries which are far behind in semiconductor technology. But without huge capital investment no country can venture into semiconductor manufacture. That makes it exclusive to a few developed countries even though the consumers are spread globally. Geographically specialised sources and globally scattered demand makes the semiconductor GSC complex.

As explained above strategical importance of semiconductors in international defence and security could be understood from the use of semiconductors as political weapons. It is better understood from the context of Japan-South Korea trade war. Japan and South Korea enjoy dominant positions in the semiconductor GSC. The economies of Japan and South Korea have been connected for years through war, trade and colonialism. South Korea was a colony of Japanese imperial rule for years and the trade war between the two countries emanated from the unhealed wounds of the colonial past. Even though the trade relations were normalised via the normalisation treaty of 1965, deliberations and internal agitations continued in South Korea for more compensation and public apology from Japan. These circumstances persisted as unsettled issues between the two countries. The issues resurfaced when the Supreme Court of South Korea ordered two major Japanese companies Mitsubishi and Nippon Steel to compensate persons who were victims of forced labour under these companies. Months after the decision of the South Korean Supreme Court, Japan removed South Korea from its white list of trading partners and reduced the export of chemicals which were critical to the South Korean semiconductor industry. The cycle of events which followed the Supreme Court's decision distorted trade relations between the two nations. It also distorted the global semiconductor trade but only to a lesser extent when compared to the simultaneous US-China trade war that shook the semiconductor electronics industry.

Japan-South Korea trade war is an example of how trade could be used as a political weapon. When the world is shrinking into a global village with increase in connectivity and communication technology, the need to control manipulation of trade as a political weapon is necessary. Otherwise, interconnected global economies will suffer due to political tug of war which will ultimately lead to scarcity of resources at the consumer's end. Capital intensive nature of semiconductor industry and its complex infrastructural requirements make it difficult for new companies to enter the GSC. But trade wars between dominant players in the supply chain will lead to shortage in supply of necessary goods. As the whole world is dependent on a few countries for critical goods, those countries enjoy superior position over its consumer nations. That is also dangerous in a political sense as developing nations and LDCs will continue to remain vulnerable to the political and technological domination of developed nations. Hence de-concentration of production and increasing the number of firms in the supply chain will be conducive to stimulating supply chain growth. Spreading the technology and resources needed for semiconductor production to economies capable of undertaking complex semiconductor manufacturing will help to decentralise or de-concentrate GSC manufacturing. These economies could also be assisted financially at the international level. There will be political barriers to such attempts but it is the need of the hour.

In the wake of trade wars like the Japan-South Korea trade war where the actual reasons for the trade war find its origin in the colonial period, deliberations might remain useless. This is because historical vengeance and power struggle will always resurface as political weapons used by political parties to gain public sentiments in democracies. In such a scenario, it will always be better to diversify production of critical goods and stabilise the supply chain so that in case of any future trade distortions, production and supply of critical goods like the semiconductor goods are not affected.

The peculiarity of the semiconductor industry is its capital intensive nature and ever-growing technologies. As generations go by, older technologies become obsolete and companies have to spend huge capital to catch up with new technologies. New firms can go for less capital intensive business models like the OSAT model to enter the semiconductor industry.

Recently, countries like Vietnam and Malaysia have ventured into semiconductor business by establishing OSAT firms. OSAT firms require less capital and low skilled labour when compared to specialised wafer manufacturing plants. OSAT firms undertake assembling, packaging and testing of semiconductor goods. It's high time that India should venture into semiconductor production. It should not back out due to many failed attempts in the past. Considering the pace of India's economic development, it should give more push to its domestic semiconductor industry and take measures to promote domestic manufacture of semiconductor chips. Provided its geographical positioning, India could easily connect with Middle East, Australia and south East Asian nations where a huge percentage of semiconductor (electronics) consumers reside. India should venture into technology transfer initiatives with dominant Asian players in the supply chain like South Korea, Tainwan etc. Hence, it is concluded that a need to diversify semiconductor production in the supply chain has brought about opportunities for countries like India to venture into semiconductor manufacture.

6.2: FINDINGS

- Relevance of semiconductors in global trade of 21st century
  Semiconductors have superseded crude oil and petrol as the most traded product in the world. Nearly all areas of human lives involve semiconductor chips. With evolution of digital economy and 5G technology, connectivity is growing in an unprecedented manner. Backed by globalisation, technology exchanges are happening in the world every second through the internet. Hence semiconductors which are the integral component in every electronic device are also the most demanded good on the planet.

- Peculiarities of the global semiconductor supply chain
  Geographic/regional specialisation is the most important characteristics of the semiconductor GSC. Capital intensive nature of the industry and the sophisticated infrastructural requirements make it highly complicated for new entrants to start production. That makes the various business models in the supply chain relevant. Without adequate financial aids from the government, it is impossible for any firm to venture into semiconductor manufacture.

- Causes of Japan-South Korea trade war

  The causes of the trade war find its origin in the history of colonialism shared by Japan and South Korea. Japan never tendered a public apology to South Korea for the atrocities South Korea had to experience during Japanese colonial rule. This instilled anti-Japanese sentiments in the minds of Korean public which are often weaponised by Korean political parties for their political gains. Trade relations between the two nations began to distort when the South Korean Supreme Court ordered two Japanese companies to compensate its Korean workers who were forced to work under inhuman conditions during World War II. Both Japan and South Korea removed each other's names from the white list of trading partners. The events that followed adversely affected the trade of critical semiconductor goods between the nations. That proves the strategical importance of semiconductor production in the 21st century.

- Effects of the Japan-South Korea trade war on global semiconductor supply chain

  Even when trade war continued, the demand for semiconductor goods saw a rise. Unexpected restrictions implemented on export of critical chemicals by Japan shook the South Korean industry but strategies adopted by the South Korean government helped the economy to reduce the adverse effects of the trade war. One such strategy is the "Countermeasures to Enhance the Competitiveness of Materials, Parts, and Equipment" implemented by the South Korean Ministry of Trade, Industry and Energy. South Korean government also gave impetus to local manufacturers through financial and technological to boost domestic production of critical goods. It also adopted various methods to reduce import dependency on Japan. Meanwhile Japan is losing dominance in certain areas of the semiconductor production due to entry local South Korean manufacturers and Chinese manufacturers into the supply chain. It could be concluded that when Japan restricted its supply of critical goods to South Korea, South Korea began to develop alternate ways of procuring those critical goods leading to the entry of new suppliers in the semiconductor GSC. On a positive note, the international domain realised the need to diversify production and to de-concentrate the value additions in the supply chain.

- Measures that could be adopted to reduce the effects of trade wars on global supply chains (w.r.t semiconductor GSC)

The common effects of trade wars include shortage of resources/raw materials on one end, difficulty in procurement of goods, stagnancy of capital and the like. Import diversification, diversification of production or de-concentration of production in the supply chain, providing incentives to boost domestic manufacture of critical goods, building new trade links and taking measures to curb chokepoint effects are the methods to control trade distortions caused by trade wars. When nations compete for dominant position in the supply chain, tensions arise owing to trade distortions. Countries should promote cooperation over competition and deliberations over trade wars.

- New global trade opportunities evolved out of Japan-South Korea trade war for countries like India that still remains as a consumer nation in the supply chain

  Countries like India are characterised by labour surplus and capital deficiency. Hence OSAT business model is most suitable so that with limited capital and government aids, the country could venture into semiconductor supply chain. Later, on procuring adequate funds, it could initiate wafer fabrication by jumping right into latest technology used for the same and by skipping older and obsolete production techniques. A large number of design firms function in the Indian cities. Most of these firms are wholly owned by or are subsidiaries of foreign semiconductor firms. India has highly skilled semiconductor design engineers. That makes India a suitable location for more fablite design firms. Gradually, by succeeding in the fablite design model and OSAT model of business, India can take bigger steps towards building large scale semiconductor wafer fabrication plants. India has achieved self-sufficiency in mobile production provided the fact that semiconductors needed for the same are exported to India. In the coming years, with adequate government aids, it can successfully undertake manufacture of semiconductors. It needs to undertake technology transfer programs with countries like Taiwan, South Korea and the like. It also needs to grab more foreign investments to build infrastructure necessary for semiconductor industry. The Semiconductor Integrated Circuit Layout Design Act, 2000 provides a comprehensive and strong intellectual property protection to integrated circuit layout design. As the industry is only at its nascent stage in India, the industry and the legal institutions of the country is yet to explore the scope of the act. As the country already have a strong IP protection for software through statutes and precedents, layout design and mask works will be better protected in the years to come. It is pertinent to note that administrative and compliance oriented delays should be eliminated as technology becomes obsolete within a short span of time.

6.3: SUGGESTIONS AND CONCLUSION

Without setting long term developmental goals, India cannot venture into semiconductor production. Semiconductor technologies evolve after decades of intense R&D. Huge initial capital and high R&D requirements means that India will have plan for long term as it takes decades to actually reap profits out of semiconductor trade. BY opening 100% FDI the government has been actively procuring foreign investments in its electronics sector. Along with that developing a technically skilled labour force is also necessary. The government needs to give more attention in the human resource domain also. This could be done by collaborating research organisations and companies with national universities and educational institutions.

Coming to the context of Japan-South Korea trade war, Japan and South Korea should undertake deliberations presided by independent arbitrators. A conclusive settlement of the historical issues is needed. Recurring trade distortions will hinder economic growth of both the nations as the trade war is also indirectly linked with political stability. Japan and South Korea are neighbouring nations and hence should focus more on trade cooperation instead of competing to gain regional dominance.

CHAPTER 7

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